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The Productivity of Using Current Generating Circular Tanks for Tilapia Fingerling (*Oreochromis niloticus* (Linnaeus, 1758)) Production

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ABSTRACT

This research conducted to determine the optimum water current models for growth performance and survival rate of tilapia fingerlings (*O. niloticus*) in circular tanks. The method used in this research is Completely Randomized Design (CRD), which consists of three treatments and four replications. The treatments are circular tanks without water current (control), circular tanks with 0.1 m·s^{-1} water current and circular tanks that combine 0.1 m·s^{-1} water current with venturi aeration. Tilapia fingerlings were kept in circular tanks with 30 cm diameter and 37 cm of height, with water level of 30 cm. 50 fingerlings with the size of 2-3 cm were reared in every circular tank. The feed is given 3 times daily with a feeding rate of 5% from biomass. Absolute growth rate, specific growth rate, survival rate, feed conversion ratio and feed efficiency were observed every ten days, while water quality was assessed weekly. After 42 days of rearing, the results showed that the 0.1 m·s^{-1} water current combined with venturi aeration had the highest dissolved oxygen level (6.5-7.3 mg·L^{-1}), the lowest ammonia levels (0.15-0.20 mg·L^{-1}), 92% survival rate, 1.17 g absolute growth rate, 3.65% specific growth rate, 1.3 feed convertion ratio and 77.8% feed efficiency.

***Keywords*: *Oreochromis niloticus*, water current, venturi aeration, round tanks, tilapia

1. INTRODUCTION

Tilapia (*Oreochromis niloticus*) in Indonesia is a fisheries commodity that has a high economic aquaculture production value. Tilapia are omnivorous, show broad tolerance to the

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environment and hold positive practical economic aspects (easy culture methods, favorable tastes and relatively affordable prices) (Tsadik and Bart, 2007).

The demand for tilapia in Indonesia is increasing, hence, there is a need to enhance the availability of tilapia fingerlings. This trend can be seen from the statistical data of tilapia production. Tilapia production in 2017 reached 1.15 million tons, increasing 3.6% from 1.14 million tons in 2016 (Directorate General of Aquaculture, 2017).

One of the main obstacles to successfully rear tilapia, besides the availability of sufficient numbers of fingerlings, is water quality. According to Begum *et al.* (2014), the maintenance of good quality of water is essential for tilapia survival and optimum growth.

One of the environmental factors that can influence fish growth and survival rate is water flow. Fish naturally favor water current conditions (Brett, 1964). Dynamic conditions generated by a water current provide stimulation for fish movement. According to Randall (1982), swimming activity in fish, in turn, is correlated with higher metabolism activity. Indeed, during prolonged swimming, oxygen uptake increases by as much as 12 to 15 times the resting value and 93% of this increased oxygen uptake is directed towards the working muscles. Blood transit time through the secondary lamellae is also reduced from around 3 to 1 s, but the arterial blood remains saturated; and cardiac output is increased by up to 3 or 4 times, largely by increases in stroke volume. Fish that have more swimming activity will have better flesh texture compared to static and idle fish, because fish that swim have more varied muscle performances than those that do not (Tajerin *et al*., 2000).

One of the favorable tank choices in aquaculture is a circular shape tank. Circular tanks are suitable because fish are more comfortable swimming in circular tanks, as there is less chance for collision with obtacles, as circular tanks are free of dead angles.

The purpose of this research is to determine the effective water current design in circular tanks that gives the best result for survival rate and growth performance of tilapia fingerlings.

2. MATERIALS AND METHODS

The materials used in this research are 8 water pumps (32 watts), several aeration systems, 0.5 inch pvc pipe, L-shaped and T-shaped pvc pipe connectors, stop valves, pH meter, DO meter, ammonia test kit, scoop net, plastic bowls, digital scales, circular tanks of 30 cm diameter and 37 cm of height with water level of 30 cm, and tilapia fingerlings with length of 2-3 cm that were obtained from the Integrated Service Unit Hatchery, Ciparay, Bandung Regency, Indonesia.

