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AQM Robiul Kawser
Department of Aquaculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Md Amzad Hossain
Department of Aquaculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Shah Alam Sarker
School of Agriculture and Rural Development, Bangladesh Open University, Gazipur, Bangladesh

Correspondence
AQM Robiul Kawser
Department of Aquaculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Growth response, Feed utilization and Nutrient retention in monosex tilapia (*Oreochromis niloticus*) fed with floating and sinking pellets in a recirculating aquaponic system

AQM Robiul Kawser, Md Amzad Hossain and Shah Alam Sarker

Abstract
An experiment was conducted for 10 weeks to compare the effects of feeding sinking and floating commercial pellets in monosex tilapia (*Oreochromis niloticus*) reared in a recirculating aquaponic system. Each of the commercially available isonitrogenous floating and sinking pellets were tested in triplicates. The water quality parameters during the experimental period were within the suitable range for fish culture. At the end of the rearing period, significant difference ($P<0.05$) was observed in % weight gain, specific growth rate, hepatosomatic index and feed conversion ratio of fish fed with floating and sinking pellets. No significant difference ($P>0.05$) was observed in the chemical composition of *O. niloticus* except lipid content. In terms of growth.

Keywords: Aquaponic, Monosex tilapia, feed, growth, nutrient retention

1. Introduction
Aquaculture is one of fastest growing sector in Bangladesh as well as in the world. The rapid expansion of aquaculture, however, has raised questions about its sustainability. As land-based opportunities are limited, vast and rich water resources offer the best possibilities for sustainability in food production and economic development. Recirculating aquaculture systems have gained momentum in various developing countries because they can sustain both omnivorous and carnivorous species at a low cost (Naylor *et al*. 2009; Martins *et al*. 2010) [19, 16]. Compared with a conventional system, a recirculating system allows fish rearing in sites where the amount of available water is low by reducing the discharge volume (McMurtry *et al*. 1997) [17]. There is a continuous pressure on agricultural land in Bangladesh for the production of cereal crops and urbanization. Water resources may also be limited in near future. Although research on the feasibility of recirculating aquaculture in Bangladesh was conducted but not yet reach the level to disseminate in farmers level (Salam *et al*. 2013) [23]. Aquaponics is a further improvement of recirculating aquaculture. It combines aquaculture with hydroponics. The plants filter waste products harmful to the fish from the system by utilizing them as a nutrient source (Rakocy *et al*. 2004) [20]. This symbiotic interaction in the system can reduce the need for filters, fertilization, mechanical maintenance, water monitoring and water changes as compared to aquaculture or hydroponics alone (Rakocy *et al*. 2004; Diver, 2006) [20, 7]. Aquaponic systems are not only eco-friendly but they are also commercially feasible and make good business sense (Rakocy *et al*. 2004) [20]. Lack of available resources in developing countries is an important factor that limits the feasibility of a cost efficient aquaponic system (Hishamunda *et al*. 1998; Kassie and Zikhali 2009; Lapere 2010) [11, 14, 15]. Formulated fish feeds represent one of the largest variable costs in traditional aquaculture systems (Naylor *et al*. 2009) [19]. Both floating and sinking pellet can produce satisfactory growth, but some fish species prefer floating, others sinking (Craig and Helfrich 2002) [4]. Tilapia can utilize both the floating pellets and sinking pellets very efficiently (Santiago 1987) [24]. The primary goal of this study is to evaluate the effects of floating and sinking pellets on the growth of monosex tilapia and their feed utilization as well as nutrient retention in a recirculating aquaponic system.

2. Materials and Methods

The experiment was conducted for a period of 70 days from 17th June to 25 August, 2014 in department of aquaculture field research area of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). The experiment was designed into two treatment groups (T_1 and T_2) consist of two different pellets each having three replications. Size of the fish rearing tanks was 300 liter where 50 fish were stocked in each of these six tanks. Commercially made floating pellets (T_1) and sinking pellets (T_2) were used to evaluate the performance of monosex tilapia where the protein percentage of both the pellets was 30% (according to manufacturer labeling).

