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The Effect of Biofloc Technology on the Growth of Ornamental Fish C. auratus (Goldfish)

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Abstract
Biofloc technology is based on microbial activities that immobilise nitrogen and carbon. The current study sought to maintain water quality while improving the production performance of *C.auratus* (Goldfish) in a zero-water exchange biofloc system. 30 *C. auratus* (Goldfish) were placed in each treatment and control tank in triplicate and fed a designed food at a rate of 3% of body mass daily. In control-2, 50% of the water was exchanged weekly in accordance with industry standards, while no water was swapped in control-1 and the treatment. Depending on the percentage of total ammonia nitrogen (TAN) in the water, molasses was added as a carbon source to the treatment tanks to maintain a C:N ratio of 20:1.The water quality in the biofloc treatment, control-1, and control-2 was suitable for *C.auratus* (Goldfish).TAN and pH levels were considerably higher in tanks with no water exchange ($P < 0.05$). The biofloc treatment significantly increased weight gain, specific growth rate, survival rate, ultimate weight, and length of *C.auratus* (Goldfish) compared to the control group ($P < 0.05$). Fish grown in the biofloc treatment exhibited a much brighter red body and fin colour than the controls. In zero-water exchange culture systems, biofloc technology can be used to maintain water quality while also improving *C.auratus* (Goldfish) productivity.

Keywords; *C.auratus* (Goldfish), TAN, Biofloc technology, zero-water exchange.

Introduction

Biofloc technology (BFT) is gaining popularity in the aquaculture industry because it improves water quality, reduces infections, eliminates waste, and increases food availability for farmed organisms (Azim and Little, 2008). Bioflocs are formed by aggregating bacteria, fungi, algae, zooplankton, and protozoa in a matrix containing particulate organic matter (Emerenciano *et al.,* 2017). BFT preserves water quality primarily by favouring heterotrophic bacterial communities over autotrophic microorganisms with a high carbon-to-nitrogen (C:N) ratio (Deocampo *et al.,* 2021). Heterotrophic bacteria may easily absorb nitrogenous byproducts (Crab et al., 2010) and regulate inorganic nitrogen accumulation in aquaculture systems via carbon metabolism and nitrogen-immobilizing microbial activity (Avnimelech and Kochba, 2009).

The majority of feeds used in semi-intensive aquaculture systems have a C:N ratio of around 10:1, whereas bacteria require approximately 20 units of carbon per unit of nitrogen digested (Minabi *et al.,* 2020). As a result, when the C:N ratio in the feed is low, carbon becomes the limiting nutrient for heterotrophic bacteria populations in aquaculture systems (Asaduzzaman *et al.,* 2009), and the bacterial population cannot grow beyond a certain point due to a limited supply of carbon (Panigrahi *et al.,* 2019). As a result, bioflocs are produced in aquaculture systems by adjusting the carbon:nitrogen ratio from 15:1 to 20:1 (Kishawy *et al.,* 2020). Cheap and locally available byproducts from the human and animal food industries are often used as carbon sources in biofloc growth systems. Carbohydrate sources such as molasses, glycerol, plant meals (e.g., wheat, corn, rice, tapioca, etc.) (Rajkumar *et al.,* 2016), sugar cane bagasse, and chopped hay (Hargreaves, 2013) have been used to maintain a high C:N ratio and manage N compounds in aquaculture systems. Rice bran, one of the most commonly used carbon sources in biofloc culture systems (Bakhshi *et al.,* 2018), is one of the most cost-effective carbon sources in Asia and Sri Lanka. BFT has been employed in brackish and marine prawn (Ju *et al.,* 2008), freshwater prawn (Crab *et al.,* 2010), and finfish aquaculture (Ekasari *et al.,* 2015). However, BFT has rarely been employed to improve production performance and preserve water quality in ornamental fish culture systems (Wang *et al.,* 2015). In 2021, the leading exporters of freshwater ornamental fish included Japan ($41.2 million), Singapore ($40.6 million), Indonesia ($34.5 million), Thailand ($34.4 million), and Sri Lanka ($20.97 million).

