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Growth and Survival Rates of Nile Tilapia *Oreochromis niloticus* L. Juveniles Reared in a Recirculating System Fed With Floating and Sinking Pellets

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Abstract

This study was conducted to compare the effects of feeding sinking and floating commercial pellets on the performance of Nile tilapia *Oreochromis. niloticus* L. (Egyptian Ismailia strain) juveniles reared in a recirculating system. Fifteen juveniles (mean weight 21.77 g) were stocked in each of the six (0.25 m^3) round tanks attached to a biofilter. Each of the commercially prepared floating (ARASCO, Saudi Arabia) and sinking (Provimi, Holland) pellets (2.0 mm in size) was tested in triplicates. The fish were fed three times daily at 5% body weight. The experiment lasted for 42 days.

The water quality parameter values obtained were far below toxic levels indicating that the recirculating system could be used to rear tilapia juveniles above the recommended maximum capacity of 4.8 kg. At the end of the experiment, juveniles fed the sinking pellets were significantly bigger (P<0.01), and had significantly higher daily gain and specific growth rate and better feed conversion ratio. Though the feed cost and the cost to produce a kilogram gain in weight for juveniles fed with floating pellets was lower than those fed with sinking pellets, it would take about 25 days longer to produce the same weight of juveniles fed with sinking pellets. No significant difference (P>0.05) was observed on the crude protein content of the carcass of the juveniles fed the two diets. However, the crude fat and ash contents of the carcass of juveniles fed with sinking pellets were significantly higher (P<0.05) than those fed with floating pellets. Biologically, the fish fed with sinking pellets performed better than those fed with floating pellets.

Introduction

The culture of tilapia has become a popular means of increasing the supply of fresh fish to cope with the increasing demand in the Arabian Gulf

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area. Although consumed mainly by Egyptians and Asians, it is slowly gaining acceptance among the locals. The popularity of tilapia as a culture species is due to its hardiness as well as the existence of the technology for its production. In fact large commercial scale tilapia farms are currently in operation in Saudi Arabia.

In Kuwait, tilapia production is done only in a small scale due to water limitation hence the recirculating system is recommended to efficiently utilize water. Since initially it was envisioned that tilapia would be produced only in seawater, the most abundant water resource in Kuwait, most of the studies done on grow-out rearing were conducted in seawater (Al-Ahmed et al. 1995; Cruz and Ridha 1991 1995; Cruz et al. 1990) and only spawning activities were conducted in brackishwater (2 to 4 ppt) and/or freshwater (Ridha and Cruz 1989, 1998; Ridha et al. 1998). However, with the idea of integrating tilapia production with agricultural crop production presently being implemented, production of tilapia in Kuwait farms is now done using entirely brackishwater (4 to 10 ppt). More than 50 agricultural farmers have now added tilapia as a cash crop to their farms. It is foreseen that more farmers will be encouraged to follow because of the subsidy that the government plans to provide to tilapia producers.

Presently, two commercial pelleted feeds for tilapia are available in the local market; one is floating and the other is sinking. In the absence of a scientific study to compare the two types of commercially produced pellets under the recirculating system, tilapia producers in the Arabian Gulf and in the surrounding areas do not know which one to use and tilapia producers are normally inclined to buy the cheaper feed available in the market. In the event that the cheaper feed could not produce the desired growth, it would not be profitable for tilapia producers to use that brand.

The aim therefore of this study is to compare the performance of Nile tilapia *O. niloticus* L. juveniles fed with commercially produced sinking and floating pellets under a recirculating system. Results should provide information that could assist tilapia producers in selecting the more efficient and cost effective type of feed for growing tilapia.

Materials and Methods

Nile tilapia *O. niloticus* juveniles of the Egyptian Ismailia strain with mean weight of 21.77 g were used in this study. Fifteen fish were stocked in each of the six (0.25 m^3) round fiberglass tanks and three tanks were randomly assigned to each pellet type. The tanks were attached to a biofilter. The total water volume of the recirculating system was 2.0 m^3: 1.2 m^3 for the fish tank, 0.6 m^3 for the biofilter tank and 0.2 m^3 for the pump tank. Extruded polypropylene with a surface area of 200 $m^2 \cdot m^3$ was used as biomedia. The water volume turnover time in the fish tanks was 1 h 40 min and the water residence time at the biofilter was 50 min. Solid particles were removed daily and 10 to 15% of the culture water was replaced daily with new water (1 to 3 ppt). All fish tanks were aerated with compressed air. The fish were acclimatized to this environment for 10 days before the experiment started.