The method used in this research is Completely Randomized Design (CRD), which consists of three treatments and four replications. The treatments are: A) circular tanks without water current (control); B) circular tanks with 0.1 $m \cdot s^{-1}$ water current and C) circular tanks that combine 0.1 $m \cdot s^{-1}$ water current with venturi aeration. Tilapia fingerlings were distributed randomly to one circular tank. Each tank sheltered 50 fingerlings. This research was conducted for 45 days, with feeding rate of 5% from biomass and feed given 3 times daily.

The observed parameters are survival rate, absolute growth rate, specific growth rate, feed conversion ratio, feed efficiency, and water quality. Obtained data were analyzed using analysis of variance (ANOVA) with $p < 0.05$ and the significant differences analyzed using the least significant difference test, while water quality was analyzed descriptively.

2. 1. Research Procedure

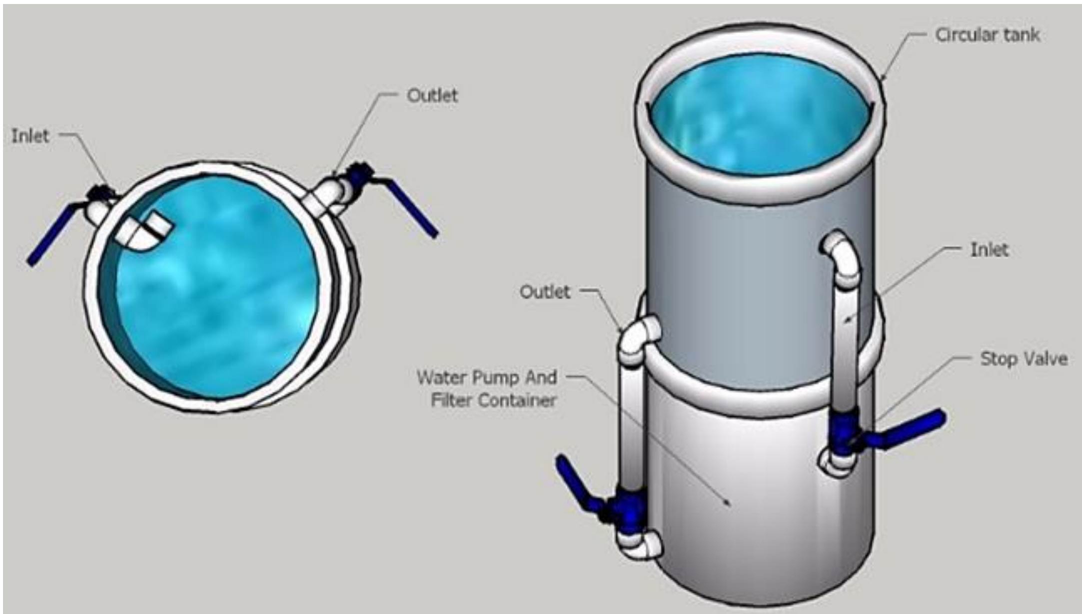

Figure 1. Circular tanks with water current design

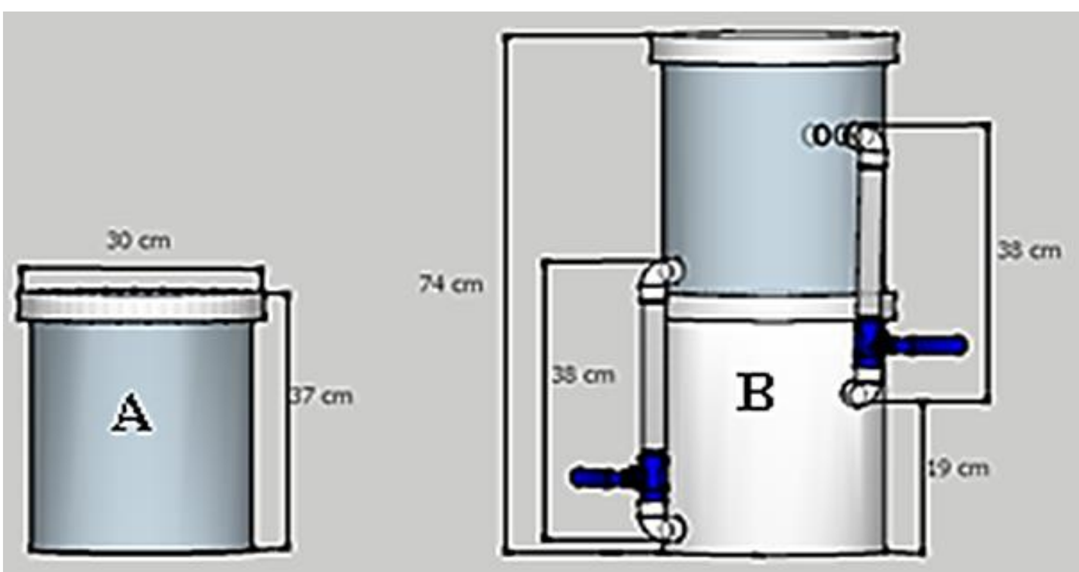

Figure 2. Circular tanks design (A = without water current; B = with water current)

The circular tanks used in this research are 20 used (but cleaned) paint buckets with 30 cm of diameter and 37 cm of height. The water current was established at 0.1 $m \cdot s^{-1}$ and was supplied as a recirculation system using water pumps and piping networks that consist of inlet, outlet and stop valve. The water current velocity was chosen through preliminary research. The inlet was within the tank's water column, while the outlet was at the bottom (**Fig. 1**). The stop valve was used to adjust water current velocity. In the combination of water current with venturi aeration treatments, the aeration hose was installed on the venturi pipe which was already pre-installed in the water pump, so it produces air induction in the water current. The circular tanks without water current (control) used common aeration (**Fig. 2**).

