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

EXECUTIVE COINCIL

Prof. Dr. Ahmed Said Diab **Chairman**
(E. Mail: ASDiab_eg@yahoo.com) (Tel: 0112261017)

Prof. Dr. Atef Ez-El-Rigal Ibrahim **Editor-in-Chief**
(E. Mail: atef_ez_elrigal@maktoob.com) (Tel: 0125818668)

Prof. Dr. Ibrahim Shaker Abd El-Fattah **Vice-Chairman**
(E. Mail: dr_Ibrahim_Sh@yahoo.com) (Tel: 0102663536)

EDITORS

Prof. Dr. Abd El_Fattah El-Sayed **Prof. Dr. Fatma M. Abd El-razik**

Prof. Dr. Gamal O. El-Naggar **Prof. Dr. Mohamed F. Osman**

Prof. Dr. Mohamed Marzouk **Prof. Dr. Samir Ghoneim**

All correspondence should be addressed to:

Abbassa International Journal for Aquaculture, Abbassa – Abou Hammad – Sharkia – Egypt. Tel.: 0020553401028 – Fax: 0020553400498

GENERAL INFORMATION

Abbassa International Journal for Aquaculture is Egyptian specific publication in aquaculture of the Egyptian society for water, aquaculture and environment. The journal is published in four volumes per year to include results of research in different aspects of aquaculture sciences. The journal publishes also special issues of advanced topics that reflect applied experiences of importance in aquaculture sector.

Abbassa Int. J. Aqua., V0l.4 No.(1) 2011. *61 -77*

PARTIAL AND TOTAL REPLACEMENT OF FISHMEAL WITH CHEESE PROCESSING BY-PRODUCT MEAL IN PRACTICAL DIETS FOR NILE TILAPIA, *OREOCHROMIS NILOTICUS* (L.) FINGERLINGS

Mohsen Abdel-Tawwab[1*], Fayza E. Abbass[2], and Medhat E.A. Seden[3]

[1]Department of Fish Biology and Ecology, [2]Department of Fish Production and Aquaculture Systems, and [3]Department of Fish Nutrition, Central Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, Sharqia 44662, Egypt.

** Corresponding author E-mail: mohsentawwab@yahoo.com*

Received 17/ 7/ 2011 *Accepted 18/ 8/ 2011*

Abstract

Aquaculture is the fastest expanding food production system in the world. This rapid development largely depends upon the increased production of aqua-feeds, which traditionally rely on fishmeal (FM) as the main protein source. The increasing demand for FM use in animal and fish diets has resulted in FM becoming difficult to obtain and more expensive. Therefore, this study was conducted as a trial to use cheese processing by-product meal (CPBM) as a substitute for FM in practical diet for Nile tilapia, *Oreochromis niloticus* (L.). Triplicate fish groups were fed on one of five isonitrogenous (30.4%) and isolipidic (7.4%) diets. The control diet (D1) used FM as the sole protein source. In the other four diets (D2 – D5), FM protein was substituted by 25, 50, 75, or 100% CPBM. Fish (3.5 ± 0.1 g) were stocked at a rate of 20 fish per 100-L aquarium and fed one of the tested diets for satiation twice daily, 6 days a week for 12 weeks. Fish growth, feed utilization, protein efficiency ratio, apparent protein utilization, and energy utilization for fish fed CPBM diets up to 75% of FM (D2 – D4) were all higher, but not significantly, than those for fish fed D1. No significant changes were found in whole-body moisture, crude protein, total lipid, and total ash contents. Cost–benefit analysis of the test diets herein indicated that CPBM was economically superior to FM. This study concluded that the optimal replacement level of FM by CPBM was 75%.

Keywords: Nile tilapia, fishmeal, cheese processing by-product meal, fish growth, feed utilization, whole-body composition.