2.1 Setting up recirculating aquaponic system

In this experiment fish was reared in plastic tanks. There were six fish rearing tanks in total where three tanks were received floating pellets and other three were received sinking pellets (Figure 1). Both groups of tanks were interconnected with siphoning pipe.

Fig 1: Fish rearing tanks used in the experiment.

Vegetable trays (51cm×24cm×17cm) were placed above a stage under shed. In this experiment water spinach (*Ipomoea aquatica*) and Indian spinach (*Spinacia oleracea*) were used. All the trays were interconnected with pipe. These six vegetable growing trays were filled with small piece of bricks. Seedlings were transplanted in aquaponic units at three weeks when plants have at least 2–3 true leaves. Separate recirculation system was established for each group of fish rearing tanks. At first all the fish rearing tanks were filled with water. For the first group of tank, a water pump of 12 watt capacity was set in the floating feed receiving tank. Opening of the one side of a pipe was jointed with the water pump while the other side of the pipe was inserted into a PVC plastic pipe that carries nutrient rich water into the elevated vegetables trays. Water from all the trays via the central trays through an outlet pipe enter into the fish rearing tank by gravitational force. Rearing tanks of each treatment were interconnected with siphoning pipe.

2.2 Stocking and rearing of fish species

Monosex tilapia (*Oreochromis niloticus*) of 3.4±0.3 g size was collected from a commercial fish hatchery. In the beginning of the experiment, fish was weighed individually, selected and distributed into each of the 300 liter tanks; 50 fish per tank. All tanks were uniformly aerated. Triplicate groups of fish were fed with commercially available floating and sinking tilapia pellets. The fish was fed up to satiation two times a day, six days in a week.

2.3 Sampling and water quality monitoring

Fish were sampled fortnightly and growth and survival monitored. Ten carcasses from each tank was pooled, washed with distilled water and stored at -20 ^{0}C for whole body chemical composition analysis. Temperature was recorded daily in each tank. For water analysis, samples from the inflow pipe and fish culture tanks were collected. Dissolved oxygen (DO) and pH were measured using Oxygen and pH meters (Hach Co., Loveland, Colorado). Ammonia level was measured weekly using a spectrophotometer (DR 5000).

2.4 Chemical Analysis of Sample

The proximate composition of fish and fish feed samples was determined according to standard method given by the Association of Official Analytical Chemists (AOAC, 2000) [2].

2.5 Growth parameters

Growth of fry in length (cm) and weight (g) was measured and the following parameters were used to evaluate fry growth: 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. % Weight gain (g) was calculated as: 100 ((Mean final weight - Mean initial weight)/ Mean initial weight). Hepatosomatic index (HSI) was calculated as: 100 (Liver weight/ Body weight). Nutrient retention (%) was calculated as: 100 ((Final carcass composition - Initial carcass composition) /Amount of nutrient fed)

2.6 Statistical analysis

Data obtained from this experiment were subjected to one-way analysis of variance (ANOVA). All statistical analyses were performed using the statistical software package (Statistics 10).

3 Results and Discussion

3.1 Water quality parameters

The average temperature, pH, ammonia and dissolve oxygen level during the experimental period was 28 ^{0}C, 7.58, 1.0 mg/l and 7.54 mg/l, respectively. The water quality parameters of this experiment did not differ significantly (P>0.05). Artificial aeration was provided in each of the rearing tanks and therefore, dissolved oxygen level during this experimental period was sufficient. The pH contents in the present study did not much fluctuate. Aminul (1996) [1] stated that the water with almost neutral reaction having pH values from 6.7 to 7.5 was the best suited for fish production. El-Sayed (1999) [9] has reported that *O. niloticus* can tolerate ammonia level up to 3.5ppm. Hassan (1992) [10] has recorded safe levels of unionized ammonia at 1.05 mg/l and 1.0 mg/l for nitrite. Therefore, the ammonia level during the present study was within the suitable range for fish production. Aminul (1996)[1] has reported that the suitable water temperature ranged from 25 °C to 35 °C for fish culture. DoF (2008) [8] reported that the range of suitable dissolved oxygen for fish culture would be 5-8 mg/1.