3. RESULTS AND DISCUSSIONS

The results showed that establishing a water current can improve water quality. The water quality parameters observed during this research are temperature, pH, dissolved oxygen and ammonia (**Table 1**).

Table 1. Water quality measurements during rearing period

Parameters	Treatments			Standard
	Without water current (control)	Water current	Water current + venturi aeration	
Temperature (ºC)	24.8-28.9	24.8-28.9	24.5-28.8	25-32*
pH	7.3-8	6.6-7.7	6.9-7.6	6.5-8.5*
DO (mg·L^{-1})	5.3-6.6	5.7-6.5	6.5-7.3	>3*
Ammonia (mg·L^{-1})	0.15-0.35	0.15-0.2	0.15-0.2	≤0.2**

Source: * Indonesian Nasional Standard (2009), ** Effendi (2000)

After 42 days of rearing, temperatures ranging from 24.5-28.9 ºC. The temperature fluctuated at the beginning of the research until the 14th day and stabilized until the end of the research (**Fig. 3**). The temperature data that were collected weekly during the research period do not show differences between treatments ranging between 24.8-28.9 ºC. Based on those numbers, however, the temperatures were still in the optimum range for tilapia culture (25-32 ºC), according to Indonesian National Standard (2009) and Tanjung *et al.* (2019).

During the research, the pH values tend to fluctuate with each difference in treatment. These ranged between 6.6 to 8 (**Fig. 4**). Thus, the pH value is still in the optimum range for tilapia fingerlings growth (6.5-8.5, according to Amri (2008)). El-Sherif and El-Feky (2009) state that each fish species has a different pH tolerance range, and the pH value can be influenced by temperature, CO_2 and alkalinity.

Water conditions that are too acidic or too alkaline will endanger the fish's survival and generate metabolic and respiratory disorders. An increase above neutral pH will also enhance the concentration of ammonia, which is very toxic to fish (Saha *et al.*, 2002; and Scott *et al.*, 2005). In contrast, pH below neutral may inhibit feeding (El-Sherif and El-Feky, 2009).

