Impact of Biofloc technology on growth performance and biochemical parameters of Oreochromis niloticus.

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ARTICLE INFO
Article History:
Received: Jan. 27, 2021
Accepted: Feb. 16, 2021
Online: Feb. 19, 2021

Keywords:
Biofloc, Hepatosomatic index, Spleenosomatic index, Hematology, Biochemistry, Oreochromis niloticus

ABSTRACT
In the present study, the experiments were conducted during the period from June to October 2019 (20-weeks) to evaluate the effect of Biofloc technology (BFT) on mono sex Nile tilapia, Oreochromis niloticus fingerlings. It was focused on water quality, growth parameters, hepatosomatic index (HIS), spleenosomatic index (SSI), Hematology, and biochemistry. Triplicated treatments were designed, two Biofloc treatments with two fish densities (12 &16 fish/200 L tank) vs two control groups. All treatments were fed with 3% of body weight in two equally divided meals. Rice brane and Molasse (1:1) were added as a carbon source to Biofloc treatments twice daily after one hour of main meals. Results indicated that total ammonia-N and Nitrite-N were significantly decreased at Biofloc treatments. Biofloc treatments showed significantly high average final body weight, better feed conversion ratio (FCR), and one-ninth water consumption. Biofloc addition had generally no significant difference of hematology, biochemistry, and hepatosomatic index (HSI), while spleenosomatic index (SSI) was significantly increased at high density only. It could be concluded that Biofloc treatments improve water parameters stability and fish growth performance while it decreased water consumption. High density (16 fish/200 L) is a more yield productive treatment.

INTRODUCTION
Aquaculture plays a key role in eliminating hunger, promoting health, reducing poverty, in the developing countries (FAO., 2014). High growth rate of aquaculture is needed to solve the problem of feeding's protein shortage (Subasinghe, 2005; Gutierrez-Wing and Malone, 2006 and Matos et al. 2006). However, environmental and economical limitations can hamper this growth. Intensive aquaculture coincides with the pollution of the culture water by an excess of organic materials and nutrients that are likely to cause acute toxic effects and long-term environmental risks (Piedrahita, 2003). High-density culture in intensive systems requires high amounts of feed to be added to the systems. This will cause water quality deterioration due to the high concentrations of organic compounds (Avnimelech, 2007). Elevated concentrations of ammonia affect growth, oxygen consumption and even can eventually cause mortality of fish. Increased nitrite concentration negatively affects the growth performance and survival of fish (Mallasen and Valenti, 2006).
Biofloc technology (BFT) system can be an environmentally friendly strategy to establish a near to zero water exchange culture system while providing potentially consumable biomass to the cultured animal (Avnimelech, 2014 and Bossier & Ekasari, 2017). This operates on the principle of increasing carbon to nitrogen ratios, through the addition of an exogenous carbon source that consequently stimulates natural heterotrophic bacterial growth in the system (Hargreaves, 2006 and De-Schryver et al. 2008). These bacteria will then convert otherwise toxic nitrogenous metabolites into microbial biomass known as Biofloc aggregates (Avnimelech, 2014 and Ebeling et al. 2006). Biofloc aggregates consist of various organic materials such as bacteria, microalgae, uneaten food and zooplankton which can serve as a constant supply of additional nutrients for aquatic animals that are capable of collecting and consuming these small particles (Emerenciano et al. 2013 and Bossier & Ekasari, 2017).

So, the aim of this work is to establish the effect of Biofloc technology (BFT) system on the fish density, water quality (total ammonia-N, Nitrite-N and Nitrate-N) and fish quality focused on growth parameters, haematology and biochemistry of produced fishes.

**MATERIALS AND METHODS**

**Fish experiment:**

The study was conducted in twelve 250-Liter (L) with used 200-L circular tanks. Monosex fingerlings of *Oreochromis niloticus* with 30.0 ± 2.1 g weight and 9.5 ± 1.1 cm length reared for 20 weeks extended from 11 June to 30 October 2019 at the Aquaculture Lab, Animal House, Faculty of Science, Al-Azhar University, Cairo.

Fishes were fed with 30% protein floating pellets. The proximate analysis of basic diet composed of 29.8% protein, 7.5% lipid, 12.4% ash and 6.9% water content. All fishes were fed with 3% of their body weight as two equal diets daily at 9:00AM and 4:00 PM, seven days a week. The feeding rate were calculated fortnightly by measuring not less than 30% of fishes of each group.

