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FISH MEAL FREE-DIETS FOR NILE TILAPIA *OREOCHROMIS NILOTICUS (L.)*, *MUGILL CEPHALUS* AND *LIZA RAMADA* IN SEMI-INTENSIVE POLYCULTURE SYSTEM IN EARTHEN PONDS

O.M. El–Husseiny[1] ; A.M.A.-S. Goda[2]; G.M. Abdul-Aziz[1] and E.R. El-Haroun[1]

[1]Animal Production Department, Faculty of Agriculture, Cairo University, Egypt.
[2]Fish Nutrition Research Laboratory, National Institute of Oceanography and Fisheries (NIOF),Cairo, Egypt.

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SUMMARY

A 22-wk feeding experiment was conducted to study the effect of complete replacement of fish meal by dried hatchery waste (DHW), poultry by-product meal (PBM) or soybean meal (SBM) on growth, nutrient digestibility and amino acid retention of *Oreochromis niloticus (L.)*, *Mugill cephalus* and *Liza ramada* in a semi-intensive polyculture system. Four diets isonitrogenous (25 % crude protein) and isocaloric (14 MJ ME kg diet^{-1}) were formulated. The results showed that fish fed the diet containing PBM and DHW exhibited excellent comparable growth to those fed a fish meal–based diet. Digestibility of protein was increased when Nile tilapia; *M. cephalus* and *L. ramada* fed the diet containing DHW. The highest significant ($P \leq 0.05$) levels of apparent digestibility coefficient for lipid and gross energy were showed for all fish species when fed with FM diets. The higher significant ($P \leq 0.05$) whole body protein of *O. niloticus*, *M. cephalus* and *L. ramada* were showed when fishes fed DHW diet. Whole body lipid was showed the highest level for all fish species when fed with FM diet, while feeding on DHW reduced whole body ash content in all species. The total essential amino acid was showed more retention when Nile tilapia fed SBM diet, while lower values was recorded with PBM diet. *M. cephalus* and *L. ramada* recorded the highest levels of total essential amino acid retention when fed DHW diet, while the lower level was recorded with PBM diet. Estimated total non-essential amino acid retention showed the highest value for Nile tilapia when fed FM diet, while *M. cephalus* and *L. ramada* recorded the highest levels when fed diet containing DHW. The results suggest that when DHW and PBM are available in reasonable price; it could be successfully used as excellent alternatives protein. However, reduction in fish growth was observed when SBM used as a sole source of dietary protein. These results indicate that soybean meal could be used as partial replacement of dietary FM rather than used as complete replacement in fish diets.

***Keywords:** alternative protein sources, Nile tilapia, Mugill cephalus, Liza ramada, polyculture, semi-intensive.*

INTRODUCTION

Nile tilapia is an economically important cultured species in several areas of the world. Egypt made an impressive increase in aquaculture tilapia production, from 24 916 mt in 1990 to 487000. mt in 2005, accounting for 55 % of Egyptian total fish production (879000, mt years^{-1}) (FAO 2004 and GAFRD 2006). Most of fish farms in Egypt classified as semi-intensive farms; most of them are located in the northern or eastern parts of the Nile Delta. Polyculture is widely used for fish culture in Egypt; the main species cultured in commercial ponds are Nile tilapia; common carp, followed by mullet and small amounts of silver carp *Hypophthalmichthys molitrix.* Semi-intensive aquaculture provides about 75 % of Egypt's total aquaculture production. Tilapia contributes 44 % of the annual harvest, followed by mullet (25 %) and carp (24 %) (El-Gamal 2001). The polyculture of several fish species that fed on different natural resources are an important management technique to use efficiently the production potential of the pond (Karplus et al.1996). Synergistic interactions between fish species are manifested by higher growth and yield in polyculture than in monoculture (Hepher et al.1989).

Feed cost is the highest recurrent cost in aquaculture, ranging from 40 % to 70 % of variable operating costs, depending on the intensity of the operation (Muzinic et al. 2006). Growth, feed utilization and body composition of fish closely depend on contents of protein and energy in feed (Wang et al. 2004). Fish meal is the main protein source for aqua-feeds due to its high protein content, balanced essential amino acids profile, the high bioavailability of the amino acids and their highest palatability (Ogunji 2004). However, one of the major problems confronting the fish production is the increasing cost and short supply of fish meal. Therefore, fish nutritionists and feed manufacturers attempted to use alternative plants and animal protein sources for partially or totally replace fish meal, to reduce the cost of fish production (Ogunji 2004; Tzachi et al. 2004 and Wang et al. 2004). One of the best candidates to replace fish meal is soybean meal (Lovell 1988). Soybean meal is cost effective, readily available, high in protein content and has the best protein quality among plant protein feedstuffs used as alternative protein sources to fish meal in fish diet (Rumsey et al. 1993). However, considerable variations exist in the ability of different fish species to utilize soybean protein. Hypotheses explaining this lack of success include less than optimal amino acid balance in soybean meal protein and the presence of residual levels of trypsin inhibitors (Webster et al. 1992, 1995; Refstie et al. 1997, 1998).

Rendered animal protein, such as meat and meat and bone meals, poultry by-product meal and blood meals derived from animal rendering plants and waste recycling process, have long been used in compound feeds for terrestrial monogastric animals such as poultry and swine (Parsons *et al.* 1997). Recently, many studies have also shown that rendered animal protein ingredients are useful for fish feed formulation and comparatively less expensive than fish meal (Fowler 1991, Bureau et al. 1999, 2000. Fasakin et al. 2003, 2005). Poultry by-product meal (PBM) and dried hatchery waste (DHW) are two potential alternative animal protein sources because of their high protein contents and low price compared to the fish meal (Tacon and Jackson 1985). Previous studies have shown that PBM cannot replace more than 50 % of fish meal in fish diets (Gallagher and Degani 1988; Fowler 1991; Steffens 1994). Mahmod (2003) observed the same levels (50%) for Nile tilapia when fed PBM and DHW diets. Other studies have shown that with the recent improvement of the quality of PBM, it could replace 75% or even 100% of dietary fish meal without significant decrease in fish growth (Alexis 1997; Nengas et al. 1999; Takagi et al. 2000).

This study was designed to determine the effect of complete substitution of fish meal (FM) with dried hatchery waste meal (DHW), poultry by-product meal (PBM) and soybean meal (SBM) on growth performance, feed utilization, nutrient digestibility and amino acid retention of Nile tilapia, *M. cephalus* and *L. ramada* at semi-intensive polyculture system using well water.

