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PARTIAL AND TOTAL SUBSTITUTION OF FISH MEAL BY POULTRY BY-PRODUCT MEAL IN DIETS FOR MONOSEX NILE TILAPIA (*OREOCHROMIS NILOTICUS*).

BY

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ABSTRACT

This study was conducted to evaluate the suitability of poultry by-product meal (PBM) as a partial or total substitution of the fish meal component of practical diets (PBM) for Nile tilapia fingerlings (mean initial fish weight 23.64g ±0.53 SE). PBM are waste materials of the local poultry industries, which could be used as an animal protein source in diets for some fish species. Six tested diets formulations based on a herring fish meal (HFM) as the reference protein source were used in this study. The experimental diets were designed to contain PBM at 20, 40, 60, 80 and 100% replacement of total protein content as fish meal in the control diet (100% fish meal). All diets were isonitrogenous and isocaloric in gross terms. The results showed that there were significant differences ($P<0.05$) between the final average body weight of fish at the end of a 12 weeks feeding trial. The mean final body weight of fish fed control diet, 20 and 40% PBM was 83.81, 76.71 and 73.65g, respectively, while that of fish fed 60, 80 and 100% PBM was 66.27, 63.55 and 58.63g, respectively. The poorest response was observed for fish fed 80 and 100% PBM diets. Similar trends were also observed in specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and feed intake (FI). Hepatosomatic index, (HSI) did not reflex any significant differences for all fish fed the experimental diets. Economic analysis showed the possibility of using PBM as an alternative protein source in Nile tilapia feed. Diets contained the levels of 60, 80 and 100% of PBM provided the best economic efficiency of fish weight gain compared with other tested diets. The results of the present study indicated that the local poultry by-product meal (PBM) can replace at 40% of fish meal in the diets for monosex Nile tilapia without compromising growth and feed conversion.

Key words: Monosex Nile tilapia, poultry by-product meal, fish meal, economic analysis.

INTRODUCTION

Protein is the most expensive component in aquaculture feeds. Fish meal supports good fish growth because of its high protein quality and good palatability for fish. Much of the costs of aquafeed production are due to the extensive use of fishmeal in the feed (Tacon 1994 and Higgs *et al.* 1995). Therefore, numerous attempts have been carried out to develop economical alternative protein and energy sources for inclusion in fish diets. Considerable efforts are also being made to improve fishmeal quality so that maximum nutritive value can be obtained from this expensive dietary component. Historically, fish meal is the most desirable protein concentrate used in formulated feeds; however, this is an expensive resource for use in warm water fish diets. The demand for fish meal is expected to increase the price of compounded feeds even higher than the present levels due to the rapid expansion of aquaculture, (Tacon 1996). This will be an increasing problem in countries that rely on the impact of this resource for fish feed manufacture. Alternative feed ingredients will become even more cost effective for incorporation in diets especially those destined for warm water fish species such as carp, tilapia and catfish (Rumsey, 1993). Gouveia, (1991) critically reviewed the use of animal by-products in diets for salmonids. He described the use of various protein concentrates that originated from the rendering industries. One of the more promising sources is poultry by-product meal (PBM), the rendered product of poultry processing waste, made from inedible portions of poultry, excluding feathers. PBM has been previously evaluated in diets for gibel carp *Carassius auratus gibelio*, (Yang *et al.*, 2004 and 2006), monosex Nile tilapia *Oreochromis niloticus,* (Abdelghany *et al.*, 2005), African catfish *Clarias gariepinus* (Abdel-Warith *et al.*, 2001), chinook salmon *Oncorhynchus tshawytscha,* (Fowler 1990 and 1991). PBM has been tested as a partial fishmeal replacement in the diets of channel catfish *Ictalurus punctatus* (Brown *et al.*, 1985) and rainbow trout *Oncorhynchus mykiss* (Alexis *et al.*, 1985).

However, compared to fishmeal, animal by-products may be deficient in one or more of essential amino acids (Davies *et al.*, 1991). Nengas *et al.* (1999), reported that diets containing poultry meat meal (PMM), poultry feather meal (PFM) mixture and PBM at 40% replacement of fishmeal for gilthead seabream *Sparus aurata,* indicated that the first limiting essential amino acid (EAA) was methionine. Investigations concerning the use of animal by-product meals have been achieved with other freshwater fish species mainly carp and tilapia with good results (Rodriguez-Serna *et al.*, 1996). Also, turkey meal has been used in diets for sunshine bass (*Morone chrysops x Morone saxatilis*) by Muzinic *et al.* (2006).

