

Original Article

Growth Performance and Feed Utilization of Hybrid Red Tilapia, *Oreochromis niloticus* (Linnaeus) X *Oreochromis mosambicus* (Peters) Fed Different Dietary Protein and Energy Levels under Rearing in Seawater Conditions

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Abstract

A 3 X 2 factorial design of three dietary protein levels (25, 30 and 35%) and two levels of energy (18 and 20 MJ/kg) in three replications was conducted to investigate the proper dietary protein and energy levels for the growth of hybrid red tilapia, *Oreochromis niloticus* X *Oreochromis mosambicus*. Eighteen net cages (100 X 40 X 100 cm, L X W X H) were stocked with 10 fry of fish weighing 0.4 g/fish and fed to 16-weeks. No significant differences ($P>0.05$) in final body weight, gain and specific growth rate were observed among fish fed diet containing different energy levels. However, at the dietary protein level of 25 and 30%, growth performance parameters were improved as dietary energy level increased from 18 to 20 MJ/kg. The improvement of growth, feed conversion, nutrient efficiency utilization were achieved with the diet containing 30% protein and 20 MJ/kg diet corresponding to P/E ratio of 15 g/kJ. Moisture and lipid contents were affected by dietary protein levels not by energy levels. Fish protein content tended to increase as protein level increased in the tested diets.

Key words: *red tilapia, seawater, protein, energy, protein sparing effect*

Received: 2 May 2014

Accepted: 9 July 2014

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Introduction

Tilapia culture is one of the fastest growth farming activities with an average annual growth rate of 13.4% during 19760-2002 (El-Sayed et al., 2005). Tilapias are widely cultured in about 100 countries in tropical and subtropical regions. The world production of farmed tilapia representing about 6% of total farmed finfish (FAO, 2004). Recently interest has been shown by commercial aquaculture sector to expand tilapia culture in sea and brackish water in Egypt (El-Sayed et al., 2003) and in Southeast Asia as well as South America (Green, 1997). The major reason for this need is that there are a large number of shrimp ponds available, resulting from either failure in shrimp farming or desires to diversify shrimp culture. Tilapias appear to be the most appropriate choice for such a culture system because their efficient to grow and feed efficiency. This interest in seas and brackish water culture is particularly strong in Thailand and Vietnam where shrimp culture is now commonly reduced to one crop per year, leaving the ponds empty for half a year (Yi et al., 2002). Tilapia culture is also attractive to shrimp farmers as a by-product to utilize abundant phytoplankton in either shrimp ponds or their effluents. Red tilapia has been becoming more and more popular in many parts of the world, and there is a great potential to culture this species in brackish water and seawater ponds (Yi et al., 2002). At the same time results of tilapia-shrimp polyculture systems either in separated tanks or in cages of hapa net in the same culture pond (Bolivar et al., 2003) encouraged us to study the possibility of red tilapia as a marine culture species. Red tilapias were successfully rearing in intensive enclosed shrimp raceways, the reached to the marketable size producing 8-

25 kg/m³ productivity under Egyptian conditions (Uupublished data). For the maximization of optimum growth rate and productivity of red tilapia, it is necessary to determine the protein and energy requirements of this fish under mariculture conditions. Since the protein content in finfish diets usually constitutes the largest single cost factor in feeds. The protein requirement of fish varies with fish species, fish size, dietary non-protein energy level and environmental conditions (NRC, 1993). Increasing protein level in diets can lead to improved fish productions (Lee and Kim, 2001). However, excessive dietary protein level is not economical for fish culture because it is responsible for a large part of the feed cost. Dietary protein and energy levels are known to influence the growth and boy composition of fish (Lovell, 1989). Insufficient energy in diets causes protein waste due to the increase of dietary protein proportion used for energy and produced ammonia can reduce the water quality. On the contrary, body lipid deposition and growth reduction were found because of a lack of necessary nutrient for growth (Daniels and Robinson, 1988). Therefore, it is important to improve the dietary protein utilization for body protein synthesis rather than for energy purposes. In addition, the optimization of the ratio to play an important role in protein and energy utilization for fish (Kaushik, 1994). Many authors have studied protein and energy requirements for tilapia species that reared in freshwater and brackish water, but they are scarce for red tilapia reared in seawater. Therefore, the current study was conducted to evaluate the effect of dietary protein at two energy (lipid) levels on the growth, feed and nutrient utilization and body composition of red tilapia reared in seawater.