MATERIALS AND METHODS

Feeds and Feeding practice

The fish meal, feed-grade soybean meal and poultry by-product meal were purchased from Animal Production Islamic Company APICO (Gaber ben Haian St., Dokki, El-Giza, Egypt). The fresh poultry hatchery waste (infertile eggs, un-hatchery eggs and egg-shells) was supplied from hatchery house of Middle East Company for Land Reclamation (El-Mansoria, El-Giza Governorate, Egypt). The fresh hatchery waste was put into a large container contained boiled (100 °C) water for 15 minutes. The water discarded and the residual dried at 80 °C in an oven for 48 h, then the product ground by a mixer. Four isonitrogenous (25% CP) and isocaloric (14 MJ ME kg $diet^{-1}$) diets were formulated: a control diet in which fish meal was used as a main source of protein and three tested diets were formulated to contain 100 % replacement of FM protein with each of either dried hatchery waste (DHW), poultry by-product meal (PBM) or soybean meal (SBM) (Table 1). Test diets were supplemented with DL-Methionine and L-Lysine at 1% and 0.5%, respectively for the three alternative protein test diets to cover fish requirements. The available essential amino acid (EAA) profiles of the experimental diets are shown in Table (2). The diets were processed by blending the dry ingredients into a homogenous mixture, then passing the mixed feed through a laboratory pellet mill (California Pellet Mill Co., San Francisco, CA, USA).

At the beginning of the experiment, one hundred fish from each species weighed individually and the amount of daily ration (3 % of body weight) was adjusted accordingly. The daily ration was offered three time a day (09.00, 11.30 and 15.00 h) 6 days a week. Random fish samples of at least 10% from each experimental treatment

Table (1): Composition and proximate analysis of the experimental diets (% dry matter).

Ingredients , %	FM	DHW	PBM	SBM
Fish meal	22.5	-	-	-
Dried hatchery waste	-	30.0	-	-
Poultry by-product	-	-	34.0	-
Soybean meal	-	-	-	47.0
Yellow Corn	30.0	32.0	45.5	14.0
Wheat bran	43.5	34.5	15.0	31.5
DL- Methionine	-	1.0	1.0	1.0
L- Lysine		0.5	0.5	0.5
Corn oil	2.0	-	2.0	4.0
Vitamin and minerals premix[1]	2.0	2.0	2.0	2.0
Proximate analysis, %				
Crude protein	25.0	25.7	25.7	25.5
Crude lipid	6.5	9.8	8.1	7.5
Total carbohydrates (including crude fiber)	56.1	51.7	56.6	55.2
Ash	12.4	12.8	9.6	11.8
Gross energy (MJ kg^{-1}) [2]	18.1	18.8	18.9	18.5
Metabolizable energy(MJ kg^{-1})[3]	13.6	14.1	14.2	13.8
Digestible energy (MJ kg^{-1})[3]	12.7	13.2	13.2	13.0
Protein energy ratio (mg CP: kJ GE g^{-1})	13.9	13.7	13.6	13.8

FM: fish meal, DHW: dried hatchery waste, PBM: poultry by - product meal and SBM: soybean meal.

[1] Vitamin and mineral mixture each 2-kg of mixture contains: Per kg mix: 4 000 000 IU vitamin A, 480 000 IU vitamin D3, 40 000 mg vitamin E, 2400 mg vitamin K3, 4 000 mg vitamin B1, 6 000 mg vitamin B2, 40 000 mg niacin, 10 000 mg Ca-D-pantothenate, 4 000 mg vitamin B6, 10 mg vitamin B12, 100 mg D-biotin, 1 200 mg folic acid, 40 000 mg vitamin C ve 60 000 mg inositol, 23 750 mg Mn, 75 000 mg Zn, 5 000 mg Zn, 2 000 mg Co, 2 750 mg I, 100 mg Se, 200 000 mg.

[2] Calculated using values of 23.6, 39.5 and 17.2 kJ g^{-1} for protein, fat and carbohydrate, respectively according to Brett (1973).

[3] ME and DE were calculated as 75% and 70%, respectively of GE values of Hepher *et al.* (1983).

species group were weighed every three weeks and feed allowance was corrected after weighing fish.

Experiment Fish and Growth Trials

The experiment was conducted at Fish Farm of Middle East Company for Land Reclamation (Tamo, El-Giza Governorate, Egypt). Nile tilapia *Oreochromis niloticus* were obtained from Nawa farm, Kalubiya Governorate, Egypt. *Mugilleda* spp. (*M. cephalus* and *L. ramada*) were obtained from Edko Lake, Alex. Governorate, Egypt. The experimental fish were carefully stocked into eight ponds (600 m^3 each and 1.5 m depth) with duplicate pond for each diet. The pond water was obtained from well source. The turnover rate of water was 50% $pond^{-1}day^{-1}$. Paddle wheels working for 45 min h^{-1} aerated each pond and rest for 15 min h^{-1}. The fishes were stocked at a rate of 7000 Nile tilapia, 2000 *M. cephalus* and 2000 *L. ramada* fish, respectively for each pond. The average initial body weight was 27.2 g ± 0.5 for *O. niloticus* and 12.0 g ± 0.3 for *M. cephalus* and *L. ramada*. Fish were acclimatized for 2 wk, than the actual experimental period extended for 22 wk. However, at the beginning of the experiment, three samples of 10 fish from each species were obtained and used for assessment of the initial proximate body composition. In addition, at the end of the experimental, 10 fishes from each species group ware obtained for final chemical body composition.

Growth Indices

To estimate the growth performance indices during the experimental period, initial and final as will as intermediate samples weight of individual fishes were measured using an electronic balance with the accuracy of 0.01 gram. Weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), protein productive value (PPV), fat retention (FR) and energy retention (ER) were calculated using the following equations:

WG = Final body weight (g) - Initial body weight (g)

SGR = [(ln FBW - ln IBW) ×100]/days, where: FBW is final body weight (g); IBW is initial body weight (g); and ln = natural logarithmic; FCR = Feed intake (g)/weight gain (g).

