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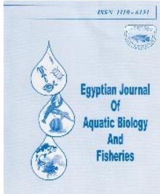


# The Growth Rates of the Nile Tilapia (*Oreochromis niloticus*) and the Common Carp (*Cyprinus carpio* L.) Under Biofloc Technology by Using Different Carbon Sources

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## ABSTRACT
The study aimed to evaluate the impact of different carbon sources on biofloc generation of Nile tilapia, *Oreochromis niloticus* and common carp, *Cyprinus carpio*. 360 healthfully Nile tilapia and common carp were subject to an experiment for the current research work. The Nile tilapia had a starting body weight of 6.5±0.4g, while the common carp had a starting body weight of 6.9±0.1g. The samples were divided into six equal groups, with the initial three groups designated for the Nile tilapia and the remaining groups for the common carp. Each group was duplicated three times with 20 fish in each replication. Four diets were adjusted for the experiment. The first and fourth groups, serving as control groups, were given a baseline control diet containing 25% crude protein (CP). Groups two, three, five, and six were given a basic diet with 25% CP, along with additional molas and starch for carbohydrate supplies.The trial extended for 60 days. Both the Nile tilapia and common carp exhibited the highest feed conversion ratio and a superior weight gain when provided with starch and molasses compared to the control group. There was no notable change in water temperature across the groups. The biofloc groups had higher oxygen levels compared to the control group. Ammonia levels decreased in all treated groups in comparison with the control groups. The Nile tilapia and the common carp experienced an improvement in both growth performance and water quality in a biofloc system utilizing different carbon sources.

## INTRODUCTION

In 2020, the aquaculture industry made a substantial contribution by producing 122 million tons of food to global food security **(FAO, 2022; Khanjani *et al*., 2023a)**. Since the 1980s, aquaculture has become more important in supplying fish for human consumption, as shown by **FAO (2018)** and **Tinh *et al*. (2021)**. Thus, future growth in the aquaculture industry should focus on maximizing resource efficiency, as suggested by **Crab *et al*. (2012)** and the **World Bank (2013)**.

Enhancing the effective use of essential natural resources including water, land, and fish feed is vital for aquaculture operations **(Tinh *et al*., 2021)**. Sustainable growth is necessary to protect the environment, conserve natural resources, and maintain the profitability of the aquaculture industry. Aquaculturists globally are keen in sustainable production techniques viz. biofloc technology **(Bossier & Ekasari, 2017; Salama *et al*., 2021)**.

Biofloc technology (BFT) is a method created to address these issues **(Ahmad *et al*., 2017; El-Sayed *et al*., 2021; Mabroke *et al*., 2021; Khanjani *et al*. (2023b)**. **Ekasari and Crab (2015)** advocated using aquaculture biofloc technology systems as an efficient alternative to traditional fish raising systems to solve water conservation and minimize water circulation. Biofloc technology is hailed as the upcoming "blue revolution" in aquaculture because to its capacity to stimulate the growth of microorganisms by the addition of carbohydrates, including sucrose, glucose, cassava, starch, molasses, or cellulose to the water in order to regulate the carbon-to-nitrogen ratio (C:N ratio). Higher C:N ratio promotes bacterial development, resulting in rapid proliferation **(Khanjani *et al*., 2023b)**.

BFT is a potential strategy for improving water quality and decreasing nutrient-rich effluents in the environment because of its low water exchange, as demonstrated by **Martínez-Cordova *et al*. (2015)** and **Walker *et al*. (2019)**. Biofloc technology utilizes a consortium of microorganisms, including bacteria, microalgae, fungus, and zooplankton, to enhance water quality through the formation of protein-rich microbial bioflocs. This approach decreases the feed conversion ratio (FCR) of aquatic species, enabling the utilization of low-protein feeds, and resulting in cost reduction and economic benefits in aquaculture. In order to achieve low or zero-water exchange in BFT, it is essential to use cost-effective or easily accessible waste carbon sources to decrease expenses and improve overall profits **(Zaki *et al*., 2020)**.