3.2 Growth response of *O. niloticus* in aquaponic system

The average initial weight of *O. niloticus* was 3.40±0.30 g in both the treatments (Table 1). The average final weight of *O. niloticus* fed with floating and sinking pellet differ significantly ($P<0.05$). The average weight gain (%) and the total fish production differ significantly after 70 days of rearing period. Although no significant difference was observed in the survival rate of *O. niloticus* after 70 days of rearing.

Table 1: Total weight gain, production and survival rate of monosex tilapia (*O. niloticus*) using floating and sinking pellets after 70 days of rearing.

	T_1 (Floating pellet)	T_2 (Sinking pellet)
Initial Weight (g)	3.40±0.30 ^{a}	3.40±0.30 ^{a}
Final Weight (g)	32.40±0.41 ^{a}	21.73±0.11 ^{b}
Weight gain (g)	29.0±0.89 ^{a}	18.33±0.57 ^{b}
Weight gain (%)	952.94±1.13 ^{a}	639.11±1.22 ^{b}
Production (kg/m^3)	5.30±1.10 ^{a}	3.48±1.12 ^{b}
Survival rate (%)	98.00±2.00 ^{a}	97.00±2.00 ^{a}

*Means with different superscript in a row are significantly different ($P<0.05$).

The growth curve of *O. niloticus* was initially quite similar. But as the rearing period continues to 4th week there was a size variation of fish that received sinking pellets was observed (Figure 2).

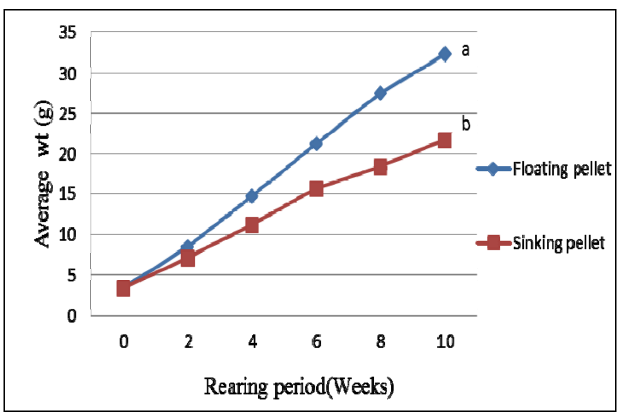

Fig 2: Fortnightly growth of *O. niloticus* fed with floating and sinking pellets. Means with different letter differ significantly ($P<0.05$).

Specific growth rate (% day^{-1}) and hepatosomatic index of *O. niloticus* fed with floating pellet was significantly higher compare to sinking pellet. Feed conversion ratio of *O. niloticus* fed with floating pellet was better than sinking pellet (Table 2).

Table 2: Specific growth rate (SGR), hepatosomatic index (HSI) and Feed conversion ratio (FCR) of *O. niloticus* fed with floating and sinking pellets.

	T_1 (Floating pellet)	T_2 (Sinking pellet)
SGR (% day^{-1})	1.50±0.01^a	1.32±0.05^b
HSI	2.05±0.45^a	1.4±0.38^b
FCR	1.40±0.12^a	2.17±0.09^b

*Means with different superscript in a row are significantly differently ($P<0.05$)