Apparent Nutrient Digestibility

At the end of experiment, the apparent digestibility coefficients (ADCs) were measured for nutrients content of each test diets. The digestibility trail was conducted in Animal Production Department aquarium, Faculty of Agriculture, Cairo University, Egypt. The fish were acclimated for two weeks in laboratory glass tanks. After acclimation, the healthy and strong fish were randomly stocked into glass tanks (70 cm x 45 cm x 40 cm) with 45 L of water at 10 fish per tank. The fish were fed the diets at 2% body weight twice daily. Each treatment was replicated thrice. The tanks were cleaned daily by siphoning out faecal matters and replacing 30% of the water in the tanks. All fish in each tank were weighed weekly and the new feed rate adjusted. The water quality parameters of the culture tanks were measured at 09.00 h using standard methods. Temperature was maintained at 28 ± 1.0 ^{5}C. Fish was maintained on a natural photoperiod approximating 14 h light: 10 h dark. Tanks were filled with dechlorinated tap water. Dissolved oxygen was measured daily using YSI model 56 oxygen meter (Yellow Springs Instrument, Yellow Springs, OH, USA). Water was aerated to supply oxygen. Ammonia concentration was maintained at less than 0.3 mgL^{-1} and pH at 8.00. However, all water quality guidelines were within acceptable limits for tilapia (Hepher and Pruginin 1981). Feaces samples were collected according to procedure of Nwanna (2004) using siphon technique for 21 days. The samples were collected every 6 hours after feeding by siphoning with 5 mm tubing. The collected samples were dried at 105 °C for 5 h, pooled for each treatment and analyzed for crude protein and lipid according to AOAC (1995). Energy content of feaces was determined with an automated bomb calorimeter (Model 1272, Parr Instruments Inc., Moline, IL, USA) using benzoic acid as the standard substance. The ADCs for protein, lipid and gross energy were calculated according to the formula of Austreng (1978) using acid insoluble ash as an indicator:

$$\text{ADC}=100-\left(\frac{\text{Indicator\% in diet}}{\text{Indicator \% in feaces}}\times\frac{\text{Nutrient \% in feaces}}{\text{Nutrient \% in diet}}\right)100$$

Water Quality

Water quality parameters, such as temperature, dissolved oxygen; pH and ammonia were monitored to ensure that water quality remained well within limits recommended for fish. Water temperature was recorded daily using a mercury thermometer suspended at 30-cm depth. Dissolved oxygen (DO) was measured using YSI model 56 oxygen meter (Yellow Springs Instrument, Yellow Springs, OH, USA) and pH by using a pH meter (Orion pH meter, TX, USA). Ammonia and alkalinity were measured at weekly intervals according to (APHA 1985).

Analytical Methods

The chemical composition of fish, diets and feaces samples were determined according to procedures of AOAC (1995). Analyses of samples were made on dry matter basis after drying the samples in an oven (105 °C) for 24 h. Ash by incineration at 550 °C for 12 h, crude protein by micro-Kjeldhal method, N×6.25 (a Kjeltech autoanalyzer, Model 1030, Tecator, Höganäs, Sweden), crude fat by Soxhlet extraction with diethyl ether (40 - 60 °C). For the amino acid analysis, 5 mg of the dried samples were hydrolyzed with 6 N HCl at 110 °C for 24 hours. Hydrolysate AA was derivatized with phenylisothiocyanate (PITC) before analysis (Waters Manual 1989). Derivatives AA was determined on a C-18 reverse phase HPLC column using a Waters HPLC separation system (Waters Chromatography Division, Millipore Corp., Milford, Massachusetts). Other procedures for the analysis have been reported (Ogunji and Wirth 2001). Gross energy content of diet and carcass samples was calculated according to gross caloric values of Brett (1973) by applying the factor of 23.6, 39.5 and 17.2 kJ g^{-1} of crude protein, crude fat and total carbohydrate, respectively. The Metabolizable energy was estimated by applying the coefficient of 75 % to convert determined gross energy (GE) to Metabolizable energy (ME) according to Hepher et al. (1983).

Essential amino acids retention efficiency (EAAR) was evaluated by the following equation according to Rollin et al. (2003):

$$\text{EAAR} = \frac{(W_f \times N_f \times (\text{EAA})_f) - (W_i \times N_i \times (\text{EAA})_i)}{D_i \times N_d \times (\text{EAA})_d} \times 100$$

Where:

- W_f and W_i are the mean final and initial body weight, respectively.
- N_f and N_i are the mean contents of the whole body protein of fish at the end and at the beginning of the experimental period, respectively (g g^{-1} protein).
- D_i is the dry diet intake during the experimental period (g DM).
- N_d is the protein content of the experimental diets (g g^{-1} protein).
- $(\text{EAA})_f$, $(\text{EAA})_i$ are the mean EAA contents of the whole body fish at the end and at the beginning of the experimental period respectively (g g^{-1} protein).
- $(\text{EAA})_d$ is the EAA content of the experimental diets (g g^{-1} protein).

Statistical Analysis

Data were analyzed by ANOVA using MSTATE version 4 software program (MSTATE 1987). Duncan's multiple range test was used to compare differences between individual means when significant F values were observed (Duncan 1955), at $P \leq 0.05$. The relationship between body EAA gain and EAA intake was tested using simple correlation analysis.

RESULTS AND DISCUSSION

No significant differences were observed in the water quality parameter among the treatment during the entire experimental period. The water temperature ranged from 26.9 to 28.3 °C, dissolved oxygen (DO) from 5.1 to 6.3 mg L^{-1}, pH from 6.3 to 8.2, and ammonia (NH_3) from 0.26 to 3.2 mg L^{-1}. Water quality parameters were within the acceptable range for tilapia and mullet growth (Stickney 1979).

The dietary amino acid profiles of different experimental treatments are illustrated in Table (2). The data showed that the animal protein sources are higher in EAA content compared to SBM content. The total essential and non-essential amino acid profiles of FM, DHW, PBM and SBM diets were compared in Table 2. When they were compared with Clyde *et al.* (1992) and NRC (1993) requirements, irrespective of dietary amino acid supplementation, methionine appeared as the first limiting EAA in DHW, PBM and SBM diets for the three fish species, followed by lysine, while tryptophane and threonine were the 1st and 2nd limiting amino acid in FM diet. However, SBM diet appeared to be limiting in threonine for all fishes species.

The growth performance of experimental fishes fed different experimental protein sources are presented in Table (3). The results showed that fish fed the diet with PBM and DHW exhibited comparable growth to those fed a fish meal–based diet. The gain (g fish biomass 150 days^{-1}) and SGR (%g fish biomass day^{-1}) followed the same trend. The highest significant ($P \leq 0.05$) feed intake (g fish biomass 150 days^{-1}) was showed for fish fed with PBM diet, while fish fed with FM diet recorded the lowest significant value. However, fish fed diets with FM

Table (2): Essential amino acid content of the experimental diets (% dietary CP).

EAA	FM	PBM	DHW	SBM	Fish requirements		
					*O. N.**	M.C.**	*L.R.***
Arginine	5.4	5.6	4.6	4.3	4.2	3.2	3.2
Histidine	1.9	1.6	1.7	2.1	1.7	1.3	1.3
Isoleucine	3.9	4.5	3.5	3.6	3.3	2.4	2.4
Leucine	6.0	7.7	5.2	3.7	3.4	4.4	4.4
Lysine	6.2	5.4	5.1	5.7	5.1	3.8	3.8
Methionine	3.0	2.6	3.0	2.7	2.7	1.3	1.1
Phenylalanine	4.0	4.1	3.6	2.4	3.8	2.6	2.5
Threonine	3.4	3.7	2.9	1.9	3.8	3.1	2.8
Tryptophane	0.7	0.7	1.0	0.7	1.0	-	-
Valine	4.7	5.8	3.3	2.3	2.8	3.2	2.7
Total	39.2	41.7	33.9	29.4	31.8	25.3	24.2

O.N. = *O. niloticus*, M.C. = *M. cephalus*, L.R. = *L. ramada*
*According to NRC (1993), ** According to Clyde *et al.* (1992).

showed the better FCR than that PBM, DHW or SBM values (Table 3).