**Experimental design**

Fishes were grouped into two stocking densities each of three replicates; low stocking density (T1) consists of 12 fish (60 fish/m³) and high stocking density (T2) consists of 16 fish (80 fish/m³). All previous groups had molasses and rice bran (1:1) as a carbohydrate additional diet to achieve C: N equal to 15:1 according to (Avnimelech, 1999). Carbohydrate was fed after one hour of main meals with only addition of evaporation loss of water every week. Another six tanks (C1&C2 each of three replicates) were used as control without any additional carbohydrate and 50-70 % water was replaced every week to maintain the nitrogenous wastes under tolerable conditions.

**Water quality:**

Temperature (°C) and pH were checked every day by portable pH meter Adwa. Floc volume were measured by Imhoff cone within 20 minutes of precipitation according to (Avnimelech, 1999). Dissolved oxygen (mg/L), were measured two times weekly by
Winkler titration method while total ammonia nitrogen (TAN), nitrite nitrogen (NO$_2$-N) and nitrate nitrogen (NO$_3$-N) were measured spectrophotometrically every week according to (APHA, 1995)

**Measurements of growth performance**

Growth in weight (%), total weight gain (g/fish), average daily weight gain (mg/fish/day), specific growth rate (%/day), feed conversion ratio, Protein efficiency ratio (%) and feed efficiency of *Oreochromis niloticus* were determined according to (Recker., 1975 and Castell & Tiews., 1980) and using the following equations:

- Total weight gain (g/fish) = final fish weight ($W_F$) - initial fish weight ($W_I$)
- Average daily weight gain (mg/fish/day) = total weight gain (mg)/ duration period (days)
- Growth in weight (%) = total weight gain (g) - initial fish weight (g)
- Specific growth rate (SGR, % / day) = ($\ln W_F$ - $\ln W_I$) * 100/ duration period
- Food conversion ratio (FCR) = feed intake (g)/ total weight gain (g) (Tacon, 1987)
- Protein efficiency ratio (PER) = total gain (g)/ protein intake (g) (Davies & Morries, 1997)
- Protein intake (PI) = feed intake (g) × Protein% in the diet/100
- Feed efficiency (FE) = Weight gain (g) / Feed intake (g)

**Hepatosomatic (H.S.I) & Spleenosomatic (S.S.I) indices:**

Whole fish, liver and spleen were wet weighted to the nearest 0.01 g.; these indices were calculated according to the following equations:

\[
\text{Hepatosomatic index} = \frac{\text{wet weight of Liver (g)}}{\text{wet weight of fish (g)}} \times 100
\]

\[
\text{Spleenosomatic index} = \frac{\text{wet weight of Spleen (g)}}{\text{wet weight of fish (g)}} \times 100
\]

**Haematological and biochemical analysis:**

Total red blood cells (RBCs, 10$^6$ /ml), total white blood cells (WBCs, 10$^3$ /ml) and blood platelets (10$^3$ /ml) were counted according to (Dacie & Lewis, 2010). Hemoglobin concentration (HGB, g/dl) was determined spectrophotometrically based on cyanomethemoglobin method (blood was diluted in a Drabkin solution) then the concentration determined using standard curve (Noga, 2010).

Total protein was analyzed according to (Reinhold, 1953) and Albumin was analyzed by (Doumas et al. 1971) using a kit of Vitro Scient Company. Alanine amino transferase and Aspartate amino transferase (ALT and AST) were analyzed spectrophotometrically according to (White et al. 1970) using a Bio-Edwic kits.

**Statistical analysis:**

The Shapiro-Wilk normality test and Bartlett’s homoscedasticity test were employed at 5% significance. Three-way analysis of variance (ANOVA) was applied to the growth parameters and nutritional values using (SAS, 2003)
RESULTS