The results of the present experiment indicated that the use of floating and sinking pellets causes variation in growth of tilapia fry. Cruz and Laudencia (1978) [5] have found that 20-30% crude protein was required for optimum growth of *O. niloticus*. Production of *O. niloticus* in a recirculating aquaponic system was 6.38 kg/m^3 during 10 weeks of experimental period (Rakocy *et al*. 2006) [21]. Floating pellet has a smooth surface. It floats on the water thus allows fish to observe the pellet more easily and consume it. Floating pellet is soft enough thus easy to chew and digest for the animal (Santiago, 1987) [24]. Floating pellets are usually more palatable and uniform than sinking pellets (Craig and Helfrich 2002) [4]. Except some bottom dwelling fish most fish species prefer floating pellets than sinking pellets (Craig and Helfrich 2002) [4]. Cruz and Ridha (2001) [6] have conducted an experiment on growth and survival rates of Nile tilapia (*Oreochromis niloticus*) juveniles reared in a recirculating system fed with floating and sinking pellets and found that the survival rate was 100% in both cases. Mohamed (2009) [18] conducted an experiment on the effect of dietary protein level on the growth performance and body composition of monosex Nile tilapia (*O. niloticus*) reared in fertilized tank and observed 97% survival. Flow rate in the recirculation system during this experiment was 3.61litre/min. A higher flow rate might ensure better water quality and put less stress to fish by improving water quality. Resley *et al*. (2009) [22] have obtained SGR value of 4.7 (% day^{-1}) in the growth and survival of juvenile cobia, in a recirculating aquaculture system. Kamal *et al*. (2006) [13] have obtained SGR value of 1.6 (% day^{-1}) in an aquaponic production of Nile tilapia (*Oreochromis niloticus*) and Bell pepper (*Capsicum annuum*) in recirculating aquaponic system. Rakocy *et al*. (2006) [21] have found SGR value of 4.4 (% day^{-1}) in an intensive Nile tilapia and basil aquaponic production system. In this experiment the SGR value was moderately low compared to other studies. This might be due to confinement of the tanks and lack of nutritionally balanced diet required for *O. niloticus*. In the present study, non-uniform and low palatability of sinking pellets may attribute to higher FCR value of sinking pellets. But with 30% protein level Mohamed (2009) [18] found a FCR value of 2.11 in a recirculating aquaponic system.

3.3 Proximate composition of whole body carcasses

The average protein percentage of *O. niloticus* fed with floating pellet was 63.61±0.89% on dry weight basis. The average lipid, moisture and ash percentage was 20.23±1.28%, 70.78±1.22% and 14.89±1.91%, respectively. On the other hand, the average protein percentage of *O. niloticus* fed with sinking pellet was 63.71±1.04% on dry weight basis. The average lipid, moisture and ash percentage was 17.22±0.63%, 71.85±1.49% and 15.02±0.77%, respectively. Only the average lipid% of *O. niloticus* fed with floating and sinking pellet did differ significantly ($P<0.05$) (Figure 3).

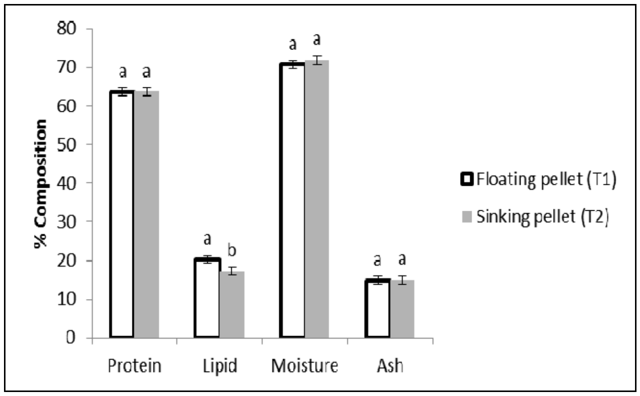

Fig 3: Proximate composition of whole body carcasses of *O. niloticus* fed with floating and sinking pellets. Means with different letter are significantly different (P<0.05). Crude protein, crude fat and ash contents are on dry matter basis.

Nutrient retention of *O. niloticus* after 70 days of rearing indicate that, use of floating or sinking pellet does not affect the nutritional composition of *O. niloticus* (Table 3). Protein efficiency ratio of *O. niloticus* fed with floating and sinking pellets was 0.075±0.01and 0.048±0.01, respectively after 10 weeks of rearing period which did not differ significantly.

Table 3: Nutrient retention of *O. niloticus* fed with floating and sinking pellets.