Irrespective of polyculture system used in present study (Table 4), Nile tilapia fed diets with PBM, DHW and SBM showed slightly reduced in the final body gain (by 8.2, 10.9 and 23.7%, respectively) compared with FM diet. Comparable final body gain of *M. cephalus* was obtained with DHW and FM, while PBM and SBM reduced final body gain by 6.5% and 13.4%, respectively. The final body gain of *L. ramada* was highest with PBM and DHW by 27.6% and 12.4%, respectively, while SBM reduced final body gain by 10.7%, compared with FM diet.

The proximate chemical body compositions of experimental fishes are shown in Table (5). The higher significant ($P \leq 0.05$) whole body protein of *O. niloticus, M. cephalus* and *L. ramada* were showed when fishes fed DHW diets. Whole body lipid content was showed the highest level for all fish species when fed with FM diet, while feeding on DHW reduced whole body ash content in all species.

Positive correlation between the total essential amino acid intake and gain were showed for the three species. This correlation was higher for *O. niloticus* (r = 0.92, n= 3); *M. cephalus* (r = 0.84, n =3) and for *L. ramada* (r = 0.84, n = 3) when fed diets contained DHW, FM and SBM, respectively. While this correlation was lower for diet with SBM (r = 0.75, n = 3) for *O. niloticus*, PBM for either *M. cephalus* (r = 0.69, n =3) or *L. ramada* (r = 0.70, n = 3).

The total essential amino acid (Table 6) was showed more retention when Nile tilapia fed SBM diet (81.2%), while lower value was recorded with PBM diet (29.9%). *M. cephalus* and *L. ramada* recorded the highest values of total essential amino acid retention when fed DHW diet (74.8 and 85.1%, respectively), while lower value was recorded with PBM diet (36.9 and 41.8%, respectively). Estimating total non-essential amino acid retention showed the highest value for Nile tilapia when fed FM diet (33.8%), while *M. cephalus* and *L. ramada* recorded the highest value when fed diet containing DHW (27.7 and 28.9 %, respectively). In generally, arginine was showed the least retention values among essential amino acid. Histdine, phenylalanine, methionine, threonine and often lysine being the highest figures of retention efficiencies in the descending order.

The apparent digestibility coefficients (ADCs) of experimental diets are illustrated in Table (7). The highest ADC of protein was showed for Nile tilapia (91.7%), *M. cephalus* (86.8 %) and *L. ramada* (87.3 %) when fed with DHW diet. Nile tilapia fed FM diet showed the highest ADC of dry matter (81.3%), ether extract (91.5%) and digestible energy (79.6%). A same trend was observed for *M. cephalus* (75.1, 88.3 and 77.7%, respectively) and *L. ramada* (76.6, 91.8 and 79.4%, respectively). However, in all species the lower significant ($P \leq 0.05$) ADC of dry matter, crude protein, crude fat and digestible energy were observed when fish fed PBM diet except for lower value of dietary crude fat of *L. ramada* that was showed with SBM diet.

Table (3): Average body biomass growth performance of fish fed different experimental diets.

	Initial Body Biomass (g.)	Final Body Biomass (g.)	Feed intake (g/ fish/ 150 days)	Weight gain *	SGR **	FCR ***
FM (Mean)	**17.1 ± 1.4**	**216.3 ± 3.7^{a}**	**315.8 ± 6.1^{b}**	**199.2± 0.1^{a}**	**1.6 ± 0.1^{a}**	**1.59± 0.3^{c}**
O.N.	27.1 ± 0.5	217.0 ± 0.8	-	189.9 ±0.3	1.4 ± 0.9	-
M.C.	12.1 ± 0.1	348.0 ± 1.5	-	335.9 ± 0.1	2.2 ± 0.1	-
L.R.	12.1 ± 0.1	83.9 ± 1.2	-	71.8 ± 0.2	1.3 ± 0.1	-
DHW (Mean)	**17.7 ± 1.6**	**213.4 ± 2.9^{a}**	**326.6± 6.1^{b}**	**195.8 ± 0.2^{a}**	**1.6 ± 0.1^{a}**	**1.67 ± 0.4^{b}**
O.N.	27.2 ± 0.9	196.4 ±1.2	-	169.3 ± 0.1	1.3 ± 0.2	-
M.C.	12.9 ± 0.1	350.3 ±1.2	-	337.4 ± 0.2	2.2 ± 0.2	-
L.R.	12.9 ± 0.2	93.6 ± 0.5	-	80.7 ± 0.7	1.3 ± 0.1	-
PBM (Mean)	**17.4 ± 1.6**	**210.7 ± 3.8^{a}**	**440.4 ± 7.1^{a}**	**193.3 ± 0.2^{a}**	**1.7 ± 0.3^{a}**	**2.28 ± 0.7^{a}**
O.N.	27.0 ± 0.7	201.3 ± 0.6	-	174.3 ± 0.1	1.3 ± 0.1	-
M.C.	12.5 ± 0.4	326.5 ± 1.4	-	314.0 ± 0.3	2.2 ± 0.2	-
L.R.	12.8 ± 0.2	104.4 ± 0.9	-	91.6 ± 0.1	1.4 ± 0.1	-
SBM (Mean)	**17.4 ± 1.1**	**183.9 ±2.7^{b}**	**288.8± 8.1^{c}**	**166.6 ± 0.9^{b}**	**1.5 ± 0.1^{b}**	**1.73 ± 0.2^{b}**
O.N.	27.2 ± 0.1	172.0 ± 1.1	-	144.8 ± 0.2	1.2 ± 0.4	-
M.C.	12.2 ± 0.4	303.0 ± 1.0	-	290.8 ± 0.3	2.1 ± 0.3	-
L.R.	12.7 ± 0.1	76.8 ± 0.9	-	64.1 ± 0.1	1.2 ± 0.1	-

O.N. = O. niloticus, M.C. = M. cephalus, L.R. = L. ramada

FM : fish meal, DHW : dried hatchery waste, PBM : poultry by - product meal and SBM : soybean meal.

a, b, c ….. Means in the same column with different superscripts are significant ($P \leq 0.05$).

* Weight gain = Final body gain (g) – Initial bogy weight (g).