INTRODUCTION

Nowadays, aquaculture industry accounts for a massive 68% of global fishmeal (FM) consumption and 88% of fish oil consumption (Naylor *et al*., 2009). Fish meal is a major conventional ingredient in many aquafeeds (El-Sayed, 2004); however, FM is the single most expensive macro-feed ingredient and is highly sought after by other livestock industries (Tacon and Forster, 2000). With static or declining clupeid fish populations that are harvested for FM, any negative market disturbance, supply disruption, or availability problem, can lead to dramatic increases in the commodity price (Tacon and Forster, 2000). Further, the capture of wild fish used to feed cultured fish is unsustainable at current levels according to most experts (Naylor *et al*., 2000). Current developments in aquaculture feed production are seeking the substitution of FM by alternatives such as terrestrial plant material, rendered terrestrial animal products, krill, seafood by-products or materials of protest origin. The National Organics Standards Board (NOSB) has proposed limiting the use of FM in organically certified aquaculture products with a 12-year phase-out schedule (Board, 2008). These developments are being driven by both economic and ethical concerns.

As the tilapia industry expands, there is a need to formulate nutritious, economical diets that do not rely on FM as a major protein source. One approach to reducing FM in Nile tilapia diet is to replace it with alternative, less expensive animal or plant protein ingredients. This would alleviate the dependence on marine-derived protein, allow for continued expansion of global aquaculture, utilize renewable ingredients, and help decrease production costs. The use of environmentally friendly approach is desirable in modern aquaculture and cheese processing by-product meal (CPBM) fulfills this objective; however it is readily available and renewable ingredient. This by-product achieves a protein content of 34% to 89% (USDEC, 2004); that nominees it to partially or totally replace FM in fish diets. Therefore, this study was conducted as a preliminary study to evaluate the use of CPBM in fish diets instead of FM and its impact on growth, survival, feed efficiency, and body composition of Nile tilapia, *Oreochromis niloticus* (L.).

MATERIALS AND METHODS

Diet preparation

Cheese processing byproduct meal was obtained from local cheese manufacture. It was centrifuged at 10,000 *g* for 15 min and oven dried at 55 ^{o}C for 24 hours. AOAC method (AOAC 1990) was used to determine its proximate chemical composition. Moisture, crude protein, crude fats, and total ash contents of CPBM were 77.1, 42.2, 14.3, and 28.4%, respectively.

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

Ingredients	**Cheese processing by-product (%)**				
	0.0 (Control)	25	50	75	100
	D1	D2	D3	D4	D5
Herring fish meal [1]	10.1	7.6	5.1	2.5	0.0
Cheese processing byproduct	0.0	4.4	8.7	13.1	17.4
Soybean meal [2]	43.1	43.1	43.1	43.1	43.1
Corn meal	17.4	17.4	17.4	17.4	17.4
Wheat bran	14.5	14.5	14.5	14.5	14.5
Cod liver oil	2.1	2.1	2.1	2.1	2.1
Corn oil	1.8	1.8	1.8	1.8	1.8
Vitamins premix [3]	1.0	1.0	1.0	1.0	1.0
Minerals premix [4]	2.0	2.0	2.0	2.0	2.0
Starch	8.0	6.1	4.3	2.5	0.7
Total	100	100	100	100	100
Chemical analyses (%)					
Moisture	7.5	7.4	7.6	7.8	7.7
Crude protein	30.4	30.2	30.3	30.5	30.6
Ether extract	7.4	7.3	7.5	7.6	7.4
Ash	7.1	7.4	7.8	8.2	8.6
Crude fiber	5.0	4.9	4.7	4.8	5.1
Nitrogen-free extract [5]	50.1	50.2	49.7	48.9	48.3
GE (kcal/100g) [6]	447.1	445.4	445.9	444.6	440.9
P/E ratio	68.0	67.8	68.0	68.6	69.4

[1] Danish fish meal72% protein, 14.2% crude fat, and 11.0% ash obtained from TripleNine Fish Protein, DK-6700 Esbjerg, Denmark.

[2] Egyptian soybean flour 44% protein, 1.1% crude fat, and 7.9% ash obtained from National Oil Co., Giza, Egypt.

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

[4] 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.

[5] Nitrogen-free extract = 100 – (crude protein + total lipid + crude fiber + total ash).

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

Table 2. Amino acid composition of the tested diets (as % of dietary protein) and requirements for Nile tilapia after Santiago and Lovell (1988).