A PBM available in Egypt was evaluated as the alternative protein source for tilapia. Nowadays there are many countries including Egypt suffering from big problem or disease called bird flu. In Egypt, the government will prevent the shops from selling the use of life poultry (chicken, ducks, goose,...etc) and all of these birds will be slaughtered at the slaughterhouse, thus the production of PBM will be increase and will be cheep in the Egyptian market. So that, the investigations should be directed to the use of this by-product in fish and animal feeds along in combination with other plant and animal protein sources.

The present study was undertaken to investigate the effect of optimum level of PBM in monosex Nile tilapia diets on growth performance without compromising the feed utilization efficiency and health of these fish.

MATERIALS AND METHODS

Experimental diets

Six experimental diets were formulated to contain a variable proportion of PBM to partially or totally replace the fishmeal component of the diet. PBM was obtained from a commercial source (El-Sharkya for Poultry Co.) It is usually made from inedible portions of poultry and defined as the milled dry rendered material originating from the processing of ground, rendered clean parts of the carcass of slaughtered chickens. This is inclusive of heads, feet, undeveloped ova, intestines and feathers as offal.

The product typically consists of 16.30% ash and 59.93% crude protein with a fat content of 14.85% as shown in Table (1). All diets were designed to be in similar gross nutrient terms and were adjusted at appropriate levels to contain 32% crude protein, 11% lipids and 445-457 Kcal gross energy / 100g diet. The proximate feed formulation and composition of the experimental diets are shown in Table (2). A control diet based on herring fishmeal (HFM) served as the reference source of dietary protein was used to substitute with PBM. Wheat bran was also included in diets component. Five diets were formulated with an incremental substitution 20% of fishmeal with poultry by-product meal up to 100% replacement.

Feeding regime and experimental system

Fish were fed on the control diet for one week for acclimation and free their gastrointestinal tract from the pre-experimental diet until the feeding response was uniform. Fish were fed twice daily by hand at a rate of 3% of body weight per day during all the experimental period (12 weeks). The fish were weighed bi-weekly. The feeding trail was conducted at the Fish Experimental Station belonging to Department of Animal Production, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt. The experimental fish were stocked in twelve rectangular fiberglass tanks (1 × 2 × 0.5m) supplied with dechlorinated tap water through a closed water recycling system provided with mechanical and biological filter tanks. Tank of water was aerated continuously using an air compressor.

Table (1): Chemical composition (%DM) and amino acid profile of herring fish meal and poultry by product meal.

	DM	CP	EE	Ash	CF	NFE
HFM	93.10	72.30	9.80	13.62	0.80	3.48
PBM	88.60	59.93	14.89	16.30	2.41	6.47
Wheat bran	88.77	14.60	3.92	6.37	12.32	62.79
Corn meal	89.61	9.43	4.21	1.62	5.12	79.62
	Amino acids profile (% of dry matter)*					
		HFM		**PBM**		
Arginine		5.02		4.03		
Cystine		0.81		0.93		
Histidine		1.80		1.08		
Isoleucine		3.41		2.54		
Leucine		5.64		4.28		
Lysine		5.83		3.10		
Methionine		2.27		1.13		
Phenylalanine		2.94		1.97		
Threonine		3.16		2.08		
Tryptophan		0.83		0.50		
Valine		4.68		3.06		

* Calculated according to Lovell (1998).

Table (2): Formulation and chemical composition of experimental diets fed to monosex Nile tilapia.

Ingredients%	*Con.*	*20% PBM*	*40% PBM*	*60% PBM*	*80% PBM*	*100% PBM*
Fish meal	38.00	30.50	23.00	15.50	7.80	—
PBM	—	9.20	18.40	27.50	36.70	45.80
Wheat bran	26.00	25.00	26.00	25.00	25.00	26.00
Corn meal	20.00	20.00	20.00	20.00	20.00	20.00
Corn oil	6.00	5.00	5.00	4.00	3.00	2.00
Vit. & Min. mix.[1]	3.00	3.00	3.00	3.00	3.00	3.00
Binder[2]	2.00	2.00	2.00	2.00	2.00	2.00
Cellulose	5.00	5.30	2.60	3.00	2.50	1.20
Proximate composition% (on DM basis)						
Moisture	6.78	7.21	7.53	7.14	7.89	8.21
CP	31.82	31.92	31.74	31.42	31.00	31.00
CEE	10.50	10.50	10.50	11.00	11.00	11.50
CF	6.93	6.72	6.99	7.30	7.81	7.98
NFE[3]	41.44	42.26	40.97	40.18	39.99	39.17
Ash	9.31	8.60	9.80	10.10	10.20	10.35
GE kcal/100g[4]	453.06	457.16	450.63	450.23	447.06	445.71
ME kcal/100g[5]	274.40	276.14	273.34	274.83	272.90	272.37
P/E ratio[6]	116	116	116	114	114	113