Materials and Methods

Experimental system

The present work was performed at the Mariculture Research Center, Faculty of Environmental Agriculture Sciences,

Suez Canal University. El-Arish, North-Sinai, Egypt Experimental fish were obtained from Marine Hatchery k-21, Alexandria, Egypt. Fish were transported in polyethylene bags field with 3:1 oxygen:

seawater, respectively. At arrival fish were released in rectangular fiberglass tank filled with seawater. Fish were quarantined for one week in the rearing tank, and then sorted by weight removing all large and small individuals. The feeding trial was carried out in eighteen net cages (100 X 40 X 100 cm; L X W X H) placed in two large fiberglass tanks using three replicate cages per treatment. Ten fry fish (average weight 0.4 g/fish) were randomly stocked into each experimental cage. During the first three days of the experiment, dead fish were replaced with individuals of the same size. Approximately 35% of the water was exchanged daily and aeration was provided using submerged air diffusers and a reciprocating air blower. Salinity, temperature, pH, dissolved oxygen and photoperiod were measured daily and remained at approximately 35 ppt, 28 °C, 8.6, 7 ppm and 12:12 L.D., respectively.

Diet preparation and feeding

Experimental diets were prepared on site using locally available ingredients (Table 1). Ingredients were thoroughly mixed, then boiling water added to the mixture. The mash was palletized using a meat mincer with a 1.5-mm die. Pellets were dried at 40 °C in an oven and stored at -20 °C. A 3 X 2 factorial design using three replicates per treatment combination of dietary protein and energy levels was conducted to investigate the proper dietary protein and energy levels for the growth of hybrid red tilapia. *Oreochromis niloticus* X *Oreochromis mosambicus*. Six tested diets were formulated to contain three levels of protein (25, 30 and 35%) and two levels of energy (18 and 20 MJ/kg). Fishmeal was used, the primary protein source and dietary protein level increased in proportion to its percentage, oil mixture of sunflower and soybean (1:1 w/w) was added as 0 and 5% of diet at each protein level. Fishmeal was home made by collecting small fish and non-sealed fish named locally "Wazafa" from fish market to dry in oven at 60 C to dryness. Then dry fish were

grounded and sieved prior to keep at -20C until use, while the rest ingredients were obtained, from local markets. Ingredients and chemical compositions of the experimental diets are resented in table (1). Each diet was offered to three randomly chosen cages, six days a week for 112 days. Fish were fed 8, 6, 5, 3% of the body weight daily for 1-4, 5-6, 7-8 and 9-16 week, respectively. Daily ration was divided into three equal portions supplied at 0900, 1200 and 1500 hrs. Fish in each cage were weighed at two-week intervals and ration adjusted according to new fish weight.

Sample collection and analysis

Fish and feed samples were taken of the beginning of the experiment and stored at -2°C pending composition analysis. At the end of the experiment, all fish in each cage were killed pooled and stored -2°C for subsequent proximate analysis. Chemical analysis of feed and fish were performed according to methods described by AOAC (1993). Gross energy content of the experimental diets and fish samples were calculated by using factors of 23.4, 39.2 and 17.2 MJ/g for protein, lipid and carbohydrate, respectively (Cho et al., 1982). Specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), apparent protein utilization (APU), energy retention (ER), daily feed intake (DFI), daily energy intake (DEI), daily protein intake (DPI) were calculated as:

$$SGR = 100 \times (\ln FBW - \ln IBW) / t$$

Where FBW is final body weight (g), IBW is initial body weight (g) and t is fed days.

$$DFI = \text{dry matter intake} \times 100 / (\text{IBW} + \text{FBW} + \text{dead fish weight}) \times t / 2$$

$$DEI = \text{energy intake} \times 100 / (\text{IBW} + \text{FBW} + \text{dead fish weight}) \times t / 2$$

$$FCR = \text{weight of feed offered to fish (g)} / \text{weight gain of fish (g)}$$

$$PER = \{ \text{weight gain (g)} / \text{protein intake (g)} \} \times 100$$

$$APU = \{ \text{protein retained (g)} / \text{protein fed (g)} \} / 100$$

ER= $100\{\text{energy retained in fish (MJ)}/\text{energy offered to fish (MJ)}\}$

Statistical analysis

All data of the experiment were analyzed using the two-way analysis of variance,

fixed-effect model to determine significant differences among treatment means. All statistical analysis was performed according to Steel and Torri (1980) using the SAS software. Differences were subjected to Duncan's Multiple Range-Test.

