Comparison of Fecal Quantity and Quality of Tilapia (*Oreochromis niloticus*), Walking Catfish (*Clarias macrocephalus*), Barb (*Puntius gonionotus*) and Climbing Perch (*Anabas testudineus*) Fed a Commercial Diet

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Submission: 9 November 2019 Revised: 28 January 2020 Accepted: 30 January 2020

ABSTRACT

This study aimed to quantify and qualify the feces of four fish species including tilapia (*Oreochromis niloticus*), walking catfish (*Clarias macrocephalus*), barb (*Puntius gonionotus*) and climbing perch (*Anabas testudineus*) to find suitable species for aquaponic system. Fishes were fed commercial diet containing 32% of crude protein four times a day for 60 days. After 60 days of feeding, the results showed that the body weight gain, specific growth rate, and final body weight of tilapia and catfish were significantly higher than those of climbing perch and barb ($P < 0.05$). The highest value of feed intake was significantly exhibited in catfish ($P < 0.05$); while, feed intake of climbing perch and tilapia was significantly better than that of barb ($P < 0.05$). The lowest value of feed conversion ratio (FCR) was significantly displyed in catfish and tilapia ($P < 0.05$); while, FCR of barb was significantly higher than others ($P < 0.05$). The fecal amount, expressed as % feed intake, showed that catfish and tilapia excreted the largest amount of feces compared to those of climbing perch and barb ($P < 0.05$). The nutrients namely nitrogen, phosphorus and potassium contents measured in feces were similar in all fish species. However, the nitrogen and phosphorus contents in the water effluent of catfish were significantly higher than others ($P < 0.05$), while potassium content in water of catfish, tilapia and climbing perch was significantly higher than that of barb ($P < 0.05$). Based on the results of the present study, catfish and tilapia are recommended to be suitable fish species for aquaponic system.

Keywords: Fecal quality of fishes, fecal quantity of fishes, fish excretion, aquaculture effluent

Thai J. Agric. Sci. (2020) Vol. 53(1): 11−18

INTRODUCTION

The raising of the world population leads to demand for food supply. Aquatic animal is important protein source of human food. The intensive aquaculture has been operating for providing higher yields in a limited production area. The activity of intensive aquaculture produces the large quantity of the wastes, including wastewater and solid waste released to the nature (Joyner, 1992). Fish excretion comprise of organic matters and minerals such as nitrogen, phosphorus, and other elements which are mostly in a form of soluble ammonia, urea, uric, nitrite, and nitrate (Boyd, 1985). The wastewater, solid waste and sludge from aquaculture released to natural resources usually pollute that reduces dissolved oxygen; additionally, the high loading nutrient impairs water quality by stimulating the eutrophication phenomenon (Joyner, 1992). Boyd (1985) revealed that a ton of channel catfish production releases approximately 1.2 ton of dry matter, 0.06 ton of nitrogen, 0.012 ton of phosphorus to culture water as the waste.

Nutrient–rich effluent from intensive aquaculture is able to be utilized in the hydroponic production systems which have potential to treat and reuse the wastewater in intensive aquaculture. The combination of aquaculture and hydroculture protocols help to reduce nutrients level from water which can then be re–utilized in aquaculture again as so called “aquaponics” (Petterson, 1987; Mathiru and Wang, 1995). However, the excreted feces from each fish species exhibit different components and nutrients (Brown *et al*., 1999), therefore it is necessary to understand the nutrient budgets of aquaculture practices for efficiency of input resources and to utilize output nutrient sources so as to operate the aquaponic system effectively and successfully.

Tilapia (*Oreochromis niloticus*), catfish (*Clarias macrocephalus*), barb (*Puntius gonionotus*) and climbing perch (*Anabas testudineus*) are economic fish species in Thailand due to their total production accounted for 68.3% of total production of freshwater aquaculture production (approximately 605,900 tons) in Thailand (Department of Fisheries, 2016). Likewise, these fours species have different feeding behaviors; for example, barb and tilapia are herbivorous and omnivorous species, respectively; while catfish and perch are carnivorous fish. The present study was aimed to compare the quantity and quality of fish excretion in economical fish species in Thailand that have different feeding behavior so as to search for the appropriate fish species used for aquaponic system.