[1] Vitamins & minerals mixture /kg premix : each 1 kg contains : Vit A 4.8millinIU, D_3 0.8millionIU, E 4g, K 0.8g, B_1 0.4g, B_2 1.6g, B_6 0.6g, B_{12} 4g, Pantothenic acid 4g, Nicotinic acid 8g; Folic acid 400mg; Biotin 20mg; Choline chloride 299g; Copper 4g; Iron 12g; Manganese 22g; Zinc 22g; and Selenium 0.04g.

[2] Carboxymethyl Cellulose

[3] Nitrogen free extract (NFE) = 100-(CP+EE+CF+Ash).

[4] Gross energy (GE) was calculated as 5.65, 9.45 and 4.2 Kcal/g for CP, EE, and NFE, respectively according to Hepher, *et al.*, 1983.

[5] Metabolizable energy (ME) was calculated as 3.9, 8.0 and 1.6 Kcal/g for CP, EE, and NFE respectively.

[6] Mg protein /Kcal ME.

The water temperature was maintained at 27 ±1 ^{0}C, pH, ammonia (NH_3), nitrite (NO_2^-), nitrate (NO_3^-) and dissolved oxygen, were monitored and remained at acceptable levels throughout the experimental period. The range for dissolved oxygen was 5-7.5 mg/l, total ammonia was 0.01-0.03 mg/L and pH 6.5-7.5 and NO_2 and NO_3 were 0.007 and 0.28 mg/L, respectively.

Experimental fish

Monosex Nile tilapia (*O. niloticus*) were obtained from private farm in Kafer el Sheikh Governorate, Egypt. After one week adaptation period, a number of fish representing about 25% of the population was netted from the stock tank and weighed individually to obtain the nearest average initial weight of the experimental fish. A total number of 240 fingerlings tilapia with initial average body weight 23.84±0.53g were randomly distributed among 12 fibreglasses at 20 fish per tank; two replicate tanks were used for each experimental diet. All experimental fish were weighed biweekly in order to adjust the daily feed amount which was 3% of the total biomass twice daily for 12 weeks. Thirty fish with the initial average weight were killed and stored frozen (at –20 ^{0}C) to determine the initial body composition. Six fish (n=6) were randomly collected from each treatment at the end of the experimental period for determination of the whole body proximate composition. All experimental fish were apparently healthy.

Proximate analysis

Proximate analysis of ingredients, diets and whole body of fish were performed according to AOAC (1990) for crude protein (CP), ether extract (EE), ash, dry matter (DM) and crude fiber (CF).

Statistical analysis

All data were analyzed by using one-way analysis of variance (ANOVA). Duncan's Multiple Range test (1955) was used to compare between treatment means. Differences were considered significant at 0.05 probability level. All statistical analysis were performed using the SAS program (Statistical Analysis System, 1999).

RESULTS AND DISCUSSION

Growth performance

The growth performance and feed utilization data for monosex Nile tilapia fed the six experimental diets are shown in (Table 3). There were significant differences between the final average body weights of fish fed the different experimental diets. Fish fed the fishmeal based control diet demonstrated the highest mean final body weight (83.81g). However, the lowest value (58.63g) was observed for tilapia fed the 100% inclusion level of PBM in the diet replacing the entire fishmeal component.

The control diet supported the highest weight being 60.93 g, while fish fed the PBM 100% diet exhibited the lowest are being 35.12g. It was apparent that above 40% inclusion of PBM resulted in significant reduction in growth performance of fish as final mean body weight.

The specific growth rate (SGR) values further supported this trend, reduced from 1.55 for the control diet to 1.09 for the fish fed the 100% PBM diet. Fish fed the 40 and 60% level inclusion of animal protein source (PBM) performed better than those on the 80 and 100% level of (PBM), while 20% level inclusion was nearly similar to the control group. No mortality was observed during the experimental period and the overall health of the fish appeared normal.