Table 1. Ingredients and proximate analysis of the experimental diets

Item	Protein diets					
	25/18	25/20	30/18	30/20	35/18	35/20
Ingredients						
Fish meal ¹	50	50	150	150	200	200
Soybean meal	340	340	340	340	340	340
Yellow corn	50	50	50	50	50	50
Wheat milling by-product	480	390	340	290	290	260
Wheat bran	100	100	100	100	100	100
Sunflower oil	0	25	0	25	0	25
Soybean oil	0	25	0	25	0	25
Vitamins ²	10	10	10	10	10	10
Minerals ³	10	10	10	10	10	10
Chemical composition proximates (% on DM basis):						
Dry matter(%)	90	90.05	89.98	90.25	90.36	90.28
Crude protein	25.04	25.12	30.01	30.01	35.05	35.04
Crude lipid	6.19	15.58	6.18	15.16	6.17	15.15
Crude fiber	2.43	2.48	2.38	2.43	2.34	2.39
Ash	9.46	8.97	10.85	10.37	12.25	11.77
Carbohydrate	56.88	47.85	50.58	42.03	44.19	35.64
Gross energy (MJ/kg ⁻¹)	18	20	18	20	18	20
PE ration(gkJ ⁻¹)_	13.86	12.42	16.54	14.86	19.24	17.29

1) Fishmeal-homemade contained 58.59 and 14.84% crude protein and lipid, respectively.

2) Vitamin mixture (g/100 g) was 960000 IU, 160000 IU, 0.8g, 80mg, 0.32g, 0.12 g, 0.8 g, 0.8mg 1.6g, 80mg, 4mg, 40g. of vitamin A, D3, E, K, B1, B2, B6, Pantothenic acid, B12, Nilacin, Folic acid Biotin, Choline chloride, respectively.

3) Mineral mixture (g/100 g) was 12.75, 72.85,

Results

Growth performance

The survival rate recorded during the experimental period was 100% Fish fed 30% protein exhibited higher body weight, gain and SGR than other tested levels. However, increase protein percentage to 35% resulted in a decrease of growth and performance (Table 2). The lowest growth rate was found with diets containing 2% protein. Concerning to the effect of dietary energy level on growth performance of red tilapia reared

in seawater shows no significantly differences ($P>0.05$) among fish fed diet containing 18 and 20 MJ/kg diet (Table 2). However, at the dietary protein level of 25-30%, growth performance parameters were improved as dietary energy level increased from 18 to 20 MJ/kg but at the protein level Table growth, feed and nutrient efficiencies utilization of red tilapia fed different protein and energy levels under seawater conditions.

Table 2. Growth rate, survival, feed intake, feed conversion ratio and protein efficiency ratio of red tilapia fed different protein and energy levels reared under seawater conditions.

Diets	Weight gain g/fish	SGR %/day	Survival %	TFI	FCR	PER
25/18	39.20	4.11	100	80.48	1.85	2.16
25/20	43.50	4.18	100	73.63	1.55	2.59
30/18	44.50	4.21	100	95.84	1.74	1.91
30/20	49.40	4.31	100	88.34	1.62	2.06
35/18	45.65	4.24	100	82.00	1.63	1.76
35/20	44.25	4.21	100	81.94	1.67	1.73
Analysis of variance, P>F						
Protein	0.184	0.16		0.06	0.14	0.001
Energy	0.32	0.34		0.26	0.21	0.11
Interaction	-	-		-	-	0.15
PSE	1.54	0.03		2.76	0.03	0.04

* Values in the same column not sharing superscripts are significantly different (P<0.05)

Table 3. Body composition, protein productive value and energy retention of red tilapia fed different protein and energy levels under seawater conditions.