Amino acids	CPBM levels (%)					Requirement
	0.0 (Control)	25	50	75	100	
	D1	D2	D3	D4	D5	
Essential						
Arginine	6.25	6.12	5.94	5.51	5.21	4.20
Histidine	3.32	3.34	3.33	3.29	3.26	1.72
Isoleucine	4.01	4.62	3.96	3.83	3.66	3.11
Leucine	7.23	7.35	7.39	7.27	7.18	3.39
Lysine	6.65	6.93	5.52	5.19	4.85	5.12
Phenylalanine	4.34	4.29	4.14	3.94	3.75	3.75
Methionine	2.32	2.15	1.98	1.85	1.72	2.68
Threonine	5.29	5.24	5.05	4.85	4.63	3.75
Tryptophan	1.41	1.35	1.32	1.26	1.21	1.0
Valine	4.44	4.38	4.29	4.13	3.85	2.8
Non-essential						
Alanine	4.62	4.47	4.29	4.16	4.11	
Aspartic acid	9.62	9.53	9.41	9.15	8.95	
Cystine	2.63	2.53	2.37	2.25	2.13	0.54
Glycine	4.44	4.22	3.92	3.77	3.54	
Glutamic acid	15.16	14.86	14.52	14.17	14.06	
Proline	4.93	4.53	4.24	4.14	4.10	
Tyrosine	3.61	3.53	3.46	3.37	3.24	1.79
Serine	4.11	3.86	3.75	3.72	3.63	

Five diets were formulated to be isonitrogenous (30.4% crude protein) and isolipidic (7.4% total fat) with CPBM replacing herring FM at different levels. All diets contained a constant level of plant protein from soybean meal, corn meal and wheat bran to complete the protein requirement. These diets were formulated to contain the same protein and lipid contents. The control diet (D1) was prepared with 100% herring FM, the remaining four diets (D2 – D5) were prepared with 25, 50, 75, or 100% of herring FM protein substituted by CPBM protein. The dietary ingredients were thoroughly mixed and moistened by the addition of 100 ml warm water per kg diet and then made into pellets by a mincing machine. Pellets were cut into shape manually, dried in an oven at 55 ^{o}C to less than10% moisture and stored in a freezer at -2 ^{o}C until use. The composition and proximate analyses (dry-matter basis) of these diets are given in Table 1, while the amino acid contents are given in Table 2.

Fish culture and feeding regime

Nile tilapia, *O. niloticus* (L.) were obtained from the fish hatchery, Central Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, Sharqia, Egypt. Before starting the experiment, fish were acclimated and hand-fed to apparent satiation twice a day for 2 weeks. For the experiment, 15 100-L aquaria were used and oxygenated to saturation by air pumps and 20 fish (3.5 ± 0.1 g) were stocked in each aquarium. The tested diets were administered to five fish groups with three replicates per each. Fish were hand-fed for satiation twice daily (at 9:30 and 14:00 hours), 6 days a week for 12 weeks. Settled fish wastes along with three-quarter of aquarium's water were siphoned daily. Siphoned water was replaced by clean and aerated water from a storage tank. Every 2 weeks fish per each aquarium were group-weighed. Fish were starved for a day before weighing. During the experiment, the water quality was checked periodically. The water temperature ranged from 24.2 to 26.4 ^{o}C, pH from 7.4 to 7.6, dissolved oxygen was 4.9 – 5.3 mg/L, and unionized ammonia was <0.2 mg/L.

Fish growth and feed utilization

At the end of the experiment, fish per each aquarium were harvested, counted, and weighed. Fish growth and feed utilization variables were calculated as follows:

Weight gain (g) = final weight – initial weight;

Weight gain % = 100 x weight gain / initial weight;

Specific growth rate (SGR; %/day) = 100 (Ln final weight – Ln initial weight) / days;

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

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

Apparent protein utilization (APU; %) = 100 [protein gain in fish (g) / protein intake in feed (g)];

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

Chemical analysis of diets and fish

The proximate chemical analyses of the tested diets and fish samples were done for moisture, crude protein, total lipid, and total ash according to the standard methods of AOAC (1990). Moisture content was estimated by drying the samples to constant weight at 85 ^{o}C in drying oven (GCA, model 18EM, Precision Scientific group, Chicago, Illinois, USA). Nitrogen content was measured using a microkjeldahl apparatus (Labconco, Labconco Corporation, Kansas, Missouri, USA) and crude protein was estimated by multiplying nitrogen content by 6.25. Lipid content was determined by ether extraction in multi-unit extraction Soxhlet apparatus (Lab-Line Instruments, Inc., Melrose Park, Illinois, USA) for 16 hours. Total ash was determined by combusting dry 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).