The inclusion of alternative protein sources for the partial or total replacement of fishmeal in fish diets has been studied in previous investigations for numerous fish species. It was concluded that increasing animal derived protein to replace fish meal has a detrimental effect on growth rate and feed utilization above certain constraints although partial substitution is quite feasible. The feasibility of poultry by-products in fish diets was found to depend on fish species and size as well as composition and processing techniques. Yang *et al.* (2006) reported that diets containing high quality of PBM were better than the control diet which contains only fish meal fed to gibel carp. Takagi *et al.* (2000) had found that yearling red sea bream fed diets with up to 100% fish meal (FM) replaced by PBM showed a growth performance and feed utilization similar or better than fish fed FM based control diet. Lu and Kevern (1975) found that a diet containing 30% PBM and 70% salmon feed lowered the growth rate of channel catfish, *Ictalurus punctatus*. On the other hand, up to 75% of fishmeal could be replaced by defatted PBM in coho salmon diets, *Oncorhynchus kisutch* without adverse effects on growth (Higgs *et al.*, 1979). At a 100% substitution level, growth was significantly compromised. However, a mixture of PBM and feather meal supplemented with essential amino acids effectively replaced fishmeal in rainbow trout diets (Tiews *et al.*, 1976). Whereas, Higgs *et al.*, (1979) reported at least 28% of PBM may be included in the diet of coho salmon, without amino acid supplementation.

Table (3): Growth performance and feed utilization values of monosex Nile tilapia fingerlings fed the experimental diets.

	Con.	*20% PBM*	*40% PBM*	*60% PBM*	*80% PBM*	*100% PBM*
Mean initial body weight(g)	22.89	23.68	24.23	24.18	23.34	23.51
Final body weight(g)	83.81^{a} ±1.69	76.71^{ab} ±2.33	73.65^{b} ±1.97	66.55^{c} ±1.37	63.55^{cd} ±1.65	58.63^{d} ±1.47
Weight gain(g)	60.92^{a}	53.03^{ab}	49.43^{b}	42.37^{c}	40.21^{cd}	35.12^{d}
Total feed intake(g/fish)	107.74	102.24	96.15	93.17	85.95	83.02
Protein consumption (g/fish)	34.28	32.63	30.52	29.27	26.65	25.74
FCR[1]	1.77^{d} ±0.06	1.93^{c} ±0.010	1.95^{c} ±0.06	2.20^{ab} ±0.11	2.14^{b} ±0.08	2.36^{a} ±0.06
PER[2]	1.78^{a}	1.63^{b}	1.62^{b}	1.45^{cd}	1.51^{c}	1.36^{d}
SGR[3]	1.55^{a} ±0.02	1.40^{b} ±0.01	1.32^{bc} ±0.04	1.21^{c} ±0.04	1.19^{c} ±0.01	1.09^{d} ±0.03
PPV[4]	24.62^{a}	24.64^{a}	22.84^{b}	20.16^{c}	19.88^{cd}	20.71^{c}
HSI[5]	1.56	1.49	1.58	1.55	1.52	1.61

[1] Feed conversion ratio (FCR): Feed intake (g)/body weight gain (g).
[2] Protein efficiency ratio (PER):Body weight gain (g)/protein intake (g).
[3] Specific growth rate (SGR): (Ln final BW (g)-Ln initial BW (g))/experimental period ×100
[4] Protein productive value (PPV) : (Retained protein (g) / protein consumption (g)))×100
[5] Hepatosomatic index (HSI): Liver weight (g)/fish weight (g)×100
Values with the same superscript are not significantly different ($P > 0.05$).

In the present study, the results for monosex Nile tilapia demonstrate that PBM can replace up to 40% of a high quality fishmeal protein without amino acid supplementation, whilst shown slightly compromising growth performance and feed utilization. Sadiku and Jauncey (1995) investigated the nutritional value of a feathermeal and poultry by-product meal blend for *C.gariepinus*. They reported similar conclusions as these of our investigations. The highest mean final weight, SGR, PER and the lowest FCR values were recorded for fish fed the control diet, 20 and 40% PBM diets.