Carbohydrates are vital nutrition for animals. Sufficient carbohydrate levels in farmed fish diets enhance the quality of extruded feed pellets and support the protein sparing effect for energy requirements. Carbohydrates are a cost-efficient and ideal energy source in diets. However, fish species vary in their ability to use carbohydrates depending on their feeding habits, the quantity of dietary carbohydrates, and the complexity of their diet. Studies have shown that animals maintained in a controlled setting benefit from ingesting biofloc by experiencing an improved growth rate, a decreased feed conversion ratio, and reduced feed costs **(Burford *et al*., 2004; Wasielesky *et al*., 2006)**. Bioflocs including bioactive compounds that improve survival and defense mechanisms, offer nutrients, and control water quality. This suggests a novel approach to health management in aquaculture by boosting the innate immune system of cultivated animals **(Ahmad *et al*., 2017)**.

Catfish and tilapia, freshwater finfish species cultivated using the BFT technique, were the predominant aquaculture species globally in 2016, accounting for more than half of total aquaculture production, as reported by **FAO (2018)**. The Nile tilapia is a warm-water omnivorous fish specimen that is widely farmed for its fast growth, high fillet yield, and strong resistance to diseases **(Wang *et al*., 2005)**. The Nile tilapia can efficiently metabolize up to 40% of digestible food carbohydrates, making it an ideal fish species for investigating the effects of dietary carbohydrates in long-term studies.

There is a growing interest in cultivating freshwater fish from the Cyprinidae family using the BFT technique. Minimal attempts have been made to evaluate the effectiveness of the system with various species in this family **(Kamilya *et al*., 2017)**. These fish exhibit suspension-feeding behavior and possess a greater tolerance to increased quantities of suspended solids, making them ideal for thriving in the BFT system **(Romano *et al*., 2018)**. Using different carbon sources in a biofloc system significantly affects water quality indicators, microbial community composition, and the growth and survival of common crop fry **(Mishra *et al*., 2024)**. The amount of organic carbon significantly impacts the water quality and the development of the Nile tilapia in biofloc systems **(AbouelFadl *et al*., 2022)**.

This study intended to assess the effects of different carbon sources on water quality indicators and the growth rates of the Nile tilapia and common carp.

## MATERIALS AND METHODS

### Experimental site and duration

The research was carried out in El-hag Bahy El-deen Monir Farm in Kafr El-Sheikh Governorate, Egypt, and spanned a duration of 60 days.

### Study design and dietary treatments

360 healthy Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*) were obtained from a private farm in Kafr El-Sheikh, Egypt. The initial body weight was 6.5±0.4 g for the Nile tilapia and 6.9±0.1g for the common carp.The fish were kept in a water circulation system to maintain ideal circumstances. The research was conducted in eighteen plastic containers, each with a capacity of 35 liters and measuring 48 x 35 x 20 cm. The fish were acclimated for 20 days before starting the experiment. Before the experiment started, the participants were divided into six equal groups, with three groups per species, and each group was reproduced three times with 20 fish in each replication. Four experimental diets were presented for discussion: The first and fourth groups were assigned as controls and received the baseline control diet containing 25% crude protein (CP). Groups two, three, five, and six were given a baseline diet with 25% CP, supplemented with molas and starch for carbohydrates. The fish were given a daily ration equivalent to 5% of their body weight, split into two feedings every day. Every 20 days, fish in each replicated tank were weighed, and adjustments were made to the daily meal and carbon source quantities according to the fish's weight.

### Supervising the quality of water

The study involved daily and weekly measurements of water temperature, dissolved oxygen levels, pH, and ammonia concentrations using thermometers, portable digital pH meters (Martini Instruments type 201/digital), and waterproof portable BOD and DO meters (type Hanna waterproof IP67). TAN was measured using **El Sayed**'s **(2006)** technique.

### Growth performance parameters

Measurements of growth parameters were taken at 20-day intervals. After the feeding trial, growth parameters such as initial weight, weight gain (WG), survival rate (SR), specific growth rate (SGR), and feed conversion rate (FCR) were computed using the formulas outlined by **Castell and Tiews (1980)**.