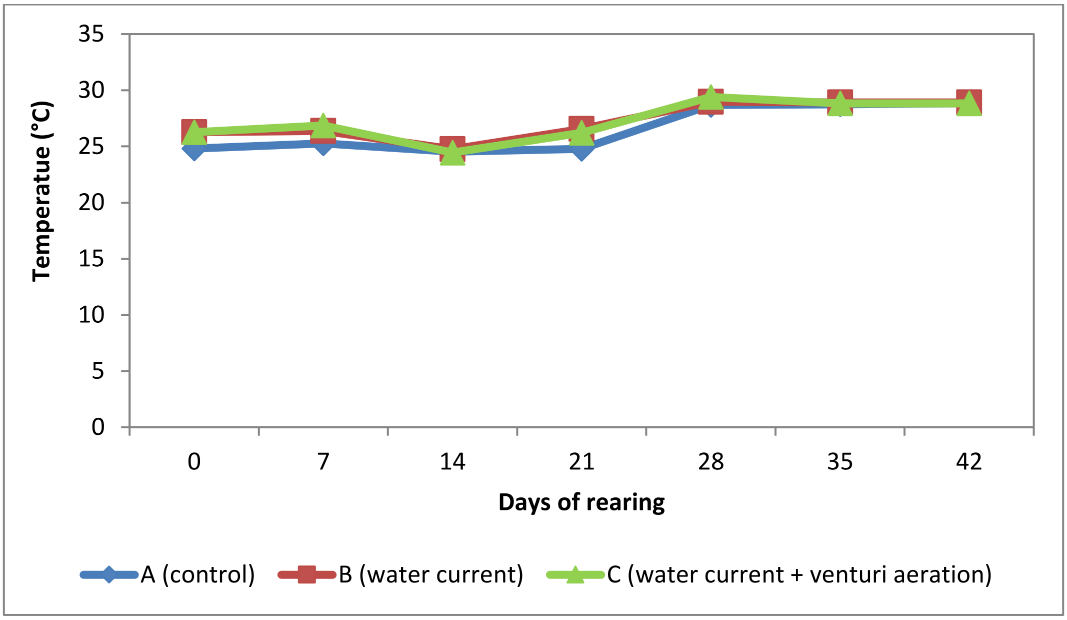

Figure 3. Temperature Level During Rearing Period

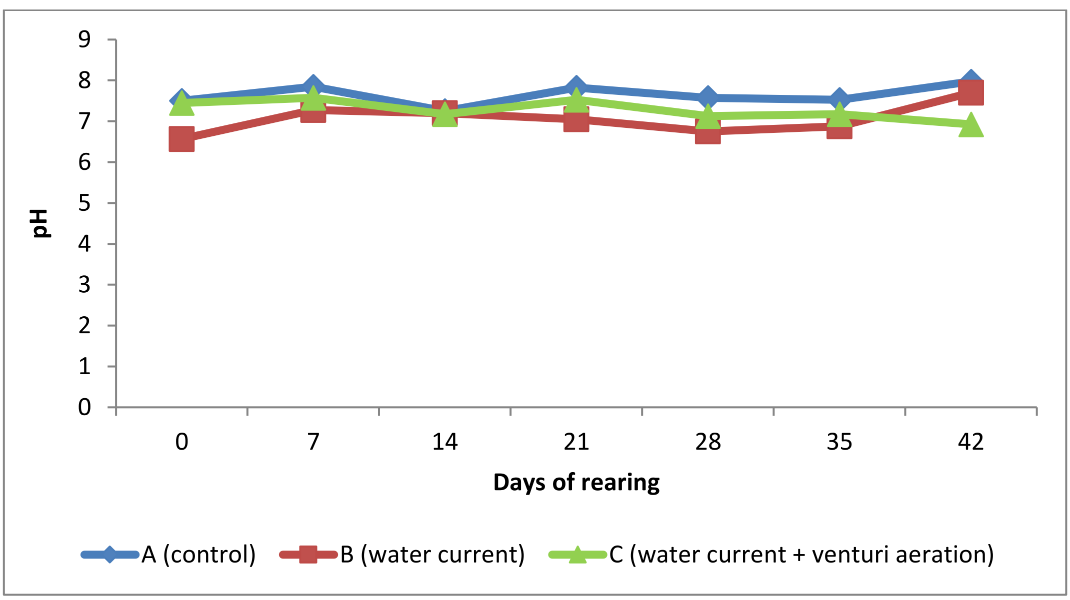

Figure 4. pH Level During Rearing Period

The dissolved oxygen level (DO) was still at its optimum range no matter the treatment (**Fig. 5**), but the C treatment has higher dissolved oxygen compared to other treatments (B and A). In this treatment, dissolved oxygen values ranged from 6.5 to 7.6 mg·L^{-1}, while B treatment and A (control) ranged from 5.3 to 6.5 mg·L^{-1} (Fig. 5). The DO in the control treatment (without water current) has the lowest value during the rearing period (5.3 mg·L^{-1}). According to Indonesian National Standard (2009), the optimum DO value is > 3 mg·L^{-1}.