1. Water quality

The data in Table 1, showed water quality parameters of tanks that contain Oreochromis niloticus reared at different densities of Biofloc versus control groups for 20 weeks. They were at an acceptable range. Water temperature values fluctuated between 25.8 ± 2.7 at control low density group and 25.6 ± 2.7 °C at control high density group. pH values fluctuated between 7.6 ± 0.15 for control low density group and 7.0 ± 0.36 for Biofloc high density group.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Density</th>
<th>Treatment</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp (°C)</td>
<td>Low density</td>
<td>25.8 ± 2.7</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>25.7 ± 2.8</td>
<td>0.055</td>
</tr>
<tr>
<td>pH</td>
<td>Low density</td>
<td>7.6 ± 0.15</td>
<td>0.655</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>7.1 ± 0.37</td>
<td>0.773</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>Low density</td>
<td>5.8 ± 0.57</td>
<td>0.420</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>5.8 ± 0.54</td>
<td>0.093</td>
</tr>
<tr>
<td>TAN (mg/L)</td>
<td>Low density</td>
<td>0.89 ± 0.34</td>
<td>&gt; 0.001</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>1.06 ± 0.38</td>
<td>&gt; 0.001</td>
</tr>
<tr>
<td>Nitrite-N (mg/L)</td>
<td>Low density</td>
<td>1.10 ± 0.61</td>
<td>&gt; 0.001</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>1.18 ± 0.67</td>
<td>&gt; 0.001</td>
</tr>
<tr>
<td>Nitrate-N (mg/L)</td>
<td>Low density</td>
<td>246.8 ± 34.4</td>
<td>0.730</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>266.6 ± 41.8</td>
<td>0.166</td>
</tr>
<tr>
<td>FV ml/L</td>
<td>Low density</td>
<td>1.7 ± 0.5</td>
<td>&gt; 0.001</td>
</tr>
<tr>
<td></td>
<td>High density</td>
<td>2.6 ± 0.6</td>
<td>&gt; 0.001</td>
</tr>
</tbody>
</table>

DO= Dissolved oxygen, TAN= total ammonia Nitrogen and FV= Floc volume. * significant at (p<0.05).

Dissolved oxygen concentration ranged between 5.8 ± 0.57 and 5.4 ± 0.69 mg/L for low density control group and high density Biofloc group respectively. Total ammonia nitrogen (TAN) concentrations ranged between 1.06 ± 0.38 and 0.55 ± 0.17 mg/L for control high density and Biofloc low density groups, respectively. Nitrite-N concentrations fluctuated between 1.18 ± 0.67 and 0.65 ± 0.25 mg/L for control high density and Biofloc low density groups, respectively. Nitrate-N concentrations fluctuated between 266.6 ± 41.8 and 246.8 ± 34.4 mg/L for control high-density and low-density groups, respectively. Whereas the Floc volume measured were fluctuated between 21.7 ± 5.0 and 1.7 ± 0.5 ml/L for low density control and high density Biofloc groups, respectively (Table 1 and Figure 1).

Statistical analysis revealed that, no significance in temperature, pH, DO and Nitrate-N between Biofloc and control groups while total ammonia, Nitrite-N and Floc volume revealed a significant difference at all cases (p<0.05).
Impact of Biofloc technology on growth performance of *Oreochromis niloticus*.

2. Growth parameters.

Data in **Table 2**, revealed that final body weight values fluctuated between 192.9 ± 20.0 and 168.3 ± 17.5 g/fish for Biofloc high density and control high density groups, respectively. Total weight gain was fluctuated between 164.9 ± 17.2 g/fish for Biofloc high density and 139.5 ± 14.8 g/fish for control high density group. Average daily weight gain values ranged between 1175.9 ± 123.1 and 996.4 ± 106 mg/fish/day for Biofloc high density and control high density groups, respectively. Specific growth rate values ranged between 1.4 ± 0.1 and 1.3 ± 0.04 %/day for Biofloc high density and control high density groups, respectively.

Feeding conversion ratio fluctuated between 1.9 ± 0.2 and 1.4 ± 0.2 for high density control group and low density Biofloc groups, respectively. Protein efficiency ratios ranged between 2.3 ± 0.3 and 1.8 ± 0.2 for Biofloc low density and control high density groups, respectively. Feed efficiency fluctuated between 0.7 ± 0.1 and 0.5 ± 0.1 for Biofloc high density and control low density groups, respectively (**Table 2**).

**Figure 1.** Nitrogen waste compounds, TAN (A), Nitrite-N (B) and Nitrate-N (C) of tanks of *Oreochromis niloticus* reared at different experimental groups for 20 weeks.
Hepatosomatic index values fluctuated between 3.35 ± 0.69 % and 1.8 ± 0.52 % for high density Biofloc and control groups respectively. Spleenosomatic index values fluctuated between 0.28 ± 0.09 % and 0.07 ± 0.04 % for high density Biofloc and control groups respectively (Table 2).

All growth parameters revealed significant difference between Biofloc and control groups at high density while at low density only final body weight, Specific growth rate (SGR) and FCR were significant.

