African Journal of Biotechnology Vol. 8 (13), pp. 3092-3096, 6 July, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315

Full Length Research Paper

Growth performance and feed utilization of *Tilapia zillii* (Gervais, 1848) fed partial or total replacement of fish meal with poultry by-product meal

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Accepted 22 May, 2009

The aim of this study was to investigate the growth performance, feed utilization and body composition of *Tilapia zillii* fed diets where poultry by-product meal replaced fish meal protein at 0, 50 and 100% levels in high energy diets. This is the first research study conducted to evaluate poultry by-product as an alternative feed source for *T. zillii.* Experimental diets were prepared isonitrogenously and isocalorically (55% CP; 20.5 kJ GE g^{-1}). Ninety fish (mean weight 2.45 ± 0.04 g) were cultured in glass aquariums containing brackish water (25°C average temperature and 11‰ salinity) for a period of 45 days. At the end of the trial, relative growth rate, specific growth ratio and daily dry protein intake in fish fed diet 1 (control) and 2 (50% poultry by-product meal inclusion) were similar and appeared significantly ($p < 0.05$) better than the fish fed diet 3 (100% poultry by-product meal inclusion). Feed conversion ratio was significant different among diet 2 and diet 3 ($p < 0.05$). No differences were found among diets, in terms of fish whole body proximate composition. The results of this study show that *T. zilli* can be cultured in brackish water with feeding a diet containing 50% poultry by-product meal without any adverse effect on growth performance of fish.

Key words: *Tilapia zillii*, poultry by-product meal, growth performance, feed utilization, body composition.

INTRODUCTION

Tilapias are the second most popular cultured fishes in the world after the carps. The major producing countries are China, Egypt, Indonesia, Philippines and Thailand. The overall aquaculture production of tilapia was reported to be 2.5 Mmt with an increase of 11.3% year in 2007. It is presently valued at US $ 3.3 billion annually (FAO, 2009).

Fish meal has been an important source of protein in fish diets because of its high protein quality and palatability. However, fish meal is very expensive and can substantially increase feed costs. Since fish meal is used as the main protein source in aqua-feeds, recent researches have been concentrated on the partial or total replacement of fish meal with less expensive and locally available protein sources for tilapia (Shiau, 2002). Total or partial replacement of fish meal with less expensive animal protein, such as poultry by-product meal (PBM) may help to reduce feed costs, although these sources may be lower in digestibility, palatability and essential amino acids (Barlow, 1997; Hertrampf and Piedad-Pascual, 2000; Emre et al., 2003; Hu et al., 2008).

The terrestrial animal by-products such as poultry by-product meal and meat and bone meal have high protein contents and appropriate essential amino acid (EAA) profiles (Tacon, 1993). Several studies have been carried out to investigate the effects of total or partial substitution PBM with fish meal in tilapia (Sadiku and Jauncey, 1995; El-Sayed, 1998), common carp (Steffens, 1988), mirror carp (Emre et al., 2003), African catfish (Abdel-Warith et al., 2001; Goda et al., 2007), gibel carp (Yang et al., 2006; Hu et al., 2008). An efficient utilization of meat and bone meal and poultry by-product meal as single protein

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Table 1. Formulation and proximate composition of the experimental diets.

Ingredients	Diet 1	Diet 2	Diet 3
Fish meal[1]	773	380	0
Poultry by-product meal[2]	0	432	850
Fish oil	79	40	2
Corn starch	90	90	90
Vit.Min premix	35	35	35
Attractant	3	3	3
Binder	20	20	20
Proximate composition g/kg dry basis)			
Moisture	80	71	101
Crude lipid	122	121	121
Crude ash	928	102	111
Crude protein	552	548	544
Nitrogen-free extracts[3]	153	158	123
Gross energy (kJ/g diet)[2]	20.5	20.5	19.8

[1] Proximate analysis (%) moisture 8.0; protein 71.4; lipid 5.5; ash 12.0
[2] Proximate analysis (%) moisture 5.0; protein 64.0; lipid 14.0; ash 13.0
[3]Calculated by difference
[4]Calculated using gross caloric values of 23.63, 39.52 and 17.15 kJ/g for protein, fat and carbohydrate, respectively (Brett, 1977).

source has been reported in red tilapia and Nile tilapia, respectively (El-Sayed, 1998; Mansour, 1998). Abdel-Tawwab (2008) reported that could be used moderate levels of Azolla meal as protein sources in *Tilapia zillii* diets. In other study demonstrated that PBM as FM alternatives has a high potential as feedstuffs replacing FM (Soltan, 2009).