Amino acid composition in duplicate samples of fish diets was determined in acid hydrolysate (6 N HCl under reflux for 24 h at 110^{o}C) using an automatic amino acid analyser (LKB 4151 plus, Biochrom Ltd., Cambridge, UK). Tryptophan was determined colorimetrically after hydrolysing triplicate samples in 4.2 N NaOH (Basha and Roberts, 1977).

Economical evaluation

The cost of feed to raise unit biomass of fish was estimated by a simple economic analysis. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in L.E./kg) were as follows: herring fish meal, 12.0; CPBM, 3.0; soybean meal, 2.5; corn meal, 1.50; wheat bran, 1.40; starch, 3.0; fish oil, 9.0; corn oil, 7.0; vitamin premix, 7.0; mineral mixture, 3.0. An additional 50.0 L.E./ton manufacturing cost.

Statistical analysis

The obtained data in this study are presented as means ± SD of three replicates. One-way analysis of variance was used to test the effects of the diets. Duncan's Multiple range test was used for mean comparisons. Differences were regarded as significant when $P < 0.05$. Second-order polynomial regression analysis of the relationship between the fish growth and the replacement levels of protein of CPBM was used to estimate the optimal replacement level of protein of FM by CPBM in the diets for Nile tilapia. All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, VA, USA) as described by Dytham (1999).

RESULTS

Growth performance including final body weight, weight gain, weight gain %, and SGR was insignificantly (P<0.01) influenced by the dietary CPBM except that fed 100% CPBM diet, which exhibited the lowest growth performance (Table 3). No significant differences were observed in survival among the treatments since its range was 96.7 - 100 % ($P > 0.05$; Table 2).

Feed intake increased in all groups during the experiment, but it decreased significantly only at 100% CPBM (D5; $P < 0.05$; Table 4). Indeed, feed intake increased in all treatments during the course of the experiment, as fish grew, but it was low in group fed D5. Feed conversion ratio showed similar values for fish fed D1 – D5; it varied between 1.35 in D1 and 1.39 in D2 (Table 4). Similarly, PER, APU, and

EU value showed insignificant differences ($P > 0.05$) among the different treatments (D1 – D5) and their ranges were 2.57 – 2.64, 44.2 – 45.8%, and 25.1 – 26.3%, respectively.

Table 3. Growth performance for Nile tilapia fed diets containing different levels of cheese processing by-product meal (CPBM) for 12 weeks.

	CPBM levels (%)				
	0.0 (Control)	**25**	**50**	**75**	**100**
	D1	**D2**	**D3**	**D4**	**D5**
Initial weight (g)	3.6± 0.06	3.6± 0.07	3.5± 0.09	3.5± 0.09	3.5± 0.06
Final weight (g)	30.2± 0.38 [ab]	30.8± 0.29 [ab]	30.8± 0.42 [ab]	31.8± 0.61 [a]	29.5± 0.61 [b]
Weight gain (g)	26.6± 0.32 [ab]	27.2± 0.30 [ab]	27.3± 0.38 [ab]	28.3± 0.52 [a]	26.0± 0.55 [b]
Weight gain %	738.9± 3.0 [c]	755.6± 7.7 [bc]	780.0± 6.5 [b]	808.6± 6.6 [a]	742.9± 3.5 [c]
SGR (%/day)	2.53± 0.004 [b]	2.56± 0.005 [b]	2.59± 0.009 [ab]	2.63± 0.009 [a]	2.54± 0.005 [b]
Survival rate (%)	98.3± 1.7	100.0± 0.0	98.3± 1.7	96.7± 3.3	100.0± 0.0

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

Table 4. Feed utilization for Nile tilapia fed diets containing different levels of cheese processing by-product meal (CPBM) for 12 weeks.