PER and FE were significantly different between Biofloc and control groups at all cases. Hepatosomatic index was non significant between Biofloc and control groups, while Spleenosomatic index was non significant only at low density.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Density</th>
<th>Treatment</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>Biofloc</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>Low</td>
<td>171.5 ± 15.3</td>
<td>187.9 ± 20.7*</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>168.3 ± 17.5</td>
<td>192.9 ± 20.0*</td>
</tr>
<tr>
<td>Total weight gain (g/fish)</td>
<td>Low</td>
<td>142.6 ± 14.6</td>
<td>155.2 ± 17.4</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>139.5 ± 14.8</td>
<td>164.6 ± 17.2*</td>
</tr>
<tr>
<td>ADWG (mg/fish/day)</td>
<td>Low</td>
<td>1018.3 ± 104.2</td>
<td>1108.3 ± 124.3</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>996.4 ± 106</td>
<td>1175.9 ± 123.1*</td>
</tr>
<tr>
<td>SGR (%/day)</td>
<td>Low</td>
<td>1.8 ± 0.2</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1.9 ± 0.2</td>
<td>1.6 ± 0.2*</td>
</tr>
<tr>
<td>FCR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein efficacy ratio (PER)</td>
<td>Low</td>
<td>1.0 ± 0.2</td>
<td>2.3 ± 0.3*</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1.8 ± 0.2</td>
<td>2.0 ± 0.2*</td>
</tr>
<tr>
<td>Feed efficacy (FE)</td>
<td>Low</td>
<td>0.5 ± 0.1</td>
<td>0.7 ± 0.1*</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.5 ± 0.1</td>
<td>0.6 ± 0.1*</td>
</tr>
<tr>
<td>Hepatosomatic Indexes</td>
<td>Low</td>
<td>2.39 ± 0.58</td>
<td>2.44 ± 0.27</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1.80 ± 0.52</td>
<td>3.35 ± 0.69</td>
</tr>
<tr>
<td>Spleenosomatic Indexes</td>
<td>Low</td>
<td>0.09 ± 0.03</td>
<td>0.16 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.07 ± 0.04</td>
<td>0.28 ± 0.09*</td>
</tr>
</tbody>
</table>

ADWG=Average daily weight gain, SGR=Specific growth rate, FCR=Food conversion ratio, PER=Protein efficiency ratio and FE=Feed efficiency.

3. Haematology and biochemistry

Haematological parameters of Oreochromis niloticus monosex fingerlings reared at BFT vs control groups were given in Table 3, and it revealed that: White blood cells (WBC’s) count fluctuated between 54.7 ± 2.0 and 40.8 ± 1.6 cell×10^3 /ml for Biofloc low density and control low density groups respectively. Red blood corpuscles (RBC’s) count fluctuated between 2.0 ± 0.6 and 1.4 ± 0.4 cell×10^6 /ml for control low density and control high density groups respectively. Hemoglobin (HGB) concentrations ranged between 9.7 ± 2.7 and 7.3 ± 2.6 g/dl for control high density and control low density.
groups respectively. Platelets count fluctuated between 210.0 ± 88.6 and 93.8 ± 11.1 cellx10³ /ml for control high density and Biofloc low density groups, respectively. All hematological parameters revealed non-significant difference between Biofloc and control groups except WBC’s at low density groups.

Total proteins concentrations ranged between 3.83 ± 0.20 and 3.57 ± 0.14 g/dl for control high density and Biofloc low density groups, respectively. Albumin concentrations ranged between 1.20 ± 0.22 and 0.97 ± 0.14 g/dl for control low density and Biofloc high density groups, respectively. Alanine aminotransferase (ALT) activity fluctuated between 87.5 ± 15.1 and 69.1 ± 13.9 IU/ml for control high density and control low density groups respectively. Aspartate aminotransferase (AST) activity fluctuated between 97.3 ± 13.5 and 75.7 ± 15.6 IU/ml for Biofloc low density and Biofloc high density groups, respectively. All biochemical investigations revealed non-significant difference between Biofloc and control groups (Table 3).