The objective of this research was to determine the effect of partial or total replacement of fish meal with poultry by-product meal in high energy diets on growth performance, nutrient utilization and body composition in tilapia, *T. zillii* cultured in brackish water.

MATERIALS AND METHODS

Diets

Three practical diets were formulated using commercially available ingredients and produced at the central fisheries research institute (CFRI) in Trabzon, Turkey. The diets were isonitrogenous and isocaloric on a crude protein (55%) and gross energy (20.5 kJg^{-1} diet) basis. White fishmeal (high quality whiting meal, 71% crude protein) was the sole protein source in the control diet.

The test diets were formulated by substituting poultry by-product meal for the white fishmeal at levels of 0, 50 and 100%. The protein, lipid, ash and moisture contents of the diets were determined by methods of AOAC (1990) and given in Table 1. The dry ingredients and oil were mixed in a food mixer for 15 min. Tap water was then blended into the mixture to attain a consistency appropriate for passing the mixture through a meat grinder. After pelleting, the diets were dried to a moisture content of 8 - 10% and cool-stored until use.

Experimental fish and rearing conditions

T. zilli were collected in breeding populations in the Köyceğiz lake, using a small hand net. The Lake is an alluvium lagoon lake, located in the southern part of the Aegean sea region in the border of the province of Muğla (36° 49' 28" N and 28° 38' 00" E). Fish were transported with plastic jar to the foundation of the fishing cooperation Dalyan (DALKO), Muğla, Turkey. The study was carried out at the research unit of DALKO.

Captured fish were transferred to 100 l acclimatization aquarium conditions for 1 month prior to starting the experiment. During the acclimatization period fish were fed a commercial feed. Experimental fish were sorted by total length and bio-mass (mean weight ± S.E.).

Experimental design and protocol

Three groups of fish (3 replicates for each diet and a total of 90 fish) each comprising 10 fish with mean initial weights of 2.47 ± 0.02 g (Diet 1), 2.43 ± 0.11 g (Diet 2), 2.41 ± 0.02 g (Diet 3) were placed in a total of 9 glass aquariums of 50-l (60 × 35 × 30 cm). Each aquarium contained a filter and aeration (aerated by air stones coupled to a low-pressure blower). Fish were hand fed 3 times a day to satiation at 08:30, 12:30 and 16:30 and the quantity of feed was recorded throughout the experimental period of 45 days. Feeding was monitored carefully to ensure even distribution to all experimental fish in the aquarium. In addition, the aquaria were siphoned daily to remove feces materials and new water was added. All groups were exposed to a natural photoperiod (13 L / 11 D). Water temperature ranged from 23.0°C to 28.0°C (average 25.1 ± 2.2°C). The anaesthetized fish were individually weighed at the beginning and the end of the experiment and every 15 days. Parameters relevant to growth, feed conversion rate and feed consumption were calculated.

Before starting the experiment, 15 fish from the initial batch were sacrificed by lowering the body temperature in a freezer, stored in polyethylene bags and frozen (-20°C) for subsequent analysis of body composition. At the end of the feeding trial, 3 fish from each tank (9 fish per treatment) were randomly sampled, sacrificed and stored for analysis in the above manner. Prior to analyses, samples were prepared by homogenizing the whole fish body in a blender. All analyses were performed in triplicate.

Data analysis

Results were presented as means and standard deviation of means (± SD). The statistical significance of differences between measured parameters was computed using analysis of variance (ANOVA, MINITAB 13 for Windows). One way ANOVA was used for determining significance at a $p < 0.05$ level.

RESULTS

All the test diets were well accepted by the experimental fish. The growth response and performance data of *T. zillii* fed high energy diets containing partial or total replacement of fish meal with poultry by-product meal are presented in Table 2. All groups increased weight steadily following exposure to their respective treatments. Significantly higher mean weights were attained in fish fed Diet 2 and secondly Diet 1 in comparison to Diet 3 (p <

Table 2. Growth performance and feed utilization of *Tilapia zillii* fed experimental diets.