**Weight gain (WG) = Final fish weight (g) – Initial fish weight (g)**

**Survival rate (%) = Number of live fishes * 100/Total initial number of fish**

**Specific growth rate (SGR %) = log FW – log IW/ t * 100**

**Feed conversation ratio (FCR) = Feed intake (g) / Weight gain (g)**

FW denotes the final weight of the fish in grams. The initial weight of fish is labeled as IW in grams, and t signifies the total experimental days.

### Statistical analysis

Excel 2013 was used to create a database for the initial investigation, employing descriptive statistics. The data were presented as the mean value plus or minus the standard deviation. The data were subjected to one-way analysis of variance (ANOVA) to assess the effect of treatment inclusion on fish performance. The data were analyzed using SPSS version 16 software **(SPSS, 1997)**. Mean differences were analyzed using Duncan's multiple range test with a significance level of $P<0.05$.

## RESULTS

### Water quality

Table (1) displays the water quality parameter measurements for the Nile tilapia and common carp. The average water temperature fluctuated between 26.6 and 26.8°C. The biofloc groups had higher dissolved oxygen levels compared to the control group in both the Nile tilapia and common carp treatments, ranging from 6.5±0.4 to 7.5±0.5 and 6.8±0.5 to 8.0±0.5 mg/L, respectively. Ammonia levels were reduced in all treatment groups in comparison with the control group. Concentrations in tilapia treatments ranged from 1.06±0.9 to 0.8±0.7, whereas in common carp treatments, concentrations varied from 1.02±0.7 to 0.6±0.4. The pH levels for the tilapia treatment ranged from 7.3±0.6 to 7.8±0.5, whereas for the common carp treatment, it ranged from 7.9±0.4 to 8.1±0.5.

**Table 1.** Water quality values of aquaria used in rearing the Nile tilapia (*O. niloticus*) and common carp (*C. carpio*) after 60 days of culture with different diets in the biofloc system

| Item | The Nile tilapia (*O.niloticus*) | | | Common carp (*C. carpio* L.) | | |
|---|---|---|---|---|---|---|
| | Control | Starch | Molas | Control | Starch | Molas |
| Temperature (o C) | 26.8±2.3 | 26.6±2.5 | 26.8±2.5 | 26.8±2.3 | 26.6±2.5 | 26.8±2.5 |
| DO (mg/L) | 6.5±0.4 | 7.3±0.5 | 7.8±0.6 | 6.8±0.5 | 7.9±0.4 | 8.0±0.5 |
| pH | 7.3±0.6 | 7.6±0.4 | 7.8±0.5 | 7.9±0.4 | 8.1±0.5 | 7.9±0.4 |
| Ammonia (mg/L) | 1.06±0.9 | 0.9±0.3 | 0.8±0.7 | 1.02±0.7 | 0.6±0.4 | 0.9±0.5 |

### Growth performance parameters

Table (2) shows the growth rates of the Nile tilapia in the control, molas, and starch groups. Weight gain and the feed conversion ratio (FCR) were somewhat higher in fish fed starch compared to those fed molas. The control group exhibited less significance in comparison with both starch and molasses. Survival rates did not differ significantly across the starch, molas, and control groups, with the highest survival rate shown in the starch group. SGR levels were somewhat higher in fish that received molas compared to the starch treatment, and both were moderately raised compared to the control group.

