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# Growth performances of Nile Tilapia, *Oreochromis niloticus*, reared in recirculating aquaculture and active suspension systems

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**Abstract.** Recirculating aquaculture system (RAS) and active suspension aquaculture system (ASS) are rearing systems which are commonly used in aquaculture productions nowadays. This study aimed at comparing the growth performances of Nile tilapia cultured at the two aquaculture systems for 42 days. The measured parameters were growth rate, weight gain, feed conversion ratio, survival rate, and nutrient utilization (protein efficiency ratio, fat efficiency ratio, and energy efficiency ratio). The results showed that Tilapia reared in the RAS had significantly higher growth rate, weight gain, lower feed conversion ratio, and more efficiently in the utilization of protein, fat, and energy compared to tilapia reared in ASS. These results may indicate that the recirculating aquaculture system provided more comfortable environments for the tilapia for growth compared to the active suspension aquaculture system. However, another study in terms of economic perspective is still required, since the recirculating aquaculture system requires more rearing tanks and operational costs, especially from electricity.

## 1. Introduction

Tilapia, *Oreochromis niloticus*, is one of the most important cultured fish species in more than 75% countries in the world due to: easy to be cultured, having wide tolerance to various environments from freshwater to seawater, fast growth, and capable of utilizing nutrients from a wide variety of sources [1, 2]. In Indonesia, the fish species is generally cultured in ponds with the flow-through water system. However, the culture system is spending a lot of water, vulnerable to diseases, and waste loaded into environments. Besides, physicochemical parameters of rearing water, such as dissolved oxygen, temperature, and pH, are difficult to control.

To solve these problems, two aquaculture systems have nowadays been developed: recirculating aquaculture systems (RAS) and active suspension system (ASS). Both systems are designed to minimize water exchange and having more control over the environmental rearing conditions [3, 4]. The main differences between the 2 systems are in terms of water treatments. RAS requires a separate tank for water treatment besides rearing tanks. The main advantages of the RAS system are the reduction of water use, re-use of energy, environment control, and simple cleaning. However, this system has also some disadvantages especially in terms of investment and operational cost [5]. Therefore, this system is



less common in developing countries. Another aquaculture system is an active suspension system (ASS), which is characterized mainly by the retention of aquaculture wastes and its conversion to natural feed within the culture system. The conversion of the culture wastes is executed by heterotrophic bacteria and algae, which are aggregated in terms of bio-flock. The advantages of this system over RAS is the more efficient in energy use (no water pump), requiring less tank (rearing tank and treatment water tank are in one tank). Some studies also reported that the system increase feed efficiency.

Thus, this study aimed at comparing the RAS and ASS in maintaining water quality and growth performance of Nile tilapia.

## 2. Material and methods

### 2.1. Experimental set-up

Two aquaculture systems (a recirculating aquaculture system and an active suspension aquaculture system) with five rearing aquaria (considered as replicates) were used in this present study. For the RAS, five 20l-aquaria were connected to a 120l- purification tank. The purification tank had three main units: a sedimentation unit, a nitrification unit with up-flow fixed media bio-filter, and a sump unit in which physically and chemically safe water was stored and pumped back to rearing aquaria at a  $21 \text{ min}^{-1}$  flow rate. Meanwhile, for ASS, five 120-l tanks were used as replicates. Two aeration tubes were used along with the tanks (longwise), to supply oxygen and to achieve sufficient mixing rate of the water as a more homogenous distribution of heated water. For water heating, a heater connected to an automatic thermostat was placed on one side of the tank, to control the temperature.

### 2.2. Tilapia

100 swim-up tilapia fry (6d post-hatching) were grown in each 20-l rearing aquarium of the RAS system or five fry.l<sup>-1</sup> in terms of living space. According to El Sayed (2006), 5-10 fry.l<sup>-1</sup> are an optimal stocking density for hatchery-reared Nile tilapia fry. Whereas in active suspension (AS) tanks, the stocking density was set lower, to approximately one fry.l<sup>-1</sup>, because it's lower carrying capacity in terms of chemically purification ability.

### 2.3. Feeding

A commercial feed of  $\pm 0.5 \text{ mm}$  diameter was used feeding the fry to apparent satiation for 30 minutes, three times daily (09.00; 12.30 and 16.00) during the first three weeks and twice a day (11.00 and 16.00) for the rest of the experimental period.

### 2.4. Water parameters

Water physicochemical characteristics were maintained on the safe levels for Nile tilapia fry (pH: 6.5-8.5; Temperature: 26-28 °C;  $\text{NH}_3 < 0.53 \text{ mg.l}^{-1}$   $\text{NH}_3\text{-N}$ ;  $\text{NO}_2 < 1.0 \text{ mg.l}^{-1}$ ; and  $\text{DO} > 5 \text{ mg.l}^{-1}$ ). To stabilize pH levels, especially in RAS systems,  $\text{NaHCO}_3$  were added based on feed input.

### 2.5. Observed parameters

**Feed intake:** Feed intakes were recorded daily based on rearing groups. This was done by weighting the initial feed in a small Petridis before feeding (a), and weighting left weight after feeding.

**Bodyweight:** To measure the larval growth, 10 fry from every rearing aquarium were dried with paper and weighted.

**Body composition:** To monitor growth and feed utilization of fry during the experimental period, the proximate analyses were done to the remaining tilapia on day 42. In this analysis, dry matter content (DM), ash content (ASH), crude protein content (CP), crude fat content (CF), and energy content were analyzed according to protocols of Animal Nutrition/Aquaculture and Fisheries Laboratory.

### 2.6. Statistical analysis

Growth performances (final weight, growth rate, weight gain, feed conversion ratio, survival rate) and feed utilization (protein efficiency ratio, fat efficiency ratio, energy efficiency ratio) of Nile tilapia were compared using ANOVA or independent t-test.