	CPBM levels (%)				
	0.0 (Control)	**25**	**50**	**75**	**100**
	D1	**D2**	**D3**	**D4**	**D5**
Feed intake (g feed/fish)	36.0± 0.46 [ab]	37.8± 0.51 [a]	37.6± 0.51 [a]	38.4± 0.76 [a]	35.3± 1.01 [b]
Feed conversion ratio	1.35± 0.037	1.39± 0.044	1.38± 0.073	1.36± 0.025	1.36± 0.035
Protein efficiency ratio	2.63± 0.020	2.57± 0.064	2.60± 0.028	2.64± 0.047	2.60± 0.073
Protein utilization (%)	44.8± 1.70	44.2± 0.93	45.8± 0.84	45.8± 1.62	45.4± 0.92
Energy utilization (%)	25.5± 0.69	25.1± 0.56	25.8 ± 0.68	26.1± 0.90	26.3± 0.52

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

The chemical composition of the whole fish body is given in Table 5. All fish displayed a change in the whole body composition (compared with that at the start of the experiment), which consisted mainly in a decrease of moisture percentage and a corresponding increase in total lipid content. No significant changes in moisture, crude protein, total lipid, and total ash contents in fish body were found due to the inclusion of CPBM in fish diets and their ranges were 74.4 – 75.1%, 65.8 – 66.5%, 18.3 – 18.6%, and 13.8 – 14.3%, respectively (Table 5).

Table 5. Proximate chemical analyses (%; on dry weight basis) of Nile tilapia whole-body fed diets containing different levels of cheese processing by-product meal (CPBM) for 12 weeks.

	CPBM levels (%)				
	0.0 (Control)	**25**	**50**	**75**	**100**
	D1	**D2**	**D3**	**D4**	**D5**
Moisture	75.1±0.32	74.7±0.28	74.4±0.49	74.5±0.44	74.5±0.52
Crude protein	66.1±0.71	65.8±0.50	66.5±0.67	65.8±076	66.2±1.22
Total lipid	18.5±0.68	18.3±0.17	18.4 ±0.63	18.6±0.35	18.3±0.75
Total ash	14.2±0.68	14.3±0.34	13.8±0.93	13.9±0.90	14.1±051

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

It is noticed that the incorporation of CPBM (D2 – D5) herein reduced the price of one kg diet as compared to the control group (Table 6). Average cost to produce on kg gain in weight for D1 – D5 were 4.59, 4.45, 4.14, 3.81, and 3.40 L.E., respectively. However, CPBM inclusion reduced the cost to produce one kg gain by 3.1, 9.8, 17.0, and 25.9% for D2 – D5, respectively (Table 6).

Table 6. Economic efficiency for production of one kg gain of Nile tilapia fed diets containing different levels of cheese processing by-product meal (CPBM) for 12 weeks.

	CPBM levels (g/kg diet)				
	0.0 (Control)	**25**	**50**	**75**	**100**
	D1	D2	D3	D4	D5
Feed cost (L.E./kg)	3.4	3.2	3.0	2.8	2.5
FCR (kg feed/kg gain)	1.35	1.39	1.38	1.36	1.36
Feed cost per kg gain (L.E.)	4.59	4.45	4.14	3.81	3.40
Cost reduction per kg gain (L.E.)*	0.0	0.14	0.45	0.78	1.19
Cost reduction per kg gain (%)**	0.0	3.1	9.8	17.0	25.9

* Cost reduction per kg gain (L.E.) = feed cost per kg gain of control (L.E.) - feed cost per kg gain of CPBM treatment (L.E.);

** Cost reduction per kg gain (%) = 100 [cost reduction per kg gain (L.E.) in D2-D5 / feed cost per kg gain of control (L.E.)].

DISCUSSION

In recent years, a significant amount of research has been conducted on the replacement of FM by alternative sources. The suitability of this replacement in terms of growth performance is highly variable among fish species and experimental conditions (El-Sayed, 1999). This is the first time to our knowledge that CPBM has bean demonstrated to be effective in replacing FM in fish diets although other authors have demonstrated FM replacement potential for a variety of animal and plant meals. The good overall growth performances with SGR of 2.53 – 2.63 %/d, FCR of 1.35 – 1.39, and PER of 2.57 – 2.64 obtained in this study confirm the suitability of the CPBM nutritional composition for Nile tilapia.