**Table 2.** Growth performance of the Nile tilapia (*O. niloticus*) after 60 days of culture using different diets in the biofloc system

| Item | Control | Starch | Molas |
|---|---|---|---|
| Initial weight (g/fish) | 6.5±0.4 | 6.5±0.4 | 6.6±0.7 |
| Final weight (g/fish) | 23.4±0.8$^{a}$ | 24.6±0.4$^{a}$ | 24.3±1.0$^{a}$ |
| Weight gain (g/fish) | 16.9±1.3$^{b}$ | 18.1±0.4$^{a}$ | 17.7±0.8$^{a}$ |
| Survival rate (%) | 96.3±1.3$^{b}$ | 97.4±0.5$^{a}$ | 96±1.3$^{b}$ |
| SGR (%/d) | 3.4±0.2$^{b}$ | 4.4±0.4$^{a}$ | 4.5±0.5$^{a}$ |
| FCR | 1.4±0.1$^{a}$ | 1.1±0.1$^{b}$ | 1.2±0.1$^{b}$ |

Values with different superscripts in the same raw indicated significant differences ($P\leq 0.05$)

Table (3) displays the growth rates and survival rate parameters findings. The starch groups exhibited the greatest weight growth in the common carp, followed by the molas group, and lastly the control group. Molas had the highest survival rate, and there was no significant difference in survival rates between the starch and control groups. The starch groups had the most significant FCR values, whilst the molas and control groups did not demonstrate any significant difference.

**Table 3.** Growth performance of common carp (*C. carpio*) after 60 days of culture using different diets in the biofloc system

| Item | Control | Starch | Molas |
|---|---|---|---|
| **Initial weight (g/fish)** | 7.2±0.08 | 6.9±0.1 | 7.1±0.2 |
| **Final weight (g/fish)** | ±0.544.2 $^{b}$ | ±0.849.1 $^{a}$ | ±2.346.5 $^{b}$ |
| **Weight gain (g/fish)** | 37±0.5$^{c}$ | 42.2±0.3$^{a}$ | 39.4±0.1$^{b}$ |
| **Survival rate (%)** | 95.2±0.6$^{b}$ | 95.8±0.5$^{b}$ | 96.8±0.4$^{a}$ |
| **SGR (%/d)** | 2.8±0.6$^{a}$ | 2.9±0.2$^{a}$ | 3.1±0.3$^{a}$ |
| **FCR** | 1.5±0.1$^{a}$ | 1.1±0.2$^{b}$ | 1.3±0.1$^{a}$ |

Values with different superscripts in the same raw indicated significant differences ($P \leq 0.05$)

## DISCUSSION

Water quality characteristics are crucial in aquaculture since they have a direct impact on fish development and weight gain in addition to playing a key role in sustaining a healthy aquatic environment **(Sunny *et al*., 2017; Khanjani *et al*., 2020, 2021; Osman *et al*., 2021)**. The study found that water quality metrics for the Nile tilapia and common carp in a biofloc system with various carbon sources matched the standard range recommended by numerous authors **(Popma & Lovshin, 1995; Awad *et al*., 2021; Abouel-Fadl *et al*., 2022)**. Biofloc technology improves water quality by converting ammonium into simpler chemicals more quickly than nitrification **(Kumar *et al*., 2019)**. Waste products and leftover nutrients from feed are converted into bacterial biomass, creating biofloc which can serve as extra food for aquatic animals **(Avnimelech, 2006)**.

The examination found that the water temperature ranged from 26.6 to 26.8 ºC in all treatments, aligning with the optimal temperature range for fish development and survival, as shown in other studies **(Essa, 1993; Boyd, 1998; Henish, 2016)**. **Hwihy *et al***. (**2021**) found that *Oreochromis niloticus* grown in biofloc systems at various stocking densities showed better outcomes than the control group of fish (28.5± 0.53, 7.8± 0.33). On the other hand, dissolved oxygen is an essential factor for differentiating between different types of water bodies **(Ibrahim & Ramzy, 2013; Osman *et al*., 2021)**. The oxygen requirements of fish in the culture system are frequently influenced by the levels of nitrite and ammonia **(Tilak *et al*., 2007; Remen *et al*., 2008)**.