### 3. Results and discussion

#### 3.1. Growth Performances

Started from the same weight of fry ( $0.01 \pm 0.00$ ), Nile tilapia reared in the RAS had higher final weight ( $1.24 \pm 0.03$ g) compared to Tilapia reared in ASS ( $1.17 \pm 0.03$ g) after being cultured for 42 days ( $t=4.21$ ,  $df$  8,  $p=0.03$ ). In addition, the weight gain of Tilapia reared in RAS was group received the same amount of feed ( $t=5.31$ ,  $df$  8,  $p=0.001$ ). This result in line with the FCR of Nile tilapia reared in RAS was lower than FCR of Nile tilapia cultured in ASS, Tabel 1. In general, Nile tilapia reared in the RAS had a better growth rate compared to Nile tilapia reared in the ASS. The growth rate of Nile tilapia obtained from both aquaculture system were all higher than previously reported by El - Sayed [6], which was  $\sim 10$  %BW/d. The average growth rate in this experiment was  $11.30 \pm 0.05$  %BW/d from ASS and  $11.46 \pm 0.06$  from RAS.

**Table 1.** Growth performances of Nile tilapia reared in the recirculating aquaculture system and active suspension system for 42 days

No	Parameters	ASS	RAS
1	Initial Weight (g)	$0.01 \pm 0.00^a$	$0.01 \pm 0.00^a$
2	Final Weight (g)	$1.17 \pm 0.03^a$	$1.24 \pm 0.03^b$
3	Weight Gain (g)	$1.15 \pm 0.03^a$	$1.23 \pm 0.03^b$
4	SGR (%BW/d)	$11.30 \pm 0.05^a$	$11.46 \pm 0.06^b$
5	Survival Rate (%)	$97.33 \pm 2.24^a$	$99.00 \pm 1.49^a$
6	Feed given (g/fish)	$0.83 \pm 0.01^a$	$0.80 \pm 0.01^a$
7	FCR	$0.72 \pm 0.01^b$	$0.65 \pm 0.01^a$

Values are averages with standard deviations of five replicates. Different superscripts indicate the average values are significantly different,  $p < 0.05$ .

#### 3.2. Survival rate

There was no significant difference in the survival rate of tilapia reared in the recirculating aquaculture system and active suspension system ( $t=1.56$ ,  $df$  8,  $p=0.16$ ). SR of tilapia obtained in the present study was  $\sim 97\%$  in ASS, and  $99\%$  in RAS, which were considered good because it was higher than SR reported in previous studies [7, 8].

#### 3.3. Body compositions

The carcass analysis of Tilapia cultured in RAS and ASS is shown in Table 3. Based on the ANOVA test, Dry matter (DM) content of ASS fry was significantly higher than for Tilapia grown in RAS,  $p < 0.05$ . Tilapia grown in ASS had a significantly lower crude protein (CP) content than Tilapia in RAS ( $p < 0.05$ ). The other compositions, Ash, Crude Fat (CF), and Energy content, are not significantly different in the tilapia reared in the two aquaculture systems,  $p > 0.05$ .

**Table 2.** Proximate analyses of tilapia after being cultured at recirculating aquaculture and active suspension system for 42 days and commercial feed.

Parameters	Tilapia		Feed
	RAS	ASS	
DM(g.Kg <sup>-1</sup> )	$247.05 \pm 3.03^a$	$254.62 \pm 4.99^b$	874.10
Ash (g.Kg.DM <sup>-1</sup> )	$134.56 \pm 1.76^a$	$136.34 \pm 6.44^a$	101.38

Crude protein(g.Kg.DM <sup>-1</sup> )	602.83±2.97 <sup>b</sup>	586.71±9.25 <sup>a</sup>	648.08
Crude fat (g.Kg.DM <sup>-1</sup> )	257.75±4.13 <sup>a</sup>	267.57±16.56 <sup>a</sup>	176.91
Energy (kJ.g.DM <sup>-1</sup> )	24.69±0.22 <sup>a</sup>	24.90±0.55 <sup>a</sup>	3.62

Values are mean and standard deviations. Difference superscript indicates there was a significant difference in their mean values,  $p < 0.05$ .

### 3.4. Nutrient utilization

The ability of Tilapia to utilize nutrient from feed during the 42day-culture periods were presented in Table 4. The table showed that Tilapia reared in RAS utilized protein energy and fat indicated by higher protein efficiency ratio (PER), fat efficiency ratio (FER) and energy efficiency ratio (EER) compared to Tilapia culture in the ASS.

**Table 3.** Feed utilization of 42-days old Tilapia fry reared in RAS and ASS aquaria.

Parameters	RAS	ASS
Protein efficiency ratio	2.78±0.043 <sup>a</sup>	2.51±0.04 <sup>b</sup>
Fat efficiency ratio	10.18±0.16 <sup>a</sup>	9.18±0.13 <sup>b</sup>
Energy efficiency ratio	0.08±0.01 <sup>a</sup>	0.07±0.01 <sup>b</sup>

Note: Treatments with no superscript in common are significantly different ( $P < 0.05$ )

Analysis of body composition also indicated that the protein level of fry in RAS was significantly higher than for fry in ASS aquaria. The difference might be due to the higher energy requirement [7]. In the active suspension system, turbulence was much higher than in RAS. Instead of using only carbohydrate or fat as an energy source, fry in active suspension systems might also use some proteins from feed to fulfill such high-energy requirements [9].

## 4. Conclusion

Tilapia cultured in RAS had a higher growth rate, lower feed conversion ratio, as well as more efficient in utilization of protein, fat, and energy from feed for their growth.

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