The present study indicated that the partial substitute of FM protein by CPBM protein has no significant adverse effect on the growth response and feed utilization for Nile tilapia; but higher amounts of

CPBM protein (D5) retarded fish growth and feed utilization significantly. These results suggest that it is possible to replace up to 75% of FM protein with CPBM protein without significant effects on fish growth response. These results are in concomitant with many authors who reported that animal by-products meals could replace 30% and 75% of dietary FM. Abdelghany (2003) evaluated the use of gambusia, *Gambusia affinis*, fish meal (GFM) in practical diets for red tilapia, *O. niloticus* x *O. mossambicus.* He formulated six isonitrogenous diets (35%) in which GFM replaced 0.0, 10, 25, 50, 75, or 100% of the protein supplied by herring FM. He demonstrated that GFM is a suitable protein source in practical diets for Nile tilapia and could replace HFM up to 50%; however, fish growth and feed and protein utilization were retarded for diets containing 100% GFM. Ahmad (2008) used the same diets for Nile tilapia and found that the highest growth was obtained at 75% GFM. Further, the complete replacement of CPBM with FM (100% GFM) reduced fish growth. This result agreed with previous studies used animal byproducts sources to partially or totally replace FM for red tilapia, *O. niloticus* x *O. mossambicus* (Abdelghany, 2003), Nile tilapia (Ahmad, 2008), and gibel carp, *Carassius auratus gibelio* (Yang *et al*., 2006). The growth reduction in fish fed the 100%-CPBM diet may be attributed to reduced palatability or attractiveness of the diet causing a reduced feed intake. Also, the low fish growth at 100% CPBM diet may be attributed to the deficiencies in lysine and methionine (Table 2). Moreover, a 100%-CPBM diet may lack a particular amino acids balance similar to that obtained in other diets. Indeed, profound deleterious effects may occur in animals not only because of EAA deficiency but also to EAA imbalances (Boisen, 2003; Peres and Oliva-Teles, 2007).

All feed utilization variables including FI, FCR, PER, and APU enhanced gradually with increasing CPBM levels up to 75% after which diet utilization and protein utilization were the lowest. Based on feed intake, the palatability of the tested diets (D1 – D4) appeared to be better than D5 (100% CPBM; Table 4). The reduction in feed utilization variables at the high replacement diets may be attributed to reduced palatability or attractiveness of the diet in addition to reduced feed intake، because of low lysine and methionine. Likewise, Abdelghany *et al.* (2005) reported that fed diets in which poultry byproduct meal (PBM) replaced up to 100% of the protein supplied by HFM had similar FCR, FER, PER, and APU to fish fed the HFM-based diet. Yang *et al.* (2006) found that FI, PER, FER, PRE, and ERE estimated for gible carp fed diet containing different PBM levels were higher than those in fish fed the control diet.

No significant changes in the proximate whole-body composition were observed because of the CPBM inclusion in fish diets. These results suggested that fish efficiently ingested, digested, and assimilated CPBM protein. These results are in agreement with Abdelghany (2003) and Ahmad (2008) who reported that partial or complete replacement of FM with GFM did not affect body composition (protein, fat, and dry matter) of red tilapia and Nile tilapia, respectively. Yang *et al.* (2006) found that no significant changes were observed in whole-body moisture and fat content of gible carp resulted from the different replacement of FM with PBM.

Most of the works reviewed have evaluated FM replacements in tilapia feeds from biological or nutritional viewpoints. Little attention has been paid to economic analyses of these protein sources. Only a few studies have been conducted into this subject and these have indicated that those unconventional protein sources were more economical than FM because of their local availability at low prices. Cost–benefit analysis of the test diets herein indicated that CPBM was economically superior to FM. Similar results were reported by other workers. The economic evaluation of animal by-product meals replaced FM for Nile tilapia indicated that these sources were economically superior to FM, even at total replacement levels (Rodriguez-Serna *et al*., 1996; El-Sayed, 1998).