** Specific growth rate (SGR) = {(In W_2 – In W_1) /150 days} x 100.

*** Feed conversion ratio (FCR) = Feed intake (g) /Body weight gain (g).

Table (4): Comparative growth performance for individual fish species fed different experimental diets.

Protein sources	Species	Initial Body Weight (g)	Final Body Weight (g)	Weight gain *	Relative fish body gain to control diet (FM)	SGR **	FCR ***
FM	*O.N.*	27.1 ± 0.5	217.0 ± 0.8^{a}	189.9 ± 0.3^{a}	100.0%	1.4 ± 0.9^{a}	1.5 ± 0.1^{b}
DHW	*O.N.*	27.2 ± 0.9	196.4 ± 1.2^{b}	169.2 ± 0.1^{b}	89.1%	1.3 ± 0.2^{a}	1.6 ± 0.2^{b}
PBM	*O.N.*	27.0 ± 0.7	201.3 ± 0.6^{b}	174.3 ± 0.3^{b}	91.8%	1.3 ± 0.1^{a}	2.6 ± 0.4^{a}
SBM	*O.N.*	27.2 ± 0.1	172.0 ± 1.1^{c}	144.8 ± 0.1^{c}	76.3%	1.2 ± 0.4^{b}	1.6 ± 0.2^{b}
FM	*M.C.*	12.1 ± 0.1	348.0 ± 1.5^{a}	335.9 ± 0.1^{b}	100.0%	2.3 ± 0.1	1.4 ± 0.2^{b}
DHW	*M.C.*	12.9 ± 0.1	350.3 ± 1.2^{a}	337.4 ± 0.2^{a}	100.5%	2.2 ± 0.2	1.7 ± 0.3^{b}
PBM	*M.C.*	12.5 ± 0.4	326.5 ± 1.4^{ab}	314.0 ± 0.3^{ab}	93.5%	2.2 ± 0.2	2.1 ± 0.5^{a}
SBM	*M.C.*	12.2 ± 0.4	303.0 ± 1.0^{b}	290.8 ± 0.3^{b}	86.6%	2.1 ± 0.3	1.5 ± 0.2^{b}
FM	*L.R.*	12.1 ± 0.1	83.9 ± 1.2^{c}	71.8 ± 0.2^{c}	100.0%	1.3 ± 0.1^{b}	1.5 ± 0.3^{a}
DHW	*L.R.*	12.9 ± 0.2	93.6 ± 0.5^{b}	80.7 ± 0.7^{b}	112.4%	1.3 ± 0.1^{b}	1.4 ± 0.3^{b}
PBM	*L.R.*	12.8 ± 0.2	104.4 ± 0.9^{a}	91.6 ± 0.1^{a}	127.6%	1.4 ± 0.1^{a}	1.6 ± 0.7^{a}
SBM	*L.R.*	12.7 ± 0.1	76.8 ± 0.9^{d}	64.1 ± 0.1^{c}	89.3%	1.2 ± 0.1^{c}	1.6 ± 0.2^{a}

O.N. = O. niloticus, M.C. = M. cephalus, L.R. = L. ramada

FM : fish meal, DHW : dried hatchery waste, PBM : poultry by - product meal and SBM : soybean meal.

a, b, c ….. Means in the same column with different superscripts are significant ($P \leq 0.05$).

* Weight gain = Final body gain (g) – Initial bogy weight (g).

** Specific growth rate (SGR) = $\{(\ln W_2 - \ln W_1)/150 \text{ days}\} \times 100$.

*** Feed conversion ratio (FCR) = Feed intake (g) /Body weight gain (g).

Table (5): The proximate whole body compositions of fish fed experimental diets (wet weight basis).

Protein source	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)
O. niloticus				
FM	70.0 ± 0.6	15.8 ± 0.3^{b}	9.1 ± 0.1^{a}	5.1 ± 0.2^{bc}
DHW	70.3 ± 0.1	16.6 ± 0.4^{a}	8.1 ± 0.2^{b}	5.0 ± 0.1^{c}
PBM	70.8 ± 0.2	15.4 ± 0.1^{b}	6.1 ± 0.5^{c}	7.7 ± 0.3^{a}
SBM	73.6 ± 0.1	15.3 ± 0.5^{b}	5.7 ± 0.8^{d}	5.4 ± 0.2^{b}
M. cephalus				
FM	69.8 ± 0.1	14.5 ± 0.4^{c}	10.0 ± 0.6^{a}	5.8 ± 0.2^{b}
DHW	68.9 ± 0.3	16.5 ± 0.4^{a}	9.3 ± 0.3^{ab}	5.3 ± 0.4^{c}
PBM	70.7 ± 0.7	15.5 ± 0.1^{b}	8.2 ± 0.1^{b}	5.5 ± 0.3^{ab}
SBM	70.3 ± 0.6	14.3 ± 0.1^{c}	9.4 ± 0.1^{ab}	6.0 ± 0.2^{a}
L. ramada				
FM	69.6 ± 0.7	14.5 ± 0.2^{c}	10.4 ± 0.4^{a}	5.6 ± 0.1^{a}
DHW	70.3 ± 0.5	15.8 ± 0.2^{a}	9.8 ± 0.3^{a}	4.2 ± 1.0^{c}
PBM	70.8 ± 0.4	15.0 ± 0.2^{b}	9.5 ± 0.4^{a}	4.7 ± 0.8^{b}
SBM	70.1 ± 0.1	15.3 ± 0.3^{c}	9.6 ± 0.4^{a}	5.0 ± 1.1^{b}

FM : fish meal, DHW : dried hatchery waste, PBM : poultry by - product meal and SBM : soybean meal.
a, b, c ….. Means in the same column with different superscripts (within each species) are significant at a level ($P \leq 0.05$).

Table (6):The apparent d ietary amino acids retention efficiency (%) for Nile tilapia, *Mugill cephalus* and *Liza ramada.*