MATERIALS AND METHODS

Experimental Condition and Fish

Four fish species with similar size (initial body weight 3.5 g/fish) were obtained from Amnatcharoen Inland Aquaculture Research and Development Center, Department of Fisheries in Thailand. Fishes were acclimated the conditions for two weeks prior to the beginning of experiments at Amnatcharoen Inland Aquaculture Research and Development Center, Department of Fisheries in Thailand. During acclimation, fish were fed to satiation with a commercial diet containing 32% of crude protein, 7.1% moisture and 16,954 J/g gross energy (Centaco co. Ltd., Pathum Thani, Thailand) four times a day.

Experimental Procedure and Sample Collection

This experiment was designed to consist of four treatments (four species of fish) with four replications. Each group of 1,000 fish were assigned to each 10–litre aquarium. All fish were hand-fed four time a day for 60 days. The aquarium were cleaned daily after feeding for an hour. Prior to beginning of the experiment, 50 fish of each tank were weighed as initial body weight. All fish in each tank were weighed at 30 days of feeding for growth rate measurement. At the end of the experiment (60 days of feeding), all fish in each tank were weighed to determine the final body weight after 48–hour starvation. Feed intake and mortality were recorded daily. The fecal and 200–ml of water samples of each aquarium were collected at 30 days and 60 days of feeding. The water samples were analysed for nutrient content. The fecal sample obtained from each aquarium was pooled into treatment and then dried at 60°C overnight for further analysis.

Analysis

The experimental diet was analysed for contents of moisture, crude protein, and gross energy according to AOAC (1995).

Fecal sample was dried and then analysed for nitrogen using total Kjeldahl method, phosphorus using nitric perchoric digestion method, spectophotometry and potassium contents using nitric perchoric digestion and Atomic Absorbtion Spectophotometry (AAS) according to AOAC (1995). Water sample were analyzed for nitrogen, phosphorus and potassium contents using the same protocol as used for fecal analysis. The temperature was measured in water using the conductivity meter and (Aquapro digital water test, HM diital, Inc., China); and pH in water was examined using pH meter (HI98103, Hanna, Romania).

Calculation and Statistical Analysis

Growth rate, feed intake, feed efficiency, and percentage of fecal amount (% of feed intake) were calculated according to the following equations.

Specific growth rate (SGR, % day^{-1}) = 100 × [In(final body weight) − In (initial body weight)] / days

Feed conversion ratio (FCR) = dry feed intake / wet body weight gain

Feed intake (g/fish) = total dry feed intake / number of fish

Fecal amount (% of feed intake) = (dry feces weight × 100) / dry feed intake

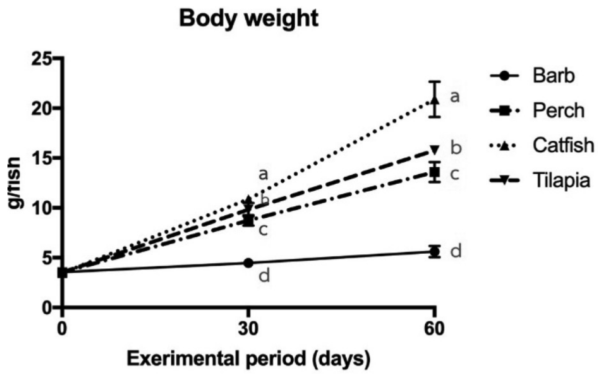
Survival rate (%) = (final number of fish) × 100 / initial number of fish

Data were previously checked for a normal distribution. One-way ANOVA followed by Tukey's multiple comparisons test was performed using GraphPad Prism version 7.00 for Mac Os X, GraphPad Software, were tested for the significant difference among the treatments. The significant difference among the treatments was considered at $P < 0.05$.

RESULTS AND DISCUSSION

Growth and Feed Utilization

The results of growth rate expressed as body weight, body weight gain, and SGR of barb, perch, catfish and tilapia are presented in Figure 1 and Table 1. At 30–day feeding, the body weight of catfish was significantly higher than other fishes ($P < 0.05$). The body weight of tilapia was significantly higher than perch and barb ($P < 0.05$), while barb showed significantly lower value of body weight than others ($P < 0.05$; Figure 1). Besides, the final body weights of four fish species at 60 days of feeding showed similar tendency of increasing body weight value to those at 30 days of feeding. The body weight gain and SGR of catfish was significantly better than others at both 30 days and 60 days feeding ($P < 0.05$). The body weight gain and SGR of tilapia were significantly lower than that of catfish but higher than that of barb at both 30 days and 60 days feeding ($P < 0.05$). Feed intake of barb fed the commercial diet for 60 days was significantly lower than others while that of catfish was significantly higher than those of perch and tilapia ($P < 0.05$). There was no any significant difference in feed intake between perch and tilapia ($P > 0.05$; Figure 2). The highest growth rate exhibited in catfish and tilapia was due to their high feed intake. No any significant difference in FCR among perch, catfish and tilapia was observed ($P > 0.05$); however, barb significantly exhibited the highest FCR ($P < 0.05$). As a result of the present study, it suggests that the survival rate of barb was significantly lower than others at both 30 days and 60 days feeding ($P < 0.05$). No significant difference in survival rate among perch, catfish and tilapia at both 30 days and 60 days feeding was observed ($P > 0.05$). These survival rates in each fish species are in normal range of practice nursing (El–Sayed,