	Initial BW (g/fish)	Final BW (g/fish)	Relative growth rate (%)[1]	Specific growth rate (%/day)[2]	FCR[3]	PER[4]
Diet 1	2.48 ± 0.03	7.55 ± 0.92[b]	204.58 ± 34.13[b]	2.64 ± 0.27[b]	3.15 ± 0.71[ab]	0.65 ± 0.13[a]
Diet 2	2.47 ± 0.07	8.66 ± 0.68[b]	245.36 ± 22.74[b]	2.98 ± 0.17[b]	2.76 ± 0.74[b]	0.74 ± 0.19[a]
Diet 3	2.41 ± 0.02	5.87 ± 0.07[a]	143.05 ± 21.14[a]	2.12 ± 0.01[a]	4.92 ± 0.69[a]	0.41 ± 0.05[a]

Values are means ± S.D. Values with the same superscript letter in the same column are not significantly different ($p < 0.05$).
[1] Expressed as 100 × (final BW - initial BW) / initial BW
[2] Expressed as 100 × (ln final BW - ln initial BW) / days
[3] Feed conversion rate= 100 × (final BW - initial BW) / dry feed intake.
[4] Protein efficiency ratio (%) = (final BW - initial BW) / protein intake.

Table 3. Inital and final proximate composition of *T. zillii* (% wet basis) (means ± sd).

Parameter	Treatment			
	Initial	Diet 1	Diet 2	Diet 3
Moisture	79.91 ± 0.12	77.31 ± 0.37[a]	77.29 ± 0.18[a]	77.28 ± 0.19[a]
Crude protein	16.57 ± 0.09	17.94 ± 0.45[a]	18.30 ± 0.45[a]	18.49 ± 0.45[a]
Crude lipid	2.05 ± 0.70	1.63 ± 0.45[a]	1.63 ± 0.45[a]	1.69 ± 0.45[a]
Ash	1.07 ± 0.01	1.19 ± 0.02[a]	1.19 ± 0.02[a]	1.17 ± 0.01[a]

Values not sharing the same superscript letters within the same row are significantly different ($p < 0.05$).

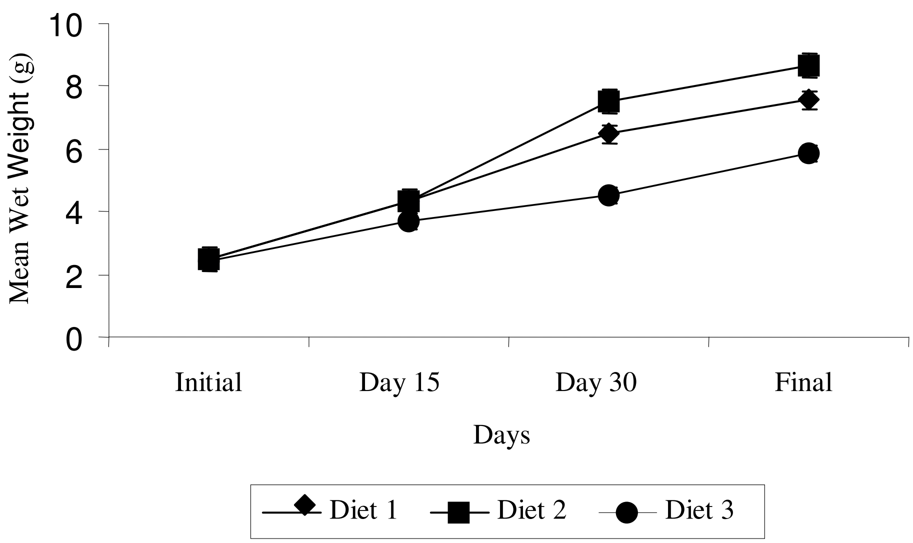

Figure 1. Mean wet weight of *T. zillii* during the course of the experiment.

0.05) (Figure 1). The performance of *T. zillii* differed from significantly ($p < 0.05$) in terms of final weight, relative growth rate (RGR %) and specific growth rate (SGR).

Feed performance of *T. zillii* fed the experimental diets are presented in Table 2. Feed conversion ratios (FCR) were estimated based on the food consumption per treatment throughout the whole research. Feed efficiency, protein efficiency ratio and daily dry energy intake were higher in the Diet 2 treatment compared to the Diet 1 and Diet 3 ($p < 0.05$).