	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine + cystine	Phenylalanine + Tyrosine	Threonine	Valine	Estimated EAA[1]	Estimated NEAA[2]
O. niloticus											
FM	25.5 ± 0.1	90.7 ± 0.4	45.9 ± 0.4	56.6 ± 0.2	52.1 ± 0.1	62.8 ± 0.1	89.9 ± 0.2	69.0 ± 0.4	52.5 ± 0.6	56.8 ± 1.0	33.8 ± 0.1
DHW	28.9 ± 0.2	72.6 ± 1.2	33.9 ± 0.2	41.8 ± 0.4	66.4 ± 0.4	69.9 ± 0.1	84.2 ± 0.8	35.5 ± 0.2	45.5 ± 1.2	50.1 ± 0.6	28.1 ± 0.5
PBM	14.6 ± 0.2	90.3 ± 0.3	22.0 ± 0.5	23.4 ± 0.1	66.4 ± 0.2	61.1 ± 0.1	53.9 ± 0.7	19.9 ± 0.2	20.4 ± 0.5	29.9 ± 0.4	21.2 ± 0.2
SBM	48.7 ± 0.1	87.0 ± 0.9	58.9 ± 0.1	92.7 ± 0.1	97.0 ± 0.5	99.3 ± 0.5	99.3 ± 0.1	86.5 ± 0.6	92.9 ± 0.9	81.2 ± 0.5	23.0 ± 0.5
M. cephalus											
FM	39.7 ± 0.1	91.7 ± 0.7	55.5 ± 0.2	68.0 ± 0.4	79.1 ± 0.4	98.5 ± 0.6	81.6 ± 0.1	65.2 ± 0.5	45.3 ± 1.1	66.6 ± 0.5	23.6 ± 1.2
DHW	51.4 ± 0.1	96.6 ± 1.0	62.5 ± 0.1	75.5 ± 0.1	97.4 ± 0.7	99.7 ± 0.2	97.5 ± 1.1	66.2 ± 0.9	53.9 ± 1.1	74.8 ± 0.5	27.7 ± 1.5
PBM	19.8 ± 1.2	99.4 ± 0.7	31.2 ± 0.1	34.9 ± 0.8	64.0 ± 0.1	98.5 ± 0.1	65.7 ± 0.1	27.8 ± 0.5	17.6 ± 1.2	36.9 ± 0.8	14.5 ± 1.9
SBM	37.6 ± 0.6	99.1 ± 0.7	54.2 ± 0.5	98.98 ± 0.9	78.9 ± 0.1	53.8 ± 1.1	98.4 ± 0.8	99.8 ± 0.1	90.5 ± 1.3	73.7 ± 0.9	24.8 ± 1.5
L. ramada											
FM	39.7 ± 0.4	91.7 ± 0.1	55.5 ± 0.9	68.0 ± 0.1	79.1 ± 0.2	98.5 ±0 .1	81.6 ± 0.2	65.2 ± 0.2	45.3 ±0.9	66.6 ±0.1	23.6 ± 0.1
DHW	49.6 ± 0.1	95.8 ± 0.1	62.9 ± 0.1	77.1 ± 0.1	100.0*±0.4	98.2 ± 0.1	80.8 ± 0.5	90.1 ± 0.1	42.9 ± 0.1	85.1 ± 0.2	28.9 ± 1.5
PBM	28.0 ± 0.3	100.0*± 0.1	32.4 ± 0.1	44.9 ± 0.3	83.9 ± 0.7	100.0*± 0.7	100.0*± 0.1	36.7 ± 0.5	24.3 ± 0.5	41.8 ± 0.8	24.7 ± 1.3
SBM	40.2 ± 0.1	100.0*± 0.1	58.4 ± 0.1	100.0*± 0.7	79.3 ± 0.6	67.2 ± 0.1	100.0*± 0.1	100.0*± 0.1	87.5 ± 0.1	76.1 ± 0.6	25.3 ± 1.0

a, b, c ….. Means in the same column with different superscripts (within each species) are significant at a level ($P \leq 0.05$).

-Tryptophane not determined.

1-EAA: Essential amino acid. 2-NEAA: Non-essenial amino acid.

* Any value over than 100%, during calculation (n=3) was considered as 100 %.

Table (7): The apparent digestibility coefficients of the different experimental diets.

	Dry matter (%)	Crude protein (%)	Crude lipid (%)	Digestible energy (%)
O. niloticus				
FM	81.3 ± 1.9^{a}	90.3 ± 1.3^{b}	91.5 ± 1.0^{a}	79.6 ± 1.5^{a}
DHW	80.8 ± 1.3^{ab}	91.7 ± 1.4^{a}	81.7 ± 1.1^{b}	74.8 ± 1.3^{b}
PBM	79.1 ± 2.3^{c}	85.4 ± 1.2^{c}	77.1 ± 1.1^{c}	71.3 ± 1.3^{c}
SBM	79.8 ± 1.0^{bc}	88.2 ± 1.4^{b}	80.2 ± 1.1^{bc}	73.7 ± 1.2^{b}
M. cephalus				
FM	75.1 ± 1.8^{a}	84.3 ± 1.2^{b}	88.3 ± 1.0^{a}	77.7 ± 1.20^{ab}
DHW	73.9 ± 1.1^{ab}	86.8 ± 1.3^{a}	84.5 ± 1.0^{bc}	75.4 ± 1.0^{bc}
PBM	73.0 ± 1.4^{b}	82.9 ± 1.2^{c}	83.4 ± 1.1^{c}	74.0 ± 1.3^{c}
SBM	74.1 ± 1.3^{a}	84.1 ± 1.3^{bc}	85.5 ± 1.0^{b}	77.3 ± 1.2^{ab}
L. ramada				
FM	76.6 ± 1.1^{a}	84.5 ± 1.1^{b}	90.5 ± 1.1^{a}	79.4 ± 1.3^{a}
DHW	75.1 ± 1.4^{ab}	87.3 ± 1.2^{a}	89.1 ± 0.9^{ab}	78.8 ± 1.3^{ab}
PBM	73.5 ± 0.9^{c}	83.6 ± 1.4^{d}	88.7 ± 0.9^{b}	76.2 ± 1.1^{c}
SBM	73.9 ± 2.0^{bc}	84.5 ± 1.2^{b}	86.5 ± 0.6^{c}	77.4 ± 1.4^{bc}

FM : fish meal, DHW : dried hatchery waste, PBM : poultry by - product meal and SBM : soybean meal.
a, b, c ….. Means in the same column with different superscripts (within each species) are significant at a level ($P \leq 0.05$).

Fish production yield of different experimental fishes are showed in Table (8). The total net productions of the fish were 2179, 2047, 2118 and 1723 kg pond^{-1} when fed on FM, DHW, PBM and SBM diets, respectively. Irrespective of fish species, the maximum total income was recorded with FM diet (20505 LE), while the total costs were highest when fed with FM diet (14426 LE). Consequently, the net return was greatest when fish was fed with DHW diet (11568 LE).