Diets	Moisture%	Protein	Lipid	Ash	APU%	ER%
Initial fish	71.89	17.18	6.52	4.40	-	-
25/18	75.1	13.73	4.67	6.41	30.9	12.31
25/20	74.6	14.26	5.04	6.11	36.8	13.23
30/18	74.5	14.91	5.1	5.49	28.5	13.00
30/20	73.4	15.87	5.6	5.11	32.7	12.63
35/18	73	16.45	6.08	4.5	28.9	13.93
35/20	72.7	16.86	6.39	4.06	29.2	12.33
Analysis of variance, P>F						
Protein	0.04	0.02	0.03	0.008	0.04	0.18
Energy	-	-	0.19	-	0.18	-
Introduction	0.33	0.17	-	0.25	-	-
PSE	0.27	0.2	0.12	0.11	0.70	0.32

*Values in a column not having a common superscript are significantly different

** Pooled standard error.

Of 35%, the differences of weight gain and SGR were not significant (P>0.05). The greatest final body weight and growth rate was achieved with the diet containing 30% protein and 18 MJ/kg diet corresponding to diet contained P/E ratio of 15 kJ/g protein.

Feed utilization efficiency

Feed intake were affected by dietary protein level and tended to increases with increasing dietary protein until level of 30% (Table). Daily feed

intake decreased with increasing dietary energy and protein levels. Feed gain ration was insignificantly (P>0.05) among all treatments. Protein efficiency ratio was significantly by dietary protein (P<0.002) and energy (P<0.04) levels. Both of APU and PER had a negative relationship dietary protein level (Table 3). Energy retention was not affected by dietary protein and energy levels (P>0/05).

Body composition

Moisture, lipid, protein and energy were affected by dietary protein level but not affected by energy level (table 4). The body moisture, lipid and energy contents tended to increase with increasing protein level from 25 to 35%. Ash content of fish tended to increase significantly ($P < 0.02$) with increasing protein ($P < 0.0001$) and energy ($P < 0.002$) dietary levels.

Discussion

Tilapia hybrids that have descended from an *O. mosambicus* parent are believed to be highly tolerant to saline waters (Romana-Eguia and Eguis, 1999). Red tilapia were reared in seawater in seawater without adverse effect in survival, growth and feed utilization in the present study. Growth rates of red tilapia fed the diets containing 18 MJ/kg diet increased with increasing dietary protein level, while this value in fish fed the diets containing 20 MJ/kg diet increased with increasing dietary protein up to 30% and then decreased at 35% protein. The different growth response to protein and energy levels in fish diets is probably due to dietary non-protein energy level (De Silva et al., 1991; Company et al. 1999. McGoogan and Gatilin 1999; Kim and Lee 2005). This indicates that 30% protein with 20 MJ/kg diet has excess energy for red tilapia cultured in seawater. Excessive dietary energy can lead to reduced growth of fish. Due to lacking of necessary nutrients for growth, resulting also from reduction in feed intake by fish (Daniels and Rebinson, 1986). Higher growth performance of red tilapia within dietary protein level of 30% and 20 MJ/kg diet could be explained as this diet provided more energy for metabolization of protein to muscle tissue. On the other hand, fish received a lower energy level (18 MJ/kg) could be utilizing part of dietary protein as energy source. The protein sparing effect, evident when