Feed consumption and feed utilization

All diets were well accepted by the tilapia fish, except diet (6), containing the maximum amount of poultry by-product meal. Total feed intake ranged between 107.74 and 83.02 g/fish. There was a noticeable effect for the higher inclusion of alternative protein sources on feed intake (Table 3). Feed intake for tilapia fed the diet containing the highest amount of fishmeal (HFM) was significantly better than those observed for fish fed diets including PBM.

Feed conversion ratio (FCR) values also differed significantly among the different groups of fish. The poorest FCR was obtained for tilapia fed the tested diet containing 100%PBM with a value of 2.36. Superior FCR were obtained for the remaining diets the control diet, 20 and 40% PBM diets showed the better FCR, being 1.77, 1.93 and 1.95, respectively.

Protein efficiency ratio (PER) was noticeably different between treatments. The fish fed the control diet displayed the best PER (1.78) while fish receiving the highest level of PBM resulted in the poorest one (1.36).

As showed in Table (3) averages of PPV for the control diet, 20, 40, 60, 80 and 100% of PBM groups decreased in a gradual and significant different between treatments order with each increase in replace level of fish meal with PBM where fish fed the control diet recorded the highest PPV (24.62) and fish fed 20, 40, 60, 80 and 100 recorded 24.64, 22.84, 20.16, 19.88 and 20.71, respectively. These results are in agreement with results obtained by (Steffens, W. 1994) who reported that the increase levels of PBM in rainbow trout diet resulted decrease values of protein utilization (PER, PPV).

It should be noted that the essential amino acids profile in fishmeal and PBM (Table 1) had an affect on the experimental diets which included high levels of PBM and clearly show a declining level of growth performance at each PBM increment. This was especially apparent for the total sulphur amino acids (meth. + cys.) and also lysine above a 60% inclusion of PBM (Table 1).

The hepato-somatic index (HSI) did not reflect any trend in tilapia sampled at the end of the study. Although, fish fed the highest level of PBM showed slightly higher value for HSI (1.61). Fish fed the other diets revealed no significant relationship after 12 weeks.

The methionine (Meth) and lysine (Lys) requirements for the African catfish have been determined by Fagbenro, *et al*. (1998a) and Fagbenro, *et al.*, (1998b) and stated to be 2.3 and 5.7% of the total protein, respectively based on semi-purified diets compared with Nile tilapia requirements of methionine and lysine stated to be 2.7 and 5.1, respectively (Luquet, 1991). In the present study, these specific amino acids were appreciably lower for all PBM inclusions above 40% of the protein component of the diet. It should also be noted that several other amino acids became progressively reduced at high PBM inclusions and may have contributed to the inferior protein utilization (PER) and growth performance of tilapia as presented in (Table 3). New researches have been reported that Met and Lys were found to be the first and second-limiting amino acids in PBM and deficiencies in hybrid striped bass performance were improved by supplementing a 100% replacement diet with sufficient Met and Lys to match levels in constant protein which was 40% for all diets provided by hybrid striped bass (Rawles *et al*., 2006).

However, Fowler (1991) was successful in rearing chinook salmon, *Oncorhynchus tschawytscha* with a diet containing 20% PBM meal without additional amino acids supplementation. Whereas, Alexis *et al*. (1985) working with rainbow trout, *Salmo gairdneri*, obtained very good results with a feed containing 20% PBM meal, with methionine supplementation.

The inferior performance of the fish receiving the higher PBM diets compared with groups receiving fishmeal in most studies is possibly a result of the lower availability of nutrients and amino acids imbalance. Alexis *et al*. (1985) listed the digestibility of some of the main animal by-products tested in their study. Values obtained were of about 85% digestible protein for fishmeal but only 60% for PBM in the rainbow trout. Gaylord and Gatlin (1996) also reported the protein digestibility coefficients of selected animal protein sources, including meat and bone meal, were close to values previously reported for various fish species. Protein digestibility of PBM in their study was very being low 49% for red drum, *Sciaenops ocellatus*, compared to values for rainbow trout and chinook salmon of 68% and 74%, respectively (NRC, 1993). Few studies determined the digestibility coefficients for protein and energy in ingredients for tropical fish such as tilapia and catfish. Hanley (1987) reported that digestibility of protein and energy values for tilapia *O. niloticus* were appreciably lower (74% and 59%, respectively) compared to fishmeal (86% and 80%, respectively). In the current study this is probably one explanation for the reduced growth performance associated with increased level of PBM for monosex Nile tilapia.