The results showed that the higher growth obtained with PBM and DHW diets compared to SBM diet could be indicated one explanation include that the higher levels of available amino acid in PBM and DHW diets. The most important EAA for Nile tilapia were methionine, lysine and threonine (NRC 1993), while Clyde et al. (1992) reported that leucine, lysine and arginine were the most important EAA for Mullet. These results agreed with the findings of Nengas et al. (1999) who noticed that PBM could be successfully replace FM for Gilthead sea bream (*Sparus aurata* L.). Steffens (1994) showed that PBM is suitable as a partial or complete replacement in diet for rainbow trout; however, complete substitution required amino acid supplementation, principally lysine and methionine. The contradiction between results regarding the use of SBM as a sole protein source in fish diets may be related to many reasons including the quality and processing method of SBM, inadequate amino acid profile, fish species and culture system (Liener 1980; Shiau et al. 1989, 1990; El-Sayed 1999; Ogunji and Wirth 2000, 2001 and Wu et al. 2003). Decreased growth as fish meal was replaced by soybean meal has been reported in a number of species including rainbow trout (Yamomoto and Akiyoma 1991), silver seabream *Rhabdosargus sarba* (El-Sayed 1994) and some salmonids fish (Hardy 1998). In the present study, the reduced performance of fish fed the SBM diet does not appear to be due to palatability problems. The amount of SBM diet consumed was not significantly different from the FM diet (Table 3). Comparison of the amino acid profile of SBM diet with the FM diet especially after cover the requirement of methionine and lysine (Table 2) does not indicate differences of sufficient magnitude to indicate problems. The methionine level of the SBM diet is slightly lower than the FM diet. However, these differences are not large, and levels in the SBM are approximately similar to those in the PBM or DWH diets, which exhibited excellent comparable growth to those, fed a fish meal–based diet. Since these results indicate that adverse effects of SBM-based diets do not seem to be caused by palatability or amino acid imbalances, it is likely that anti-nutritional factors are involved (Hertrampf and Piedad-Pascual 2000; Tidwell et al. 2005). Shiau et al. (1990) showed that poor performance for Nile tilapia with SBM diets was generally in direct relationship to level of soybean incorporation. Soybeans have anti-nutritional factors that reduce their biological value (Rackis 1974; Liener 1994). These results indicate that soybean meal could be used as partial replacement of dietary FM rather than used as complete replacement in fish diets.

Feed intake in the present study was found to be the higher for fish fed

Table (8): The economic efficiency of the experimental fishes fed different experimental diets

	FM	DHW	PBM	SBM
Total production pond (kg pond^{-1})	2179	2047	2118	1723
- *Oreochromis niloticus*	1323	1168	1264	972
- *Mugill cephalus*	692	696	649	602
-*Liza ramada*	164	183	205	149
Total income pond $^{-1}$ (LE*)	20505	19750	19984	16722
- *Oreochromis niloticus*	9261	8176	8848	6804
- *Mugill cephalus*	9688	9744	9086	8428
-*Liza ramada*	1556	1830	2050	1490
Total costs pond $^{-1}$ (LE*)	14426	8182	11546	9699
- Fingerlings	1940	1940	1940	1940
- Labor	2500	2500	2500	2500
- Feeding	8936	2692	6056	4209
- Land rent	750	750	750	750
- Fuel	300	300	300	300
Net returns pond^{-1} (LE*)	*6079*	*11568*	*8438*	*723*
Net return relative to FM pond %	*100*	*190*	*140*	*120*
Profit, %	*40*	*140*	*70*	*70*

-American dollar ($) = 5.75 Egyptian pond (LE).,

-Net returns, LE = Total income (LE) – Total variable cost (LE).

*The price of 1 kg of FM, DHW, PBM and SBM were 2.6, .73, 1.25 and 1.33 L.E., respectively

* The marketing price of 1 kg for *Oreochromis niloticus, Mugill cephalus,* and *Liza ramada* were 7, 14 and 10 L.E., respectively.

- Profit, % = (Net returns, / pond (LE*)) / (Total costs / pond (LE*))

PBM ($P \leq 0.05$) then those of all experimental diets. This result supports Davis and Arnold (2000) who reported that PBM didn't indicate any apparent palatability problem. Similarly, Shepherd (1998) was not able to observe any serious problem related to palatability of rendered products in fish diets. However, contradicted with the findings of Fowler (1991) and Quartarora et al. (1998) who reported that high PBM levels could cause reduced palatability for Chinook salmon and Australian snapper; may be due to deficiency of any EAA usually reduces palatability of the diet (Moon and Gatlin, 1994; Abdel-Warith et al. 2001). Reasons for the differences between the results of some previous reports and this experiment could be attributed to variations in row materials, and different rendering processes. PBM is suitable as a partial or complete replacement in Nile tilapia and mullet diets in polyculture; but, a complete substitution required amino acid supplementation, principally lysine and methionine.

Feed conversion ratio (FCR) data suggested that fish fed PBM diet showed significantly higher (2.28) compared to the FM, DHW and SBM diets (1.59, 1.67 and 1.73, respectively). These results confirm the findings of Webster et al. (2000) and Lee et al. (2001) who reported that replacement of FM with PBM resulted in significantly higher FCR ($P \leq 0.05$). However, Davis and Arnold (2000) found that replacement of FM with co-extruded soybean-PBM mixture resulted in equivalent FCR value.

The results of present study showed that arginine recorded the lower retention efficiency for all fish species. This may be due to the urea formation in fish. Urine is the final route of arginine metabolism and secretion pathway. Guoyao and Morris (1998) reviewed that arginine (2-amino-5-guanidinovaleric acid) is one of the most versatile amino acids in animal cells, serving as a precursor for the synthesis not only of protein but also of nitric oxide, urea, polyaminess, proline, glutamate, creatine and agmatine. The results go parallel with the previous work of El-Husseiny et al. (2002) who reported that growth of tilapia fry was less affected with arginine deficiency compared to the other amino acids deficiencies.

The higher apparent digestibility of CP for Nile tilapia, *L. ramada* and *M. cephalus* was observed when fed on diets containing DHW (Table 7), while the lower values was recorded with PBM diet. Robinson and Li (1996) reported that PBM is high in ether extract (EE), ash and indigestible components (feathers, etc.), resulting in reduced digestibility. The highest apparent digestibility coefficient of EE was recorded when Nile tilapia (76.8%) fed on diet with FM. The same trend was observed for *L. ramada* (63.3%) and *M. cephalus* (60.3%). This may be due to the nature of lipids in FM being rich in ω-3 fatty acids compared with other sources. Torstensen et al. (2000) showed that digestibility and absorption of fatty acid in fish decreased with increasing saturated and chain length fatty acid. Recently, Bahurmiz and Ng (2007) showed that the inclusion of dietary palm-origin oils (rich in saturated fatty acid) significantly reduced the total lipid digestibility of the red hybrid tilapia, *Oreochromis* sp., diets due mainly to the decreased digestibility of the saturated fatty acids. Caballero et al. (2002) reported that the higher apparent digestibility of lipid for rainbow trout *Oncorhynchus mykiss* was related to their higher content of unsaturated fatty acids. The particularly high ADC of polyunsaturated fatty acid has been documented in rainbow rout (Austreng et al. 1979) and other species (Lied and Lambertsen 1982; Ringo and Olsen 1991; Sigurgisladottir et al. 1992). Similarly, Sevdili and Erturk (2004) reported that the rich fat content of PBM in the diet of rainbow trout *Oncorhynchus mykiss* causing decrease in omega-3 fatty acids such as eicosapentaenoic (EPA) and docosahexanoic (DHA) compared with FM diet.