While many industries incurred significant losses because of the covid-19 outbreak, Sri Lanka's ornamental fish industry achieved record highs of US$ 20.97M and US$ 21.74M in 2021 and 2022, respectively (EDB, 2023).

The goldfish, *C.auratus* (Laurentii Salvii; 1758), is the most popular ornamental fish in the family *Cyprinidae* and subfamily *Cyprininae*.It was first domesticated in China about a thousand years ago, and several diverse breeds have subsequently emerged. Goldfish are omnivorous and oviparous in nature, and they can be highly resilient, making them ideal for both aquarium and laboratory environments. Ornamental fish have traditionally been fed live food, which is often

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nutritionally insufficient and a source of disease (parasitic, bacterial, and viral). Sales and Janssens (2003) evaluated the nutritional requirements (protein and minerals) for growing freshwater ornamental species, with a focus on providing live feed throughout the early stages of life. The majority (>80%) of artificial feed is wasted in the aquaculture system as uneaten feed and faeces (Daniels and Boyd, 1989).Artificial feed, which is lost in the rearing system, has a significant impact on water quality via breakdown (Homer et al 1989).As aquaculture production intensifies, the prevalence of diseases, notably infectious diseases, increases, resulting in large economic losses.The use of antibiotics and other chemotherapeutics for disease control has been criticised for its detrimental effects.Biofloc Technology (BFT) is an aquaculture technology that focusses on making better use of fertiliser input while using low or nil water exchange.The primary premise of BFT is to recycle nutrients by maintaining a high carbon/nitrogen (C/N) ratio in the water, which stimulates heterotrophic bacterial growth that transforms ammonia into microbial biomass. Avnimelech Y. (1999). In ornamental fish culture, rearing young ones is the most difficult phase, where commercial ornamental fish farmers face numerous challenges due to low survival rates, the availability of the right type of live feed, water quality management, disease incidence, and so on. However, these issues can be easily avoided using biofloc technology. The current study was conducted to determine the impact of biofloc technology in the rearing of goldfish *C. auratus* juveniles.

Materials and Methods

Experimental setup:

The experiment lasted 90 Days and used glass tanks with a size of 70 L, which were set up indoors. The tanks were shaded to keep direct sunlight out, as light penetration into the tanks could boost the growth of planktonic, filamentous cyanobacteria, which could create toxins or compete with heterotrophic bacteria. The tanks were filled with water before stocking. An oxygen pump (Model SOBO SB-248A) was used to continually aerate all of the tanks 24 hours per day. A fully randomised design was used to allocate triplicate treatments (biofloc) and control tanks (control-1 and control-2). During the experiment, no water was exchanged between treatment and control-1. Only the water lost due to evaporation was replenished in those tanks, whereas half of the water was exchanged weekly in control-2. During the experiment, no molasses was added to either control to change the C:N ratio. Control-2 was utilised to assess the impact of zero water exchange on the growth performance of *C. auratus* (Goldfish) in a culture system with no C:N ratio adjustment.

Fish stocking and maintenance:

Each experimental tank held 30 *C. auratus* (Goldfish) with an average weight of 1.50 ± 0.08 g and a standard length of 45.78 ± 1.02 mm. Fish were acclimatised for a week before the start of the investigation. They were fed a commercial diet (containing 50% crude protein, 10% crude fat, and 0.1% crude fibre) at 3.5% of their body weight every day. The feed ratio was divided into two equal amounts and distributed at 10 a.m. and 3 p.m. The feed ratio was adjusted biweekly according to changes in fish body weight. The feed weight was determined with an electrical balance (Model OHAS CORP, PA4102C).

Temperature, dissolved oxygen (DO), salinity, and pH in tank water were measured weekly by a portable multimeter (Model HQ40D). Total ammonia nitrogen (TAN) was measured weekly according to the standard phenate method using a UV-visible spectrophotometer (Model UV- 1700, Japan) (APHA, 2012). Biofloc volume in tank water was measured biweekly using Imhoff cones, registering the volume taken by the bio flocs in a 1 L volumetric cylinder after 20 min sedimentation of the enclosure water (Avnimelech and Kochba, 2009).

Determination of fish growth and feeding performance:

The body weight (measured using an electric balance, Model OHAS CORP, PA4102C) and standard length (measured with a vernier caliper) of the fish were recorded bimonthly by randomly selecting five fish from each tank.. At the end of the experiment, the fish's growth performance and feed conversion ratio (FCR) were calculated using the calculations below(Luo *et al.,* 2014).

Weight gain (g) = final body weight (g) – initial body weight (g)

Specific growth rate (SGR) (% /day) = [(Ln final weight – Ln initial weight) × 100] / Duration of the experiment.

Statistical analysis:

All statistical analyses were carried out with Minitab software (Version 17). Data were analysed using one-way ANOVA after the Anderson-Darling Normality test confirmed variance homogeneity. Results were expressed as mean±standard deviation. When significant differences were identified, Tukey's pairwise comparison test was employed to distinguish between the three treatments. P-values < 0.05 indicated significant differences.

Results

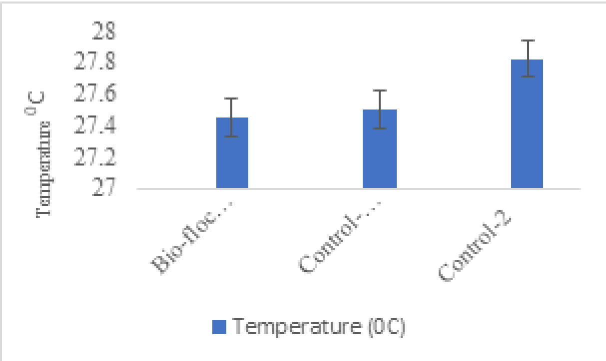
Water quality: Average water temperature was in the range of 27.45 ± 0. 12^{0}C to 27.82 ± 0.75^{0}C in the experimental tanks. Relatively high temperature was recorded in the C-2 tank (Control-2) (27.82 ± 0.75^{0}C) and a low value was recorded from Bio-floc treatment tank (27.45 ± 0. 12^{0}C) as shown in (Table -1 & Fig. 1). pH was slightly high in the experimental C-1 tank ((8.24 ± 0.17), while it was relatively low in the Bio-floc treatment tank (7.63 ± 0.25) as shown in (Table -1 &

Fig. 2). During the study period pH did not show significant variation and was found to be conducive to normal growth and survival of ornamental fishes in both experimental and control tanks. The dissolved oxygen values were recorded twice a day i.e., 9am and 4pm daily during the study period. D.O values ranged between 6.45 ± 0.85-7.66 ± 0.15. During the study, D.O levels did not show significant as shown in (Table -1 & Fig.-3). TAN values were recorded every day at 8pm during the study period.The average TAN values ranges from (0.32 ± 0.10- 1.01 ± 0.62 mg/L) but it was high (1.01 ± 0.62) in control tank-1.The difference in TAN levels between experimental and control tanks were significant as shown in (Table. 1 & Fig. 4).The lower TAN values recorded for the experimental tanks suggest efficient up-take of TAN by the Bio-floc facilitating the survival and growth of ornamental fishes. Lower TAN levels have a significant positive effect on survival and growth of ornamental fishes..

Water quality parameter	Bio-floc treatment tank	Control-1(zero water exchange)	Control-2
Temperature ^{0}C	27.45 ± 0.12^{a}	27.50 ± 0.64^{a}	27.82 ± 0.75^{a}
pH	7.63 ± 0.25^{b}	8.24 ± 0.17^{a}	7.71 ± 0.34^{b}
DO (mg/L)	6.45 ± 0.85^{b}	7.66 ± 0.15^{a}	7.51 ± 0.22^{a}
TAN – (mg/L)	0.32 ± 0.10^{b}	1.01 ± 0.62^{a}	0.36 ± 0.15^{b}
EC µScm-1	170 ± 0.56 ^{a}	200 ± 0.63 ^{a}	180 ± 0.64 ^{a}

Table 1. Physicochemical water quality parameters (mean ± SD) of ornamental fish culture water in biofloc treatment and control tanks in an 90-day trial.

Values in the same row with different superscripts are significantly different ($P < 0.05$) according to one-way ANOVA following Tukey's pairwise comparison.