Small-scale fish farmers in developing countries are constrained by both the availability and the cost of pelleted fish diets produced commercially. Hence, there is a real need to encourage fish farmers to formulate their own pelleted diets using CPBM produced near their farms as far as possible. As a conclusion of this study, it is suggested that without amino acid supplementations, CPBM could safely replace FM up to 75% in practical diets for Nile tilapia. These results may allow for formulation of less expensive diets for Nile tilapia and may reduce the diet costs for producers.

Acknowledgements

The authors appreciate the assistance provided by Dr. Mohamed H. Ahmad, Department of Fish Nutrition, Central Laboratory of Aquaculture Research, Abbassa, Sharqia, Egypt during the running of this study.

REFERENCES

Abdelghany, A.E. 2003. Partial and complete replacements of fish meal with gambusia meal in diets for red tilapia *Oreochromis niloticus* x *O. mossambicus*. Aquaculture Nutrition 8,1–10.

Abdelghany, A.E.; M.H. Ahmad; S.H. Sayed; H.I. Ibrahim and M.E. Abdel-Fatah. 2005. Replacement of fish meal with poultry by – product meal in diets for all-male mono-sex Nile tilapia, *Oreochromis niloticus*. Egyptian Journal of Nutrition and Feeds (Special Issue) 8 (1): 1049–1063.

Ahmad, M.H. 2008. Evaluation of gambusia, *Gambusia affinis*, fish meal in practical diets for fry Nile tilapia, *Oreochromis niloticus*. Journal of the World Aquaculture Society 39: 243 – 250.

AOAC (Association of Official Analytical Chemists). 1990. Official methods of analyses, 15th edition. Association of Official Analytical Chemist Inc., Arlington, Virginia, USA.

Basha, S.M.M.and R.M. Roberts. 1977. A simple colorimetric method for the determination of tryptophan. Analytical Biochemistry 77: 378-386.

Board, N.O.S. 2008. Proposed organic aquaculture standards: fish feed and relative management issues. In: Board, N.O.S. (Ed.), Formal recommendation by the NOSB to the National Organic Programme. Washington, DC, USA.

Boisen, S. 2003. Ideal dietary amino acid profiles for pigs. Pages 103–123 in J.P.F. D'Mello, editor. Amino acids in animal nutrition, 2nd ed., CABI Publications, Oxon, UK.

Dytham, C. 1999. Choosing and using statistics: A Biologist's guide. Blackwell Science Ltd., London, UK.

El-Sayed, A.-F.M. 1998. Total replacement of fish meal with animal protein sources in Nile tilapia, *Oreochromis niloticus* (L.), feeds. Aquaculture Research 29: 275–280.

El-Sayed, A.-F.M. 1999. Alternative dietary protein sources for farmed tilapia, *Oreochromis* spp. Aquaculture 179: 149–168.

El-Sayed, A.-F.M., 2004. Protein nutrition of farmed Tilapia: searching for unconventional sources. In: R. Bolivar, G. Mair, K. Fitzsimmons (Editors). New dimensions in farmed tilapia: proceedings of the Sixth International Symposium on Tilapia Aquaculture 2004, Manila, Philippines, pp 364–378.

Goering, H.K. and P.G. Van Soest. 1970. Forage fiber analysis (apparatus, reagent, procedures, and some applications). US Dept. Agric. Handbook, Washington D.C., USA, p. 379.

Naylor, R.L.; R.J. Goldberg; J.H. Primavera; N. Kautsky; M.C. Beveridge; J. Clay; C. Folk; J. Lubchenco; H. Mooney and M.

Troell. 2000. Effect of aquaculture on world fish supplies. Nature 405: 1017-1024.

Naylor, R.L., R.W. Hardy; D.P. Bureau; A. Chiu; M. Elliott; A.P. Farrell; I. Forster; D.M. Gatlin III; R.J. Goldburg; K. Hua and P.D. Nichols. 2009. Feeding aquaculture in an era of finite resources. Proceedings of the National Academy of Sciences of the United States of America 106: 15103–15110.