Table 3. Hematological and biochemical parameters of Oreochromis niloticus monosex fingerlings reared at BFT vs Control groups for 20 weeks.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Density</th>
<th>Treatment</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>Biofloc</td>
</tr>
<tr>
<td>WBCs (10³ cells/ml)</td>
<td>Low</td>
<td>40.8 ± 1.6</td>
<td>54.7 ± 2.0 *</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>44.4 ± 2.7</td>
<td>45.3 ± 3.2</td>
</tr>
<tr>
<td>RBCs (10⁶ cells/ml)</td>
<td>Low</td>
<td>1.4 ± 0.4</td>
<td>1.8 ± 0.6</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>2.0 ± 0.6</td>
<td>1.6 ± 0.7</td>
</tr>
<tr>
<td>HGB (g/dl)</td>
<td>Low</td>
<td>7.3 ± 2.6</td>
<td>8.8 ± 3.0</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>9.7 ± 2.7</td>
<td>7.8 ± 2.8</td>
</tr>
<tr>
<td>Platelets (10³ cells/ml)</td>
<td>Low</td>
<td>120.3 ± 47.2</td>
<td>93.8 ± 11.1</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>210.0 ± 88.6</td>
<td>124.3 ± 33.1</td>
</tr>
<tr>
<td>Total proteins</td>
<td>Low</td>
<td>3.73 ± 0.20</td>
<td>3.57 ± 0.14</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>3.83 ± 0.20</td>
<td>3.72 ± 0.16</td>
</tr>
<tr>
<td>Albumin</td>
<td>Low</td>
<td>1.20 ± 0.22</td>
<td>0.98 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1.07 ± 0.12</td>
<td>0.97 ± 0.14</td>
</tr>
<tr>
<td>ALT</td>
<td>Low</td>
<td>69.1 ± 13.9</td>
<td>81.5 ± 11.9</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>87.5 ± 15.1</td>
<td>78.3 ± 14.5</td>
</tr>
<tr>
<td>AsT</td>
<td>Low</td>
<td>85.1 ± 13.3</td>
<td>97.3 ± 13.5</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>88.3 ± 14.4</td>
<td>75.7 ± 15.6</td>
</tr>
</tbody>
</table>

WBC’s = White blood cells, RBC’s= Red blood corpuscles and HGB= Haemoglobin.
* = Significant difference (P<0.05).

DISCUSSION

The present study revealed that, Water quality parameters; DO, temperature, pH, TAN, Nitrite-N and Nitrate-N; were within the normal limits of fish culture. This results agreed with the finding of Stone & Thomforde, (2004) and Emerenciano et al. (2013). Temperature, pH, DO and Nitrate-N didn't show significant difference between Biofloc and control treatments that agreed with El-Shafiey et al. (2018), while Azim & Little, (2008) observed significant decrease at pH due to respiration and the processes of
degradation, assimilation and nitrification carried out by microorganisms, including autotrophic bacteria. The present work mentioned low of DO at Biofloc high density (T2) to 4.3 mg/dl that may be due to an increase in the metabolic activity of the aerobic bacteria present in the culture environment because of addition of Carbohydrate organic load that agreed with De-Schryver et al. (2008).

The present study revealed that Nitrate-N gradually increased at first four weeks as a result of nitrification, then showed slight fluctuation that may be due to Denitrification that can convert nitrate to nitrogen gas by microbial process that agreed with Ray et al. (2010).

Generally, TAN, Nitrite-N and Floc volume revealed a significant difference at all cases. At first 6 weeks there were no differences between behavior of TAN and NO₂-N. Biofloc treatments slightly fluctuated and didn’t increase after the 6th week. Because of carbohydrate addition that either assimilate nitrogen wastes by heterotrophic bacteria to bacterial biomass or convert nitrite to nitrate. This result agrees with Avnimelech (2014), where the NO₃ produced can also be reduced to NO₂ and NH₃ by the process of denitrification (Luo et al. 2014).

Growth performance of Oreochromis niloticus fingerlings at the current study showed significance difference in all the treatments (P < 0.05) at high density while at low density only FCR, PER and FE showed significant difference. This could be due to the Biofloc produced a medium rich in organic matter made of bacteria, phytoplankton, protozoa, filamentous bacteria, nematodes, ciliates, flagellates and rotifers which serve as natural food and contains a high protein level (15 ± 2 % protein, unpublished data) for O. niloticus and thus improving growth performance and survival for the cultured fish in the system. The treatments resulted in increased growth rate and lower FCR compared to control tanks. A non-significant difference between different carbon sources on both tilapia and shrimps was found (Serra et al. 2015; Da-Silva et al. 2017; Khanjani et al. 2017 and El-Shafie et al. 2018). On the other hand, growth performance of Peneus monodon was higher with addition of jaggery in Biofloc system than other carbon sources like cane sugar and molasses (Sakkaravarthi & Sankar, 2015). Meanwhile, mixture of different carbon sources (60% molasses + 20% corn flour + 20% wheat bran) positively affected the growth of Litopenaeus vannamei in comparison with molasses as a single carbon source (Wang et al. 2016).