2002; Kohinoor *et al*., 2007; Bombeo *et al*., 2012; Das *et al*., 2012).

Figure 1 Initial, 30–day, and 60–day body weights of barb, perch, catfish and tilapia fed commercial diet for 60 days; values are means ± SD of four replicate tanks (n = 4). Values with different superscript letters are significantly different among the treatment (P < 0.05)

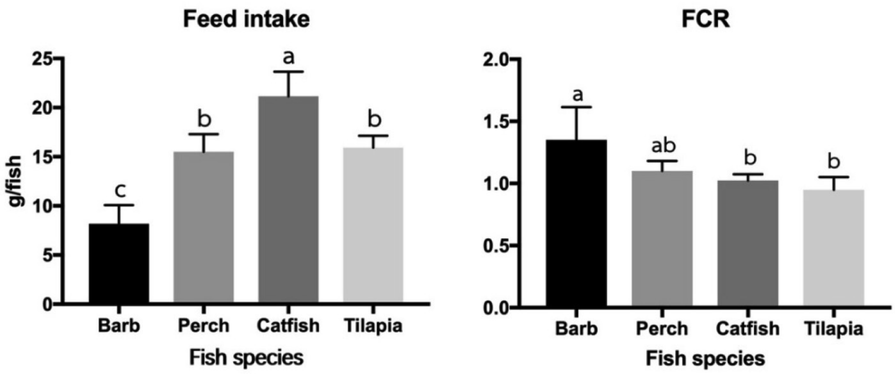


Figure 2 Feed intake and feed conversion ratio of barb, perch, catfish and tilapia fed commercial diet for 60 days; values are means ± SD of four replicate tanks (n = 4). Values with different superscript letters are significantly different among the treatment (P < 0.05)

Table 1 Body weight gain, specific growth rate, and survival rate of barb, climbing perch, catfish and tilapia fed commercial diet for 60 days; values are means ± SD of four replicate tanks (n = 4)

Treatment	Body weight gain (g/fish)		SGR (%/ day)		Survival rate (%)		Feces (% of feed intake)	
	30–day	60–day	30–day	60–day	30–day	60–day	30–day	60–day
Barb	0.9 ± 0.2^{d}	2.1 ± 0.6^{d}	0.8 ± 0.1^{d}	0.8 ± 0.2^{c}	73 ± 13^{b}	73 ± 13^{b}	0.19 ± 0.09^{c}	3.22 ± 1.95^{c}
Perch	5.2 ± 0.5^{c}	10.1 ± 1.0^{c}	3.0 ± 0.2^{c}	2.2 ± 0.1^{b}	100 ± 0^{a}	100 ± 0^{a}	0.28 ± 0.09^{b}	6.29 ± 1.59^{b}
Catfish	7.4 ± 0.5^{a}	17.4 ± 1.8^{a}	3.8 ± 0.1^{a}	3.0 ± 0.1^{a}	99 ± 2^{a}	99 ± 2^{a}	0.26 ± 0.11^{b}	10.17 ± 2.79^{a}
Tilapia	6.3 ± 0.7^{b}	12.2 ± 0.4^{b}	3.4 ± 0.2^{b}	2.5 ± 0.0^{b}	100 ± 0^{a}	100 ± 0^{a}	0.37 ± 0.09^{a}	8.08 ± 2.24^{ab}

Note: ^{a,b,c,d} with different superscript letters are significantly different among the treatment (P < 0.05)

Fecal Quantity and Quality

The amount of dried feces (as dry matter weight) is expressed as percentage (%) of feed intake (as dry matter weight) that is shown in Table 1. The highest percentage of fecal amount at 30 days feeding was significantly displayed in tilapia ($P < 0.05$); whereas, no difference in percentage of fecal amount between perch and catfish ($P > 0.05$). However, at 60 days of feeding, there was no any significant difference in percentage of dry feces amount of perch (6.29 ± 1.59%), catfish (10.17 ± 2.79%), and tilapia (8.08 ± 2.24%; $P > 0.05$).