energy is added to the diet and observed in tilapia species (Shiau and Hang 1989; 1990; De Silva et al., 1991; Shiau and Peng, 1993) and in many fish species (hutchins et al., 1998; Shalaby et al., 2001; Meyer and Fracalossi 2004; Kim and Lee, 2005), was also clearly expressed by red tilapia reared in sea water. Growth of fish fed diet of 25:20 was similar to those fed the 30:18 and 35:20 diets. These findings suggest that red tilapia is capable of efficiently utilizing dietary carbohydrates because this was the main non-protein energy source in the tested diets. According to McGoogan and Gatlin (2000), lipids are the main non-protein energy source utilized by fish. However, it is known that omnivorous species such as Nile tilapia, *O. niloticus* (Ali and Al-Asgah, 2001); Indian carp, *Labeo rohita* (Jajri, 1995); rabbitfish, *Siganus rivulatus* (Shalaby et al., 2001) are able to utilize efficiently carbohydrate as an energy source. Thus, it is important to provide an adequate level and ratio of dietary protein and non-protein energy in order to reduce catabolism of protein for energy. Protein to energy ratio affected on body weight and FCR. The present study indicated that 15 MK/g was the optimum ratio which achieves the best FCR and growth rate. These results are in agreement of Ross (1982) for Mosambique tilapia and Siddiqui et al. (1998) for Nile tilapia. Feed conversion was improved as increasing of dietary energy levels, however, the differences in FCR among dietary protein were not significant ($P > 0.05$). Daily feed intake in this study decreased with increasing dietary energy and protein levels agreeing with other species of fish (Kim and Lee, 2005), however, daily energy intake showed no relationship with both tested dietary factors. In contrast, total feed intake increased as dietary protein levels increased and not affected by energy levels due to an increase in dietary protein concentration. These

results are in agreement with those obtained by Watanabe et al., (2001); Marino et al., (2002), Lee et al., (2002); Meyer and Fracalossi (2004) and Kim and Lee (2005). However, the best way to express feed intake seems to be not in absolute values, such as total feed intake (TF), but in relation to body weight (DFI) because diets which exhibited the highest growth over time, result in higher TFI, but not necessary for DFI (Kin and Lee 2005). The present data suggest that increasing feed intake could be a compensatory way to obtain nutrients in case of fish diets are not adequate (Meyer and Fracalossi (2004). In studies deal with different dietary protein levels, diets which exhibited a higher weight gain and growth usually exhibited at the same time a higher feed conversion efficiency (lower values), as was observed by Shiau and Hung (1980, 1990); Clark et al. (1990); Twibell and Brown (1998). This response was observed for red tilapia reared in seawater, probably because fish weight gain is directly associated to the dietary protein content and also because protein is the preferential energy source in fish metabolic routes. Protein utilization parameters (PER and APU%) decreased with increasing dietary protein level (Jauncey 1982; Siddiqui et al., 1988). The present work confirmed the above finding. However, PER and APU elevated with increasing dietary energy content and they tended to decrease with high energy diets at all protein levels. These results showed protein sparing effect of lipid for red tilapia reared in seawater. At protein levels of 25 and 30%, increasing dietary energy level from 18 to 20 MJ/kg diet improved growth rate, feed intake, protein intake and PER. These results are in partial accordance with those reported with tilapia freshwater species by Shiau and

Huang (1989, 1990); De Silva et al. (1991); Shiau and Peng, (1993) and Wafa (2002).

Moisture and lipid contents were affected by dietary protein levels not by energy levels. Fish protein content tended to increase as protein level increase in the tested diets in the present study. In contrast, body fat decreased as dietary protein level increased showing agreement with findings of Shiau and Huang (1989; 1990); De Silva et al., (1991) and Shiau and Peng. (1993) and Wafa (2002) for Nile tilapia. Body protein go adversely fat content of fish fed graded levels of protein (Al-Hafeda 1999; Siddiqui et al., 1988; Kin et al. 2001; Ng. Soon and Hashim 2001; Meyer and Fracalossi, 2004). Buckley and Green (1979) reported that body lipid increased and moisture content decreased as dietary energy increased. Similar results were obtained by Shiau and Huang (1990) with Nile tilapia reared in seawater and by El-Dhhar and Lovell (1995), for tilapia Mozambique. Ash content of fish increased with increasing dietary levels of protein due to increase fish meal percentage in diets containing higher protein levels.

Conclusion

The results of this study indicate that the diet containing 30% protein and 18 MJ/kg diet energy levels is optimal for growth and effective protein utilization of red tilapia reared in seawater.

Acknowledgment

This study was financed by the Regional Council for Agricultural Research and Extension (RCARE). Ministry of Agriculture, Egypt. Special thanks to Dr. S.J. Kaushik, Fish Nutrition Laboratory, Unite Mixte INRA-IFREMER, France for reading and corrections the manuscript.

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Influence of dietary protein and energy levels on performance of red tilapia

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