NRC (National Research Council). 1993. Nutrient requirements of fish. Committee on Animal Nutrition. Board on Agriculture. National Research Council. National Academy Press. Washington, DC, USA.

Peres, H. and A. Oliva-Teles. 2007. Effect of the dietary essential amino acid pattern on growth, feed utilization and nitrogen metabolism of European sea bass (*Dicentrarchus labrax*). Aquaculture 267: 119–128.

Rodriguez-Serna M., M.A. Olvera-Novoa and C. Carmona-Osalde. 1996. Nutritional value of animal by-product meal in practical diets for Nile tilapia *Oreochromis niloticus* (L.) fry. Aquaculture Research 27: 67–73.

Santiago, C.B. and R.T. Lovell. 1988. Amino acid requirements for growth of Nile tilapia. The Journal of Nutrition 188: 1540–1546.

Tacon, A.G.J. and I.P. Forster. 2000. Global trends and challenges to aquaculture and aquafeed development in the new millennium. International Aquafeed–Directory and Buyers Guide 2001, pp. 4-25, Turret RAI, Uxbridge, Middlesex, UK.

USDEC 2004. Products definition, composition, functions. Reference Manual for U.S. Whey and Lactose Products, pp 27–40.

Yang, Y., S. Xie; Y. Cui; X. Zhu; W. Lei and Y. Yang. 2006. Partial and total replacement of fishmeal with poultry by-product meal in diets for gibel carp, *Carassius auratus gibelio* Bloch. Aquaculture Research 37: 40–48.

الاحلال الجزئى و الكلى لمسحوق مخلفات صناعة الجبن محل مسحوق السمك فى علائق أسماك البلطى النيلى

محسن عبد التواب[1] و فايزة السيد عباس[2] و مدحت السعيد عبد الفتاح سيدين[3]

١: قسم بحوث بيئة و بيولوجى الأسماك و ٢: قسم بحوث إنتاج الأسماك ونظم الإستزراع السمكى و ٣: قسم بحوث تغذية الأسماك- المعمل المركزي لبحوث الثروة السمكية-العباسة – أبو حماد – شرقية.

الملخص العربى

استهدفت هذه التجربة دراسة تغذية أصبعيات البلطى النيلى (3.5 جم) بعلائق متساوية فيما بينها فى نسب البروتين (٣٠.٤%) والدهون (٧.٤ %) ولكنها تختلف فى نسب إحلال مسحوق مخلفات مصانع انتاج الجبن محل مسحوق الأسماك حيث كانت نسب الإحلال هى صفر ، ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% على أساس وحدة البروتين. كانت كثافة الاسماك ٢٠ سمكة لكل حوض زجاجى به ١٠٠ لتر مياه حيث مثل كل معاملة ثلاث احواض زجاجية و تغذت الاسماك على أحد العلائق لحد الشبع مرتين يوميا ، ٦ ايام اسبوعيا لمده ١٢ اسبوع . أظهرت النتائج أن استخدام مسحوق مخلفات مصانع انتاج الجبن وإحلالها محل مسحوق الأسماك بنسبة ٧٥% لم يؤثر معنويا على أداء النمو لأصبعيات البلطى النيلى وكفاءة تحويل الغذاء وكفاءة الاستفادة من البروتين وذلك بالمقارنة بالأسماك التى تناولت العليقة الضابطة والخالية من مسحوق مخلفات مصانع انتاج الجبن . كانت نسبة اعاشة الأسماك فى نهاية التجربة عالية ومتماثلة إحصائيا فى المعاملات المختلفة . لم يظهر التحليل الكيماوى لجسم الأسماك أى فروق معنوية فى نسبة الرطوبة والبروتين الخام والدهن الكلى والرماد فى معاملات الاحلال المختلفة . أظهر التحليل الاقتصادى زيادة نسبة الربحية مع زيادة نسبة احلال مخلفات مصانع انتاج الجبن محل مسحوق السمك . نستنتج من هذه الدراسة أنة يمكن استخدام مسحوق مخلفات مصانع انتاج الجبن كمادة علف رخيصة الثمن و احلالها محل مسحوق الأسماك المستوردة والمرتفع الثمن دون التأثير على إنتاج أسماك البلطى النيلى .