Two pelleted tilapia feeds (2.0 mm) of different types are currently available in Kuwait market. One is floating (sold by ARASCO of Saudi Arabia) and the other is sinking (sold by Provimi of Holland). Each feed type was tested in triplicates. The feed composition as shown in the tag is presented in table 1. Retail costs per kilogram of the sinking and floating pellets are US$1.32 and 0.83, respectively. The fish were hand fed three times daily at 5% of body weight per day.

Chemical analysis on the feeds and fish (carcass) was performed using AOAC (1985) methods. Five fish in each tank were taken at the start and at the end of the experiment for chemical analysis. The fish samples were homogenized in a blender and then freeze-dried at -30°C prior to storage.

Every week, all the fish were weighed after anesthetization with 2 ppm quinaldine. The weekly bulk weight in each tank was used to adjust the weekly ration of the fish. The specific growth rate (SGR) was calculated as: SGR = 100 (ln mean final weight) - (ln mean initial weight) ÷ culture days. Feed conversion ratio (FCR) was calculated as: FCR = total feed given ÷ total wet weight gain. The protein efficiency ratio (PER) was calculated as: PER = total wet weight gain ÷ total protein fed. Net protein retention (NPR) was calculated as: NPR = 100 x total gain in body protein ÷ total protein fed. Energy retention (ER) was calculated as: ER = 100 x gain in body energy ÷ total energy fed. Feed cost per kilogram gain was calculated as the cost of feed x FCR. Cost per kilogram gain was calculated as costs of feed, labor, electricity and miscellaneous items per kilogram gain.

Dissolved oxygen (DO) and water temperature were measured twice a week using an Orion DO meter Model A-20. Total ammonia (NH_3-N), unionized ammonia (NH_3^+), nitrites (NO_2-N), nitrates (NO_3-N) and pH were measured weekly using a Hach kit. The experiment lasted for 42 days. Data obtained on the mean daily growth rate, SGR, FCR, PER, NPR, ER and carcass composition were subjected to one-way analysis of variance (ANOVA). All statistical analyses were performed using the SPSSPC+ statistical software package (SPSS 1996).

Results

The chemical composition of the two commercial pellets is shown in table 1. The crude protein (CP) content of the sinking pellets produced by Provimi (42%) was higher than the floating pellets produced by ARASCO (32.8%). The crude fat and gross energy contents of the floating pellets (3.9% and 377.2 kcal·100 g feed, respectively) were higher than the sinking pellet (3.0% and 363.8 kcal·100 g feed, respectively). The calculated protein:energy ratio in sinking pellets (115.4 mg·kcal) was higher than in floating pellets (86.95 mg·kcal). Chemical analysis of the two types of pellets indicated that the crude protein contents were higher than the guaranteed analysis provided by the manufacturer while the crude fat content of the two diets were lower than those indicated on the tag.

The rearing temperature during the experiment ranged from 30.2 to 32.2°C. The average values of the water quality parameters were as follows: 0.82 $mg \cdot l^{-1}$ for total ammonia (NH_3-N), 0.02 $mg \cdot l^{-1}$ for unionized ammonia (NH_3^+), 1.05 $mg \cdot l^{-1}$ for ammonium (NH_4), 0.05 mg l^{-1} for nitrite (NO_2-N), 14.0 $mg \cdot l^{-1}$ for nitrate (NO_3-N), 7.2 for pH, 6.9 $mg \cdot l^{-1}$ for dissolved oxygen (DO), and 2 ppt for salinity.

Table 2 shows the carcass composition and energy content of the juveniles fed with the two pellets. The crude fat and ash contents of the juveniles fed with sinking pellets (23.5% and 16.2%, respectively) were significantly higher ($P<0.05$) than those fed with floating pellets (18.8% and 11.7%, respectively). No other significant differences ($P>0.05$) were observed on

Table 1. Chemical composition and guaranteed analysis provided by feed manufacturer (A) and proximate chemical analyses (B) of sinking and floating pellets fed to *Oreochromis niloticus* juveniles.