The present results revealed that Biofloc system increases utilization of protein and converts most of the diet to the body mass in these treatments. Similar finding conquers with Emerenciano et al. (2013) result which demonstrated that Biofloc can enhance the digestion and utilization of artificial feeds as well as improving the growth performance of aquatic animals. Molasses containing sucrose, a disaccharide, which is more effective compared to other carbohydrate sources that contain starch, which is a polysaccharide. Ballester et al. (2010) showed that Biofloc is a good food, low cost strategy which is better than traditional culture system because the formed flocs have high protein, lipids, carbohydrates and ashes content and can be used as food in aquaculture industry. It is possible that Biofloc stimulates digestive enzyme activity (Avnimelech, 1999 and Kuhn et al. 2010). This could contribute to increased growth of Nile tilapia at Biofloc against control treatments. As well as some other studies demonstrated that, Bioflocs improved the growth performance and protiens utilization as
they produce exogenous microbial enzymes such as proteases (Arnold et al. 2009; Xu & Pan, 2012 and Zhang et al. 2016) and also induce the generation of endogenous digestive enzymes (Xu & Pan, 2014 and Najdegerami et al. 2016) that facilitating the digestion and absorption of feed nutrients. Water consumption in the present work at Biofloc treatments was 9 times lower than control once. This result agrees with De-Lima et al. (2018) who found decrease of water consumption with 11.5 times compared with control treatments.

Hepatosomatic index (HSI) and transaminases ALT and AST were not significantly different between Biofloc and control treatments. The same results were obtained by many authors (El-Mohammady et al. 2015 and Romano et al. 2018). Adineh et al. (2019) noticed that HSI was significantly lower in the clear water group than all Biofloc groups. An increased mobilization of liver reserves caused by higher energy demands under high density conditions can be responsible for lower HSI in clear water group (Trenzado et al. 2007).

At the present work, Spleenosomatic index (SSI) showed no significant difference between Biofloc and control treatments at low density but at high density there were significant difference that may be due to condensed bacterial biomass which may stimulate lymph organ (spleen) to be enlarged. This splenomegaly slightly effected on hematological parameters. Hembre et al. (2005) and El-Mohammady et al. (2015) mentioned that soya bean meal might cause early release of immature erythrocytes which may be responsible for increased spleen size enlargement of Oreochromis niloticus whose feed on plant origin protein.

Blood biochemistry indices are useful tools that aid in indicating the general state of fish health which can differ with water characteristic and nutritional state (Dawood et al. 2015 and El Basuini et al. 2017). Overall, blood parameter values recorded in the present study are within the acceptable limits of the Nile tilapia, the same results were mentioned by Ayyat et al. (2017) and Mahmoud & El-Hais, (2017). The present work revealed non significant difference between Biofloc and control groups at all hematological and biochemical parameters except WBC’s at low density. However, there were slightly decrease at hemoglobin and platelets that may be due to splenomegaly. These results were partially in agreement with Azim & Little, (2008) and Long et al. (2015) where their results revealed no significant effect on all hematological parameters between Biofloc and control groups of Oreochromis niloticus. On the other hand, significantly decreased hematological indices (RBC’s, WBC’s, HGB and blood platelets) were reported by increasing stocking density of Nile tilapia (Mehrim, 2009; Kpundeh et al. 2013 and Zaki et al. 2020). On the other side, Xu & Pan, (2013) found that the total hemocyte count in shrimp was significantly higher in Biofloc treatments than in the control group due to different experimental conditions.

Total protein and albumin biochemical parameters appeared non significant difference among Biofloc and control groups at the present work. The same results were mentioned by Long et al. (2015) while Verma et al. (2016) mentioned significantly difference of total proteins and albumin of Labeo rohita reared at Tapioca based Biofloc system while wheat, corn, sugar bagasse based Biofloc system were non significant.
CONCLUSION

The present study concluded that Biofloc aquaculture technology improves water parameters stability and fish growth performance with the same fish quality. As well as, the high stocking density (80 fish/m$^3$) is more yield productive treatment.

REFERENCES


Impact of Biofloc technology on growth performance of *Oreochromis niloticus*.