Barb statistically excreted the least fecal amount compared to other fishes at both 30 days and 60 days of feeding ($P < 0.05$). The aquaculture wastewaters consists of organic matter which reduces dissolved oxygen levels and builds up of bottom sediments; consequently, high nutrient loading impairs water quality by stimulating excessive phytoplankton production (Joyner, 1992). In the present study, catfish and tilapia excreted the highest amount of fecal contents considered that their culture effluent could cause mostly water pollution. On the other hand their wastewater seemed to have high potential and suitable for aquaponic system.

The nutrient contents such as nitrogen, phosphorus and potassium contents, expressed as weight (g) per 100 g dry feces, measured in dried feces are presented in Figure 3. The data presented in the present study is a pooled sample of each treatment, it could show the tendeny of nutrient budget excreted by different fishes. The nitrogen content in feces of barb at 30 days of feeding was slightly higher than those of perch, catfish and tilapia. In contrast, the nitrogen content of perch, catfish and tilapia at 60 days of feeding was higher than that of barb. The nitrogen content of all fishes at 30 days of feeding was lower than those fishes that were measured at 60 days of feeding. The phosphorus contents in feces of barb at 30 days and 60 days of feeding were much higher than those of perch, catfish and tilapia. At the 30 days of feeding, phosphorus content in feces of perch, catfish and tilapia was similar. Nonetheless, phosphorus content of perch at 60 days of feeding was lower than others. The potassium contents in feces of barb at both 30 days and 60 days of feeding were much higher than those of perch, catfish and tilapia. The potassium contents in feces of perch, catfish and tilapia at both 30 days and 60 days of feeding were similar.

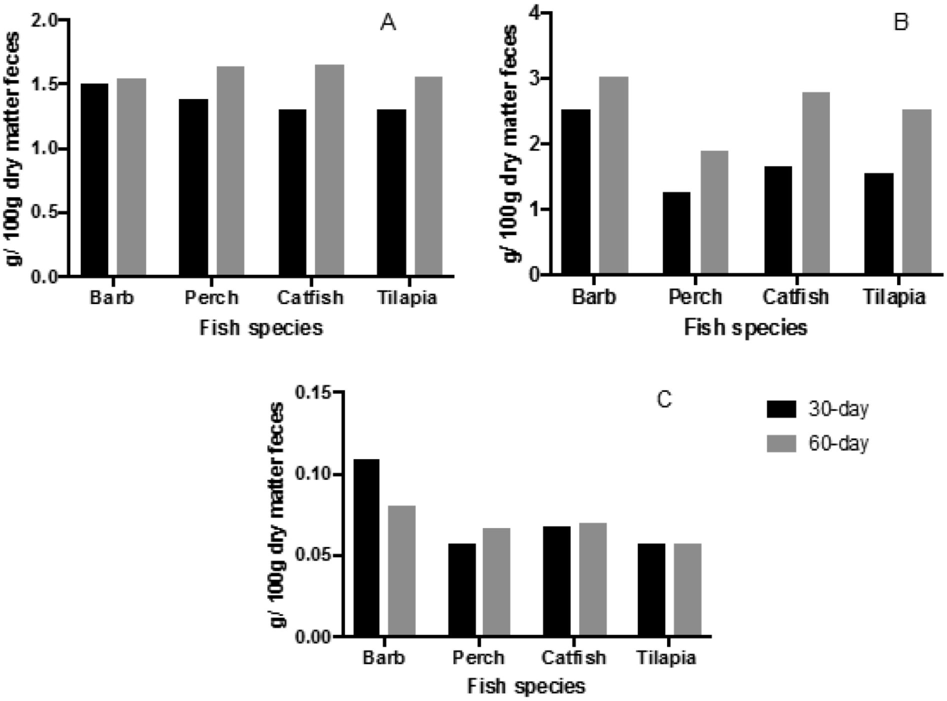


Figure 3 The 30–day and 60–day nitrogen (A), phosphorus (B) and potassium contents (C) in feces of barb, perch, catfish and tilapia fed commercial diet for 60 days; values are means of pooled samples of each treatment (n = 1)