Composition	Diets			
	Sinking		Floating	
	A	B	A	B
Crude Protein, %	39.0	42.0	32.0	32.8
Crude Fat (Ether Extract), %	9.0	3.0	6.0	3.9
Crude Fiber, %	3.3	-	3.0	-
Ash, %	9.0	10.4	-	8.94
Gross energy, kcal·100 g		363.8		377.2
Protein: energy ratio, mg·kcal*		115.4		86.9
Microingredients per kg:				
Vitamin A, I.U.	20,000		NI	
Vitamin D, I.U.	2,000		NI	
Vitamin E, mg	100		NI	
Vitamin C (Stable), mg	100		NI	
Copper, mg	5		NI	

NI = not indicated.
*Calculated: mg protein·kcal gross energy.

Table 2. Proximate composition and energy content of *Oreochromis niloticus* juveniles carcass fed with two commercial diets (data are means of three replicates).

Composition	At stocking	At harvest	
		Sinking	Floating
Moisture, %	73.3	71.1[a]	72.8[a]
Crude protein, %	48.2	50.2[a]	51.7[a]
Crude fat, %	20.9	23.5 [a]	18.8[b]
Ash, %	13.7	16.2[a]	11.7[b]
Gross energy, kcal·100 g	433.6	438.9[a]	429.2[a]

Means with different superscripts in a row are significantly different ($P<0.05$).
Crude protein, crude fat and ash contents are on dry matter basis.

the moisture, crude protein and gross energy contents between juveniles fed with sinking and floating pellets.

Results on the growth performance and nutrient utilization of Nile tilapia juveniles fed with sinking and floating pellets are presented in table 3. After 42 days of feeding, juveniles fed with sinking pellets were significantly ($P<0.01$) bigger (50.03 g·fish^{-1}) than those fed with floating pellets (39.25 g·fish^{-1}). The mean daily gain in weight, SGR and FCR (0.66 g·fish^{-1}, 1.91% and 2.03, respectively) of juveniles fed with sinking pellets were significantly higher ($P<0.01$) than those fed with floating pellets (0.43 g·fish^{-1}, 1.47% and 2.48, respectively). No significant differences ($P>0.05$) were observed on the PER (1.17 vs 1.23) between juveniles fed with sinking and floating pellets. The NPR in juveniles fed with floating pellets (68.73%) was significantly higher ($P<0.05$) than those fed with sinking pellets (60.90%). However, the ER in juveniles fed with sinking pellets (60.13%) was significantly higher ($P<0.05$) than those fed with floating pellets (45.41%). No mortality occurred in both groups. The cost of feed and the cost to produce a kilogram gain in weight were lower for juveniles fed with floating pellets at US $2.05 and $2.39, respectively compared to juveniles fed with sinking pellets at US $2.68 and $2.89, respectively.

Discussion

The ammonia and nitrite levels in this study remained within safe limits hence, no mortality was recorded and no sign of stress was observed.

Table 3. Growth rate, feed utilization efficiency, survival rate and cost of feed per kilogram gain of *Oreochromis niloticus* juveniles fed two commercial diets (data are means of three replicates).

Diets	Sinking	Floating
Mean initial weight, g·fish^{-1}	22.36	21.19
Mean final weight, g·fish^{-1}	50.03^{a}	39.25^{b}
Total biomass, g·tank^{-1}	750.45	588.70
Gain in weight, g·fish^{-1}	27.70^{a}	18.06^{b}
Daily gain in weight, g·fish^{-1}	0.66^{a}	0.43^{b}
Specific growth rate, % day^{-1}	1.91^{a}	1.47^{b}
Total weight gain, g	415.05	270.85
Total feed consumed, g	840.68	670.46
Feed conversion ratio	2.03^{a}	2.48^{b}
Total protein consumed, g	353.09	219.91
Protein efficiency ratio	1.17^{a}	1.23^{a}
Net Protein Retention, %	60.90^{a}	68.73^{b}
Energy Retention, %	60.13^{a}	45.41^{b}
Survival rate, %	100	100
Cost of feed·kg^{-1} gain, US $*	2.68	2.05
Cost kg^{-1} gain, US $*	2.89	2.39

Means with different superscript in a row are significantly different ($P<0.05$).
*1 US$ = 0.303 Kuwaiti Dinar.

Maximum values of 0.056 mg·l^{-1} for ammonia and 0.06 mg·l^{-1} for nitrite were far below the toxic levels. Hassan (1992) indicated safe levels of unionized ammonia at 1.05 mg·l^{-1} and 1.0 mg·l^{-1} for nitrite (Otte and Rosenthal 1979).