Composition (%)	Initial carcass composition	T_1 (Floating pellet)	T_2 (Sinking pellet)	T_1 nutrient retention (%)	T_2 nutrient retention (%)
Protein	62.57±1.55	63.61±0.89	63.71±1.04	0.27 [a]	0.29 [a]
Lipid	15.89±0.51	20.23±1.28	17.22±0.63	11.32 [a]	1.74 [b]
Moisture	70.44±0.45	70.78±1.22	71.85±1.49	0.24 [a]	1.01 [a]
Ash	11.99±0.60	14.89±1.91	15.02±0.77	2.22 [a]	3.01 [a]

*Means with different superscript in a row are significantly different (P<0.05)

In a previous study with floating and sinking pellets it was found that the moisture content of the carcass was not affected by the crude protein content of the two diets (Cruz and Ridha 2001) [6]. 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 floating pellets. Mohamed (2009)[18] has found that at 30% dietary protein level the crude protein, lipid, moisture and ash percentage of *O. niloticus* was 65.93%, 18.67%, 77.17% and 14.40%, respectively. In comparison of, initial and final body composition of *O. niloticus* it is observed that the ash content differ significantly because of increase size and increase in mineral content in the final body composition. Protein efficiency ratio of *O. niloticus* was 1.17 and 1.23 using floating and sinking pellets, respectively in a recirculating aquaponic system (Cruz and Ridha 2001) [6]. Protein efficiency ratio of *Cyprinus carpio* was 1.34 in an aquaponic system with spinach as a hydroponic crop (Hussain *et al*. 2014) [12]. Using castor seed meal as feed ingredient for *O. niloticus* protein efficiency ratio was 0.052 in a recirculating aquaponic system (Balogun *et al*. 2004) [3]. Protein efficiency ratio of the present study was lower than most of the previous study. This may due to poor palatability and digestibility as well as improper amino acid profile of the pellets.

3.4 Vegetable Production

After 70 days of experiment total 15.00 kg of vegetables was harvested from 9.84 square foot area of which 7.00 kg Indian spinach (0.71kg/square foot) and 8.00 kg water spinach was harvested (0.81kg/square foot). Salam *et al*. (2013) [23] conducted an experiment on aquaponic for improving high density fish pond water quality through raft and rack vegetable production and found that in raft and rack system the Spinach production was 0.9 kg/ft^2 and 0.22 kg/ft^2, respectively. Yield of Bell pepper grown hydropnically in a closed, recirculating fish and Bell pepper production system produce 11.93kg of Bell pepper per meter square (Kamal, 2006) [13]. Annual yield of basil for the aquaponic system was 0.72 kg/ ft^2 in UVI production system (Rackocy, 2006) [21].

3.5 Economic Feasibility

Economically recirculating aquaponic system for tilapia production is very much feasible. Only the initial installments cost that might create some kind of doubt in the farmer's mind. In this experiment around 70% of the expenditure was used for initial installment. Once the system is set and run for at least three cycles it may turn out to be a profitable enterprise.

4. Conclusion

The overall performance of *O. niloticus* fed with floating pellet was better than sinking pellet in terms of growth response, feed utilization and nutrient retention. If the farmers of Bangladesh adopt this recirculating aquaponic technology in mass scale and in accordance with appropriate guideline, this could be the future of fish production in Bangladesh. Further research needs to be done to optimize the stocking and planting density of fish and vegetables in different size fish rearing tanks and use of different medium for the culture of vegetables.