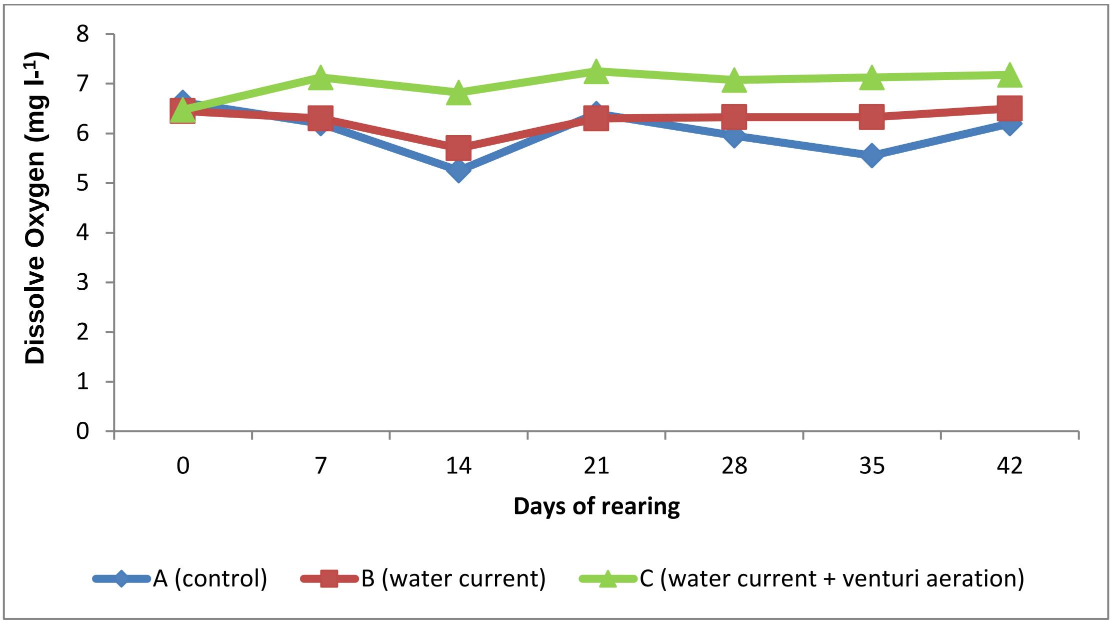

Figure 5. Dissolved Oxygen Level During Rearing Period

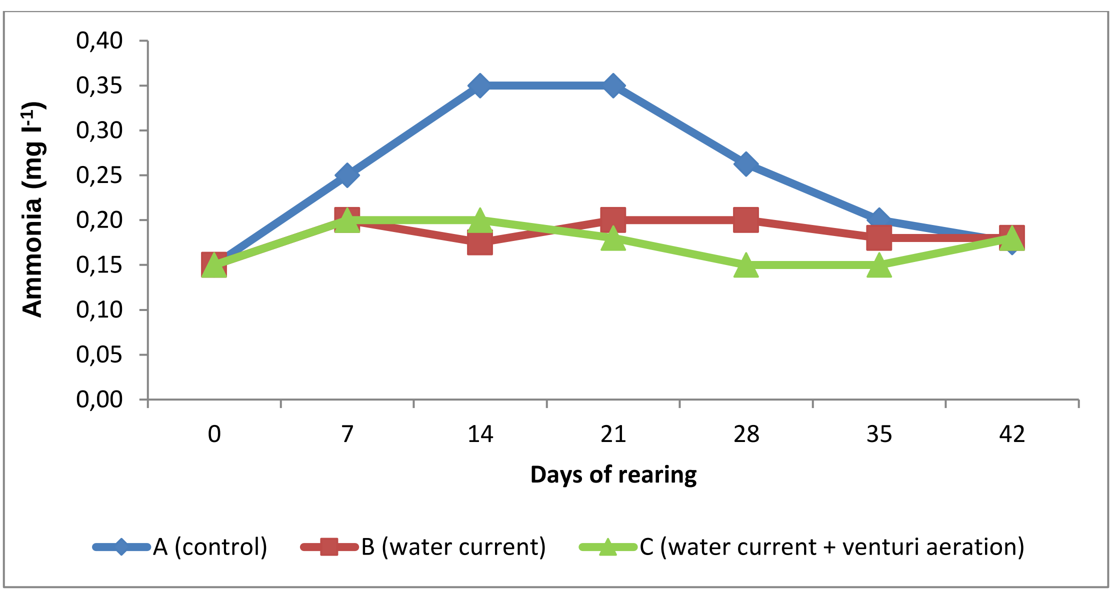

Figure 6. Ammonia Level During Rearing Period

The C treatment at 6.5 to 7.3 mg·L^{-1} (**Fig. 6**) can be considered to be very excellent for tilapia fingerlings growth. The high DO value in this treatment was obtained through oxygen diffusion by way of induced water current and by induced air induction generated from venturi aeration. High DO values can stimulate fish growth because high oxygen supplies can increase metabolic rates (Wheaton, 1942). Our results are also similar to that of Kelabora and Sabariah (2010) who stated that water currents distribute oxygen supplies more evenly and enhanced oxygen content and toxic mineral stabilization. It can be seen that DO values in B and C tend to be higher than the control (Table 1), so it can be concluded that water current improved the water quality.

Ammonia levels in the control group are high and above the maximum level for growth, ranging from 0.15 to 0.35 $mg \cdot L^{-1}$ (**Fig. 6**). Ammonia is regenerated from organic matter, especially protein from uneaten feed or metabolic waste (Avnimelech, 2015). Ammonia is one the most abundant nutrients in effluents and the most common protein metabolism product of aquatic organisms. It is soluble and very toxic even in low concentrations (1 $mg \cdot L^{-1}$) (Emerenciano *et al.*, 2017). In the control, the ammonia level ranged from 0.15 to 0.35 $mg \cdot L^{-1}$. According to Effendi (2000), maximum ammonia range for tilapia is ≤ 0,2 $mg \cdot L^{-1}$. Our results showed that common aeration without water current (control) generated higher ammonia levels. In the B and C treatments, ammonia levels ranged from 0.15 to 0.2 $mg \cdot L^{-1}$. This indicates that water current generated water circulation, so that metabolic waste and uneaten feed escaped through the water inlet and was filtered out.