From the standpoint of nutrition views, the variation in nutritional value and composition for PBM and DHW depending on the processing and the materials included in the meal. However, if suitable raw ingredient are chosen and then properly processed, a high-quality protein feed can be achieved. The data showed that Nile tilapia, *M. cephalus* and *L. ramada* seems to be able to use efficiently either PBM or DHM as the sole source of dietary protein. Meanwhile, the least net yield production has been recorded when fish fed SBM which could be attributed to amino acids content, fatty acid content, processing condition and the anti-nutritional factors content (Nengas *et al.*1999 and Ognnji 2004). Referring to economic analysis (Table 8) and taking into consideration that DHW was free of charge at the moment of experiment has been done, being a waste. According to the market prices in 2006, the input-output analysis showed that the total income of fish production using DHW was higher than FM, PBM and SBM. Meanwhile, the total costs of production when fish fed diets containing PBM or FM were higher than DHW. This was reflected on the net return of DHW, being the highest.

CONCLUSION

The results showed that when dried hatchery wastes and poultry by-product meal are available in reasonable price; it could be successfully used as excellent alternatives for fish meal in diets. However, the use of soybean meal in the fish diet as a sole source of dietary protein or as a replacement of fish meal, reduction in the final body fish weight could occur. The lowest growth rate of fish due to feeding FM alternative protein sources resulted in less entire cost of rearing period and compensating for the delayed growth or the losing time, and may be increasing profitability.

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أستخدام العلائق الخالية من مسحوق السمك لاسماك البلطى النيلى والبورى والطوبارة المرباه فى الاستزراع المختلط شبه المكثف

أسامة محمد الحسينى[١] ، أشرف محمد عبد السميع جودة[٢] ، جلال الدين عبد العزيز[١] ، ايهاب رضا الحارون[١]
[١]كلية الزراعة - جامعة القاهرة – قسم الانتاج الحيوانى – فرع التغذية
[2]المعهد القومى لعلوم البحار والمصايد- شعبة تربية الاحياء المائية- معمل تغذية الاسماك – القاهرة

أجريت هذه الدارسة لبيان أثر استخدام الإحلال الكامل لمسحوق السمك بمصادر مختلفة من مخلفات البروتين وهى المخلفات الجافة لمفرخات الدواجن ومسحوق مخلفات الدواجن وكسب فول الصويا كمصادر اساسية للبروتين فى العليقة. تم قياس معدل الأداء الإنتاجى و معدلات هضم العناصر الغذائية والاستفادة من الأحماض الأمينية للبلطى النيلى والعائلة البورية (البورى و الطوبارة) المرباه فى أحواض ترابية ومصدر مياة جوفية.

تم إعداد أربع علائق متساوية فى محتواها من البروتين (٢٥%) والطاقة (14 ميجا جول طاقة ممثلة / كجم عليقة). استخدمت فيها العليقة التى تحتوى على مسحوق السمك كعليقة قياسية (كنترول) ، بينما استخدمت الثلاث علائق التى تحتوى على مصادر مختلفة من البروتين كعلائق مختبره. و قد أظهرت نتائج التجربة ما يلى:

* أن أعلى معدل وزن نهائى للأسماك قد وجد للأسماك التى تغذت على العليقة التى تحتوى على مسحوق السمك بينما الأسماك التى تغذت على مسحوق مخلفات الدواجن والمخلفات الجافة لمفرخات الدواجن أظهرت انخفاض محدود فى الوزن النهائى للأسماك مقارنة بعليقة مسحوق السمك ،فى حين ان الأسماك التى تغذت على مسحوق كسب فول الصويا كانت أقلهم من حيث وزن الاسماك النهائى .
* أعلى معدل للغذاء الماكول للأسماك التى تغذت على مسحوق مخلفات الدواجن ، بينما الأسماك التى تغذت على مسحوق كسب الصويا سجلت أقل معدل للغذاء المأكول. وقد أوضحت النتائج أن معدل الزيادة اليومية والزيادة النوعية للنمو قد نهجت نفس النمط للغذاء المأكول . كذلك أوضحت النتائج أن مسحوق مخلفات الدواجن والمخلفات الجافة لمفرخات الدواجن وكسب فول الصويا أعطت معدل تحويل غذائى أعلى من الاسماك التى تغذت على مسحوق السمك .
* أعلى معدل للهضم الظاهرى للبروتين قد سجل لأسماك البلطى والبورى والطوبارة التى تغذت على المخلفات الجافة لمفرخات الدواجن على التوالى ، بينما أعلى معدل هضم ظاهرى للدهون سجل للبلطى النيلى الذى تغذت على عليقة تحتوى على مسحوق السمك . وقد نهج سمك البورى والطوبارة نفس النمط .
* الإستفادة من الأحماض الامينية غير الأساسية تراوحت ما بين ٥٧ ـ ٦٧ % ، ٥٠ ـ ٨٥ % ، ٢١ ـ ٤٢ % للأسماك التى تغذت على مسحوق السمك، المخلفات الجافة لمفرخات الدواجن و مسحوق مخلفات الدواجن على التوالى ، بينما الأسماك التى تغذت على كسب فول الصويا سجلت استفادة أعلى من ٧٣% من مجموع الأحماض الأمينية الأساسية . • وقد أشارت النتائج أن أعلى معدل للاستفادة من الأحماض الأمينية الأساسية كانت لجميع الاسماك التى تغذت على المخلفات الجافة لمفرخات الدواجن والتى تراوحت بين ١٤,٤٩ - ٢١,٢٣ % .

*وقد خلصت التجربة إلى أن استخدام المخلفات الجافة لمفرخات الدواجن و مسحوق مخلفات الدواجن إذا توافرت بسعر أرخص ومنافس لمسحوق السمك فيمكن استخدامها بنجاح كمصادر بديلة لمسحوق السمك فى علائق أسماك البلطى والعائلة البورية كمصدر بروتين حيوانى اساسى فى العليقة. بينما استخدام كسب فول الصويا فى علائق الأسماك كمصدر اساسية وبديل للبروتين بدلاً من مسحوق السمك يؤدى الى انخفاض ملحوظ فى النمو. لذا للحصول على نتائج جيدة من حيث نمو الاسماك يفضل استخدام الاحلال الجزئى مع إضافة الأحماض الأمينية الاساسية الليسين والمثيونين إلى العليقة نظراً للتأثير السلبى لنقصها على الأداء الأنتاجى للأسماك .