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6. References

1. Aminul IM. Qualities of Water and Soil in Aquaculture.

DoF Publication, Bangladesh, 1996.
2. Association of Official Analytical Chemistry AOAC. Official Methods of Analysis. 17th Edition, Alington, Virginia, USA. 2000.
3. Balogun JK, Auta J, Abdullahi SA, Agboola OE. Potentials of castor seed meal as feed ingredient for *Oreochromis niloticus*. Ahmadu Bello University, Zaria, Academic Press. Inc. 2004, 11-17.
4. Craig S, Helfrich LA. Understanding fish nutrition feeds and feeding. Virginia Co-operative Extension Publication. 2002, 420-256.
5. Cruz EM, Laudencia IL. Preliminary study on the protein requirements of Nile tilapia (*Oreochromis niloticus*) fingerlings. Fisheries Research Journal Philippines. 1978; 3(2):34-38.
6. Cruz EM, Ridha MT. Growth and survival rates of Nile tilapia (*Oreochromis niloticus*) juveniles reared in a recirculating system fed with floating and sinking pellets. Asian Fisheries Society, Manila, Philippines, 2001; 14:9-16.
7. Diver S. Aquaponics - integration of hydroponics with aquaculture. Retrieved from http://www.backyardaquaponics.com/Travis/aquaponic.pdf. 2006.
8. DoF. Matsha Sampad Unnoyan Ovijan. Department of Fisheries, Dhaka. 2008, 79-85.
9. El-Sayed AFM. Alternative dietary protein sources for farmed tilapia. Journal of Tilapia Culture, CABI Publishing, Cambridge, MA. 1999; 277.
10. Hassan R. Acute ammonia toxicity of red tilapia and seabass. Fisheries Bulletin of the Department of Fisheries, Malaysia, 1992, 73:8.
11. Hishamunda N, Jolly C, Engle C. Evaluation of small-scale aquaculture with intra-rural household trade as an alternative enterprise for limited resource farmers: The case of Rwanda Food Policy, 1998; 23(2):143-154.
12. Hussain T, Verma AK, Tiwari VK, Rathore G, Shete AP, Prakash C. Effect of water flow rates on growth of *Cyprinus carpio* and spinach plant in aquaponic system. Aquaculture International. 2014; 8(2):1-16.
13. Kamal SM. aquaponic production of Nile tilapia (*Oreochromis niloticus*) and Bell pepper (*Capsicum annuum*) in recirculating water system. Egypt Journal of Aquaculture Biodiversity and Fisheries. 2006; 10:85-97.
14. Kassie M, Zikhali P. Brief on sustainable agriculture: Prepared for the expert group meeting on sustainable land management and agricultural practices in Africa: Bridging the gap between research and farmers. Gothenburg, Sweden, University of Gothenburg. 2009, 111-118.
15. Lapere P. A techno-economic feasibility study into aquaponics in South Africa. University of Stellenbosch, Stellenbosch, South Africa. Retrieved from http://hdl.handle.net/10019.1/5400, 2010.
16. Martins CIM, Heinsbroek LTN, Verreth JAJ. New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability. Aquaculture Engineering. 2010; 43(3):83-93.
17. McMurtry MR, Sanders DC, Hodson RG, Hanning BCC. Efficiency of water use of an integrated fish and vegetable co-culture system. Journal of the World Aquaculture Society. 1997; 28:420-432.
18. Mohamed HB. Effect of dietary protein level on the growth performance and body composition of monosex Nile tilapia (*Oreochromis niloticus L.*) reared in fertilized tank. Pakistan Journal of Nutrition. 2009; 8(5):674-678.
19. Naylor RL, Hardy RW, Bureau DP, Chiu A, Elliott M, AP Farrell *et al*. Feeding aquaculture in an era of finite resources. Proceedings of the National Academy of Sciences of the United States of America, 2009; 106(36):15103-15110.
20. Rakocy JE, Bailey DS, Shultz RC, Thoman ES. Update on tilapia and vegetable production in the uvi aquaponic system. University of the Virgin Islands (UVI), Kingshill, 2004, 850.
21. Rakocy JE, Masser MP, Losordo TM. Recirculating aquaculture tank production systems: Aquaponics—integrating fish and plant culture. Retrieved from http://www2.ca.uky.edu/wkrec/454fs.pdf, 2006.
22. Resley MJ, Webb KA, Holt GJ. Growth and survival of juvenile cobia (*Rachycentron canadum*), at different salinities in a recirculating aquaculture system. Aquaculture. 2005; 253:398-407.
23. Salam MA, Asadujjaman M, Rahman MS. Aquaponics for improving high density fish pond water quality through raft and rack vegetable production. World Journal of Fish and Marine Sciences. 2013; 5(3):251-256.
24. Santiago SG. The effects of supplementary feeds containing different protein - energy ratios on the growth and survival of *Oreochromis niloticus* in brackishwater ponds. Aquaculture and Fisheries Management, 1987; 18:139-149.