Other parameters observed are survival, absolute growth rate, daily growth rate, feed conversion ratio and feed efficiency. These are presented in **Table 2**. Herein, the survival rate in treatments B and C are higher than that in the control group. Thus, the generated water current increased the life chances of tilapia fingerlings ($p < 0.05$).

Table 2. Performance of tilapia fingerlings production is maintained

Parameters	Treatments		
	A (control)	B (water current)	C (water current+venturi aeration)
Survival rate (%)	52 ± 9.521^{a}	86.5 ± 6.191^{b}	92 ± 2.304^{b}
Absolute growth rate (g)	0.47 ± 0.076^{a}	0.65 ± 0.099^{b}	$1,17 \pm 0.066^{c}$
Daily growth rate (%)	2.64 ± 0.431^{a}	2.82 ± 0.262^{a}	3.65 ± 0.174^{b}
Feed conversion ratio	3.17 ± 1.04^{a}	1.86 ± 0.212^{b}	1.30 ± 0.147^{b}
Feed efficiency (%)	34.3 ± 11.6^{a}	54.5 ± 6.87^{b}	77.7 ± 8.17^{c}

After 42 days of rearing, the highest survival rate was shown in the C treatment (92%), followed by the B treatment (86.5%) and A/control (52%). Hence, tilapia fingerling survival rate showed significant differences between water current treatments and the control group. Mortality was much higher in the control group, this is presumed to be a result from environmental stresses, such as low DO levels and high ammonia levels. Though the water in control group was always siphon daily to as much as 10%, and total water changes (80%) were done weekly, this regime still did not fully cleanse the water from metabolic waste and the uneaten feed that was dissolved in it.