Proximate composition of *T. zillii* fed the experimental diets is presented in Table 3. Body moisture, crude protein, crude lipid and crude ash did not differ among treatments ($p > 0.05$).

DISCUSSION

Although this research is one of the numerous studies over poultry by-product in aquaculture, it is the first study performed over *T. zillii* fish. In experiments where fishmeal is replaced by the other plant or animal protein sources, the amino acid balance of the diet is an important issue that influences growth performance of the fish. In the present study, the results show that growth performance and feed utilization of *T. zillii* were significantly affected by the experimental diets containing poultry by-product meal. Results of the present research suggest that poultry by-product meal is a suitable replacement for fish meal in well-balanced practical diets formulated for *T. zillii*. Nile tilapia efficiently utilized meat bone meal and poultry by-product meal as single dietary protein sources while blood meal produced significantly lowered growth rates and feed efficiency (El-Sayed, 1998). Significant differences were found in final mean wet weight, RGR and SGR between Diet 3 and the others. The RGR and SGR values were significantly lowered by the diet of 100% (Diet 3) poultry by-product meal compared to the Diet 1 (0%) and Diet 2 (50%). The lower RGR observed in fish fed Diet 3 may be due to increased energy spending on protein catabolism and increased production of ammonia. This finding is similar to those of Dabrowski (1977) on grass carp, Jauncey (1982) on tilapia, Emre et al. (2003) on mirror carp and Hu et al. (2008) gibel carp. FCR was significantly improved by the diets and the best FCR value was obtained from the Diet 2. Kamal and Mair (2005) reported FCR values of *Orechromis niloticus*, *Orechromis mossambicus* and their hybrids as 0.78 - 1.04 and 0.80 - 1.04 at 7.5 and 15‰ salinity, respectively. In another study on the evaluation of semipurified test diets for *T. zillii* fingerlings, FCR values were reported between 1.40 and 1.98 (El-Sayed, 1989). These findings are lower than the FCR values recorded in the present study. Abdel-Tawwab (2008) found poor FCR values in the diet 3, 4 and 5 are 5.23, 6.16 and 7.14, respectively, compare to our study diet 2. However, our FCR values (between 2.76 and 4.92 at 10 - 12.8% salinity) are in agreement with those of Winfree and Stickney (1981) who reported FCRs between 1.38 and 4.22 in *Tilapia aurea*. A similar trend was observed in diet 4 of Nile tilapia (Soltan, 2009) and catfish (Abdel-Warith et al., 2001; Goda et al., 2007). The variations of FCRs among different studies might be explained by the different experimental conditions (feed formulation and diet content, stocking density, age and sex of fish) applied (Jauncey, 1982).

The SGRs recorded for the experimental treatments in the present study are higher than those reported by El-Sayed (1989) (0.54 - 0.87% day^{-1}), Emre et al. (2003) (1.19 - 1.89% day^{-1}), Ridha (2006) (0.83 - 1.18% day^{-1}) and Abdel-Tawwab (2008) (0.10 - 0.82% day^{-1}), but comparable with those reported by Ogunji and Wirth (2001) (1.11 - 3.46% day^{-1}) and Abdel-Warith et al. (2001) (2.83 - 3.68% day^{-1}). It is reported that the growth rate may remain constant or show a decrease as the protein requirement of fish is exceeded, because dietary protein in the diet is used to metabolize the excess amino acids absorbed (Jauncey, 1982; Alvarez-González et al., 2001).

The poorer growth rate and FCR of fish fed 100% replacement diets could be explained with processing methods of PBM, quality of the ingredients, poor digestibility, the rearing conditions, palatability or a combination of all those cases. PBM contain different ratios of meat, bone, blood and due it may have different compositions and digestibility (Nengas et al., 1999; Webster et al., 2000). There were no significant differences in body crude protein, crude lipid and ash values between treatments (Table 3) ($p > 0.05$).

In conclusion, our research suggest that PBM is a suitable replacement for fish meal protein in *T. zillii* diets and that about 50% PBM inclusion did not show any negative effect on fish performance cultured in brackish water con-ditions. Surely, the profitability of substituting fish meal with PBM may vary depending on local availability and cost of the ingredient. However, lowering the feed costs to a certain degree may affect the aquaculture industry for good, and so benefit the world's marine resources by using less fish meal in aquaculture industry.

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