Investigations for the digestibility coefficient profiles for protein, individual amino acids and energy for a range of raw materials of animal protein sources in tilapia feeds were reported by Abdel-Warith (2002). The palatability of low fishmeal diets for fish is also a problem and should be addressed for even omnivorous fish such as the tilapia. At high inclusion levels of PBM in the current study there was a reduction in feed intake.

Fish body composition

Initial and final body composition of fish fed the experimental diets is presented in Table 4. The final body composition showed a treatment effect on proximate composition with respect to protein, lipid and ash content. Fish fed the fishmeal based control diet, 20, and 40 PBM diets did not yield any significant in the protein content. Whilst, fish fed the 60, 80, and 100% PBM diets had a slightly lower protein in their final carcass composition with no significant differences between the three treatments.

Fish fed the elevated level of PBM resulted significant differences in lipid content compared to fish fed control and lower levels PBM diets (Table 4). Similarly, there was no obvious trend in the carcass moisture content ($P>0.05$).

However, the ash content in the body composition of fish fed the control diets was appreciably low (23.07%) compared to tilapia fed on the higher levels of PBM (25.04%). This was found to be significant ($P<0.05$) started from 60 %

inclusion level. The whole body composition of tilapia was not affected by substitution of fishmeal with PBM with respect to moisture content. Also, the protein component remained consistent for each of the groups receiving the experimental diets. This was consistent with the similar protein and energy levels employed in the feed formulations. In this concern Belal, *et al.* (1995) found that the replacement of fishmeal with chicken offal silage for tilapia *O. niloticus* did not compromise growth performance or carcass composition. However, results of this study showed a progressive increase in the ash content of tilapia fed 60, 80 and 100% PBM. This elevated mineral retention reflected the inorganic component of the diets. Future studies should also address the mineral composition of whole carcass and selected tissues.

Table (4): Chemical composition of the whole body of monosex Nile tilapia fed the experimental diets (%DM).

Proximate composition (%)	*Initial fish*	*Con.*	*20% PBM*	*40% PBM*	*60% PBM*	*80% PBM*	*100% PBM*
Dry matter	24.99	27.39^{a} ±0.39	27.88^{a} ±0.20	27.39^{a} ±0.54	27.00^{a} ±0.65	27.40^{a} ±0.34	27.55^{a} ±0.39
Protein	50.03	58.44^{a} ±0.85	58.07^{a} ±1.01	57.00^{a} ±1.80	55.93^{b} ±1.41	55.31^{b} ±1.78	55.36^{b} ±1.60
Lipid	25.02	17.43^{b} ±0.64	17.60^{b} ±0.78	18.98^{a} ±0.56	17.99^{ab} ±0.85	19.43^{a} ±0.58	18.72^{a} ±0.82
Ash	23.09	23.07^{b} ±0.72	22.29^{b} ±0.51	22.52^{b} ±0.53	23.74^{ab} ±0.50	23.90^{a} ±0.39	25.04^{a} ±0.31

Values with the same superscript are not significantly different ($P > 0.05$).

Economic evaluation

Results in Table 5 showed the economic evaluation of tested diets including feed costs, costs of one kg weight gain and its ratio compared to the control diet. As presented in this table, cost of 1kg of the control diet and tested diets (20, 40, 60, 80 and 100% of PBM) were 3.38, 2.91, 2.57, 2.16, 1.68 and 1.14 LE, respectively. These results indicated that incorporation of PBM in tilapia diets reduced the price of 1kg diet to be 86.10, 76.04, 63.91, 44.70 and 33.73 for the diets contained 20, 40, 60, 80 and 100% of PBM as compared to the price of the control diet. Feed costs to produce one kg weight gain were the highest for the control diet and gradually decreased from 100% in the control diet to 93.98, 83.78, 79.43, 60.20 and 45.00, respectively with increasing the replacing level of PBM. These results indicated that incorporation of PBM in tilapia diets reduced the total feed costs, which was reflected on the total costs. However, all replacing levels of fish meal by PBM (20, 40, 60, 80 and 100) showed slightly decrease in the growth and feed utilization parameters when the inclusion level of PBM in the diet increase but, the incorporation of PBM in monosex tilapia diets seemed to be economic as inclusion of PBM in diets reduced feed costs by 13.90, 23.96, 36.09, 50.30 and 66.27% for the replacing levels of 20, 40, 60, 80 and 100%, respectively.