The results also showed that the absolute growth rate gives a significant difference between treatments. The average absolute growth rate from the highest to the lowest, respectively, are 1.09 g obtained by the C treatment, followed by B treatment with an average of 0.76 g while the control group only obtained an average of 0.59 g. The significant difference of absolute growth rate between treatments is brought about by the higher dissolved oxygen in all treatments that included continuous water current (Figure 5). Abdel-Tawwab (2015) stated that low DO level adversely affects fish growth and feed utilization. The low growth obtained at low DO conditions could be explained by the shortage of oxygen availability for fish growth. Beyond the dissolved oxygen level, the water current stimulates fish to swim and enhances growth. In this regard, Tajerin *et al.* (2000) reported, that fish which are actively swimming develop muscle faster, hence, swimming activity can trigger faster weight gain.

The daily growth rate of Tilapia fingerlings in the C treatment is significantly different from other treatments, while the B treatment is not significantly different from the A control ($p < 0.05$). The daily growth rate from the highest to the lowest rate, respectively, are 3.65% (C treatment), 2.82% (B treatment) and 2.64% (control group). This result is engenderd by the high feed efficiency in C treatment as seen in Table 2. Herein, the higher the value of feed efficiency, the higher the feed can be utilized by fish (Iskandar and Elrifadah 2015). Daily growth rate differences between treatments are caused by many factors, according to Aliyas *et al*. (2016).

These factors are metabolism, metabolic energy use, growth hormone levels and mitosis activity. In line with this results, Belal (2015) also reported that forced swimming can result in easier oxygen exchange, as fish who can maintain their position in fast flowing water need only to open their mouths to ventilate the gills (ram ventilation). Ram ventilation can contribute to saving energy by fish not having to pump water over their gills, which in turn, results in less turbulence, i.e. a more streamlined flow of water is maintained over the body. This hydrodynamic advantage results in small, but measurable, reductions in oxygen consumption.

The highest feed conversion ratio (FCR) value is in the control group (3.17), then the B treatment (1.86) and C treatment (1.31). The lower the feed conversion ratio, the lesser the feed used to increase fish weight. The results also showed that the highest FCR value in the control group (without water current) is not significantly different from B treatment. In contrast, the C treatment has the lowest FCR value and was significantly different to the others ($p < 0.05$), hence, the fish in C treatment needed lesser feed to gain weight. Fujaya (2004) states tha fish growth is the remaining energy after that which is used for metabolism and other life-related activities. The benefit of decreasing FCR in recirculating aquaculture systems (RAS) has economic potential (Besson *et al*., 2014) because it can reduce costs for feed.

The greatest cost in intensive fish farming is feed. This ranges from 30 to 70% of the total production costs (Doupé and Lymbery, 2004; Kolstad *et al*., 2004). Reducing feed consumption for intensive aquaculture with the same productivity level is key to achieving economic sustainability in fish farming (de Verdal *et al.*, 2017) and in reducing nutrient outputs that can increase environmental pollution (Huntington and Hasan, 2009). Feed efficiency was significantly different between all treatments ($p < 0.05$). The feed efficiency value of the C treatment was 77.8% (significantly different from others), that of the B treatment was 54.5% (significantly different from the control group) and that of the control was 34.4%. The highest feed efficiency obtained by C treatment is caused by high feed utilization by tilapia fingerlings since the feed was more evenly distributed and did not converge at one point, so there was less competition between fishes (Kelabora and Sabariah, 2010).

4. CONCLUSION

It can be concluded that the use of circular tanks with the combination of 0.1 $m \cdot s^{-1}$ water current and venturi aeration can produce the best productivities. Such a treatment had the highest dissolved oxygen levels (6.5 to 7.3 $mg \cdot L^{-1}$), best ammonia levels (0.15 to 0.2 $mg \cdot L^{-1}$), a 92% survival rate, an absolute growth rate of 1.17 g, a daily growth rate of 3.65%, a feed conversion ratio of 1.3 and feed efficiency of 77.8%.

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