The two selected carbon sources in the research exhibited significantly higher levels of dissolved oxygen compared to the control.Several writers have corroborated this discovery **(Thilakan *et al*., 2019; Tabarrok *et al*., 2020; AbouelFadl *et al*., 2022; Liu *et al*., 2023)**. The dissolved oxygen (DO) levels varied between 6 and 7.8 mg L-1 throughout the experiment. Both the tilapia and common carp biofloc groups showed elevated oxygen levels in comparison with the control group. In their study, **Hwihy *et al.* (2021)** found a decrease in the dissolved oxygen levels in the biofloc in comparison with the control group. Maintaining optimal pH levels is crucial for balancing the presence of dangerous and innocuous ammonia in aquatic settings. Notably, ammonia poisoning can be lethal to fish in ponds. The pH levels were suitable for tilapia, grass carp, and common carp in the BFT system, utilizing various carbon sources **(Tabarrok *et al*., 2020; Awad *et al*., 2021; AbouelFadl *et al*., 2022; Liu *et al*., 2023)**.

**Suita *et al*. (2015)** and **Wang *et al*. (2016)** found that bacteria in biofloc contribute to food consumption, water quality control, and the breakdown of nitrogen compounds, specifically ammonia. All experimental groups exhibited significantly reduced levels of ammonia compared to the control group, reaching optimal values for fish rearing. The group that consumed molas had the lowest amount, followed by starch in the Nile tilapia, and vice versa in the common carp. The quicker decrease in ammonia levels observed in the molas and starch groups, which use simple carbon sources, is likely because these sources are more easily absorbed and used by heterotrophic bacteria. The bacteria metabolize ammonia, improving water quality according to several studies **(Khanjani *et al*., 2017; El-Shafiey *et al*., 2018; Tabarrok *et al*., 2020; Awad *et al*., 2021; Khanjani *et al*., 2021; Liu *et al*., 2023)**. *Oreochromis niloticus* and *Cyprinus carpio* had increased final weight, weight growth, and SGR in bioflocs treatments with meals including molas and starch compared to the control group. This finding is consistent with previous studies **(Avnimelech, 1999, 2007; AbouelFadl *et al*., 2022)** which centered on *Oreochromis mossambicus*. The growth of tilapia was not affected by the use of various carbon sources in biofloc production, as reported by **Silva *et al*. (2017)**. **Mishra *et al*. (2024)** found that the growth rate of different carbon sources in the BFT system increased when raising common carp fry. Multiple authors have shown that the growth of shrimp or tilapia was not impacted by the addition of different carbon sources in the biofloc system. The growth of tilapia in a biofloc system was not affected by the inclusion of molas, sugar, or cassava starch. Both common carp and the Nile tilapia demonstrated a good adaptation to altered nutritional circumstances in a biofloc system, leading to an improved growth. Microbial clusters raised the production and effectiveness of digestive enzymes, leading to a greater nutrient absorption in the fish's gut. This likely enhanced the fish's growth and effectiveness of feed consumption **(Moss *et al*., 2001; Xu *et al*., 2012; Xu & Pan, 2012)**.

The development of the Nile tilapia and common carp fish cultivated in BFT was unaffected by the carbon source. The current research validated the finding of **Mishra *et al*. (2024)** determining that the survival rate was greater in the experimental tanks with different carbon sources in the BFT system than in the control group.The biofloc groups exhibited the most notable feed conversion ratio (FCR) values in comparison with the control groups in the study. Previous studies have linked growth, indicating good health and a lower feed conversion ratio (FCR), to biofloc technology (BFT) systems' capacity to supply necessary nutrients like unsaturated fatty acids, crude protein, vitamins, and minerals **(Azim *et al*., 2008; Bakhshi *et al*., 2018)**. Several research have shown that biofloc can lower production costs and can be used as a food source for the Nile tilapia and common carp **(Crab *et al*., 2010; Xu & Pan, 2014; Luna-González *et al*., 2017; Adineh *et al*., 2019; Zhao *et al*., 2022)**. Furthermore, **Zhao *et al*. (2012)** showed that biofloc enhanced carp production in a polyculture system.

## CONCLUSION

The study showed that employing biofloc as a substitute carbon source may improve water quality and boost development in the Nile tilapia and the common carp farming, without requiring water exchange.

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