Sinking pellets promoted significantly higher growth rate, bigger fish and gave better SGR and FCR in Nile tilapia juveniles than those fed with floating pellets. The better performance of fish fed with sinking pellets may be attributed to the higher crude protein content (42.05%). Similar results were obtained by Gur (1997) who reported that the average daily gain and FCR at a crude protein level of 40% was significantly higher and better than at 30%. He concluded that the crude protein levels for optimum growth and FCR were from 40 to 45% for Nile tilapia with initial mean weight of 13 g.

The high energy and low protein energy ratio of the floating feed might have contributed to the low growth performance of the juveniles fed with this feed. Growth depression in tilapia fed with low protein energy ratio had been reported in red tilapia by Santiago and Laron (1991) and in other species by Prather and Lovell (1973), Daniels and Robinson (1986) and Fineman-Kalio and Camacho (1987). Winfree and Stickney (1981) and Wang et al. (1985) likewise observed that growth rate and feed conversion ratio were significantly affected by the protein and energy levels of the diet.

The moisture content of the carcass was not affected by the crude protein content of the two diets. Despite the big difference in the crude protein content of the two diets, chemical analysis of the carcass showed no significant differences in crude protein content between juveniles fed with the two types of tilapia feed. Other scientists reported similar results (Davis and Stickney 1978; Mazid et al. 1979; Winfree and Stickney 1981; Jauncey 1982). Once the protein requirement of the fish was met, the excess protein was used for other bodily processes as indicated by the significantly higher crude fat content of the carcass of juveniles fed with sinking pellets. Dietary protein is the source of amino acids used for protein synthesis, that represents normal growth (Shul'man 1974). However, certain proportions of absorbed amino acid are used to obtain energy (Pfeffer 1982) or stored as fat or glycogen (Shul'man 1974; Cowey and Sargent 1979) and the amount depends mainly on the amino acid composition of dietary protein relative to fish needs, and the amount of energy provided by lipids and carbohydrates relative to that need to cover metabolic requirements (Pfeffer 1982; Wilson et al. 1985).

The significantly higher NPR although not significant for PER in juveniles fed with floating pellets, may indicate some compensatory mechanism to increase efficiency at insufficient protein levels (Berger and Halver 1987). As the carcass of juveniles fed with both diets contained the same crude protein, fat and ash significantly contributed to the fish weight. Cacho (1990) indicated that in addition to protein gain, fat along with ash, moisture, glycogen and moisture gain contribute to fish weight.

While both feeds tested have CP contents higher than the 30% optimum level recommended by some researchers (Siddiqui et al. 1988; Ofojekwu and Ejike 1984; Wang et al. 1985), the growth rate of juveniles fed with floating pellets was approximately 35% lower than that of the juveniles fed with sinking pellets. One of the ingredients used in the production of floating pellets is soybean meal. Although high in protein content, soybean meal is deficient in some essential amino acids, hence the low performance of fish fed with floating pellets despite meeting the optimum protein requirement of the fish. The extrusion process in the production of the floating feed has no advantage over those of the sinking pellet. Gur (1997) reported that even in feeds with the same composition, there is no additional benefit in producing floating pellets through dry extrusion.

The lower cost per kilogram of floating pellets resulted to $0.63 less feed to produce a kilogram gain weight than those fed with sinking pellets. However, as the growth rate was lower in juveniles fed with floating pellets, it would take about 25 days longer to produce the same weight as those juveniles fed with sinking pellets. Although the added cost in rearing the juveniles for a longer period of time did not negate the difference in the feed cost per kilogram gain of Nile tilapia juveniles, production cycle per crop will be shorter when fish are fed with sinking pellets.

The loading rate at the end of the study did not exceed the recommended maximum load of 4.8 kg by the designer of the recirculating system thus, water quality parameters were within safe levels and growth and survival data were comparable to those obtained by other investigators (Dabrowska et al. 1989; Al-Ogaily et al. 1996; Gur 1997). Based on the results, the recirculating system used in this study may be used for controlled rearing of Nile tilapia juveniles. Furthermore, the sinking pellets seem to be a better feed for Nile tilapia juveniles in terms of biological performance although it is more expensive than the floating feeds.

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