Nitrogen content in water at 30 days of feeding of catfish was significantly higher than those of barb and perch (P < 0.05; Figure 4A). The 60 days of feeding, nitrogen content in water of perch and tilapia was significantly lower than that of catfish and higher than that of barb (P < 0.05). Nitrogen content in water of all treatments increased at 60 days after feeding. At 30 days of feeding, phosphorus content in water of catfish was significantly higher than perch and tilapia (P < 0.05). Phosphorus content in water of barb was lower than the other (P < 0.05; Figure 4B). At 60 days of feeding, the highest level of phosphorus in water was found in catfish (P < 0.05), and that of perch was significantly lower than that of tilapia and higher that that barb (P < 0.05). There was no significant difference in potassium level in water among the treatments at 30 days of feeding (P > 0.05; Figure 4C). At 60 days of feeding, potassium level in water of perch, catfish, and tilapia showed no significant difference (P > 0.05) but it significantly differed from that of barb (P < 0.05). The potassium level in water of all treatments increased after 60 days of feeding. The nitrogen budget measured in feces and water was excreted from fishes through the deamination taking place in fish body (Ghaly *et al*., 2005). The nitrogen is a main element as it is vital for animal nutrition and for controlling environment pollution (Jimenez–Montealegre *et al*., 2002). According to the present study, catfish and tilapia excreted the highest level of nitrogen, phosphorus and potassium. The total production both catfish (39.2% of total freshwater fish production) and tilapia (18.7% of total freshwater fish production) reported by Department of Fisheries (2016) was approximately 320,900 ton, it can imply that the water effluent of their culture practice possibly causes adverse impact on the environment.

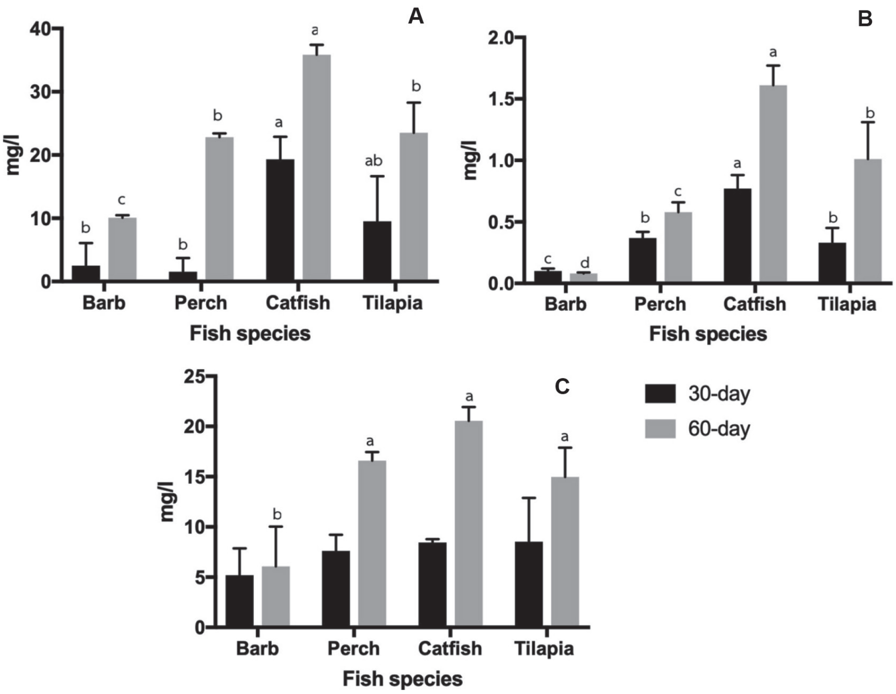


Figure 4 The 30–day and 60–day nitrogen (A), phosphorus (B) and potassium contents (C) in water reared barb, perch, catfish and tilapia fed commercial diet for 60 days; values are means ± SD of four replicate tanks (n = 4). Values with different superscript letters are significantly different among the treatment ($P < 0.05$)

CONCLUSION

According to the results in the present study, the quantity and quality of nutrient budgets of the different fishes fed commercial diet for 60 days showed the different results that feces amount of catfish and tilapia were higher than barb and perch. Nitrogen level in water reared catfish and tilapia was higher than others. Phosphorus and potassium levels were the highest in catfish and followed by tilapia, perch, and barb, respectively. Based on the result of this study, catfish and tilapia are recommended to be appropriate fish species for aquaponic system due to their high growth performance and feed efficiency; and specially their high nutrient budgets including nitrogen, phosphorus, and potassium excretions.

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