In conclusion, results of this study indicated that PBM is an acceptable ingredient for the partial replacement of fishmeal protein in practical diets for monosex Nile tilapia fingerlings. PBM can be used in balance diet formulations for this species with up to 40% replacement of fishmeal protein with limitation decline in growth performance but, no harmful effect on health criteria was observed. Also, for economic fish culture, it can be used up to 60%. Further work is required to obtain reliable digestibility data for protein, amino acids, lipid and energy components for this ingredient to realize its full potential in practical diets. This would necessitate investigations with various size classes of fish representing the complete production cycle.

Table (5): Feed costs (LE) for producing one kg weight gain by fish fed the experimental diets.

	Con.	20% PBM	40% PBM	60% PBM	80% PBM	100% PBM
Feed costs (LE/kg)*	3.38	2.91	2.57	2.16	1.68	1.14
Relative to control (%)	100	86.10	76.04	63.91	49.70	33.73
Decrease in feed costs (%)	0.00	13.90	23.96	36.09	50.30	66.27
FCR	1.77	1.93	1.95	2.20	2.14	2.36
Feed cost (LE/kg WG)**	5.98	5.62	5.01	4.75	3.60	2.69
Relative to control (%)	100	93.98	83.78	79.43	60.20	45.00

* The price of 1kg ingredient used was 7.5 LE for fish meal, 1.5 LE for poultry by product meal, 0.60 LE for wheat bran, 1.5LE for corn meal, 4LE for corn oil and 12 LE for vitamins and minerals mix and 2.5LE for cellulose according to market price during 2004.

** Feed costs/kg weight gain = FCR × costs of kg feed.

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الإحلال الجزئى والكلى لمسحوق السمك بمسحوق مخلفات مجازر الدواجن فى علائق أسماك البلطى النيلى وحيد الجنس.

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أجريت هذه الدراسه لتقدير الحد المناسب من مسحوق مخلفات مجازر الدواجن التى يمكن إحلاله محل مسحوق االسمك فى علائق أصبعيات أسماك البلطى النيلى .كان متوسط وزن الأسماك عند بداية التجربة (٢٣,٤٦±٠,٥٣جرام) وقد تم إستخدام ٦ علائق منها خمسة علائق تحتوى على نسب من مسحوق مخلفات مجازر الدواجن حلت محل مسحوق السمك فى عليقة المقارنه كالتالى ٢٠، ٤٠، ٦٠، ٨٠، ١٠٠% وتم مقارنة هذة العلائق بالعليقه المقارنه المحتوية على ١٠٠% مسحوق سمك . وأظهرت النتائج عند نهاية التجربه (١٢ إسبوع) أن هناك فروق معنويه فى الوزن النهائى للأسماك عند مستوى ٠,٠٥% بين المعاملات .وكان الوزن النهائى للأسماك التى غذيت على عليقة المقارنه والعلائق المحتوية على ٢٠، ٤٠% مسحوق مخلفات مجازر الدواجن هو ٨٣,٨١، ٧٦,٧١، ٧٣,٦٥ جرام على التوالى .بينما كان هذا الوزن للأسماك التى غذيت على العلائق المحتويه على ٦٠، ٨٠، ١٠٠%مسحوق مخلفات مجازر الدواجن منخفض معنوياً وهو ٦٦,٢٧، ٦٣,٥٥، ٥٨,٦٣ جرام على التوالى .كما أظهرت هذه النتائج أيضاً تأثير معنوى على كل من معدل النمو الحقيقى ومعدل التحويل الغذائى وكفاءة تحويل البروتين وكذلك كمية الغذاء المأكول .ولم يظهر الفحص الداخلى للكبد أى إختلافات واضحة فى حجم الكبد بين المعاملات المختلفة. وأوضح التقييم الإقتصادى أن إضافة مسحوق مخلفات مجازر الدواجن فى علائق أسماك البلطى النيلى بمعدلات ٦٠، ٨٠، ١٠٠% كانت أفضل من الناحية الإقتصادية عند حسابها على أساس الزيادة فى الوزن .وكذلك دلت نتائج هذه الدراسة على أنه من الممكن إضافة مسحوق مخلفات مجازر الدواجن فى علائق البلطى النيلى وحيد الجنس وإحلالها محل مسحوق السمك بمعدلات حتى ٤٠% دون أى تأثير على معدلات النموومعامل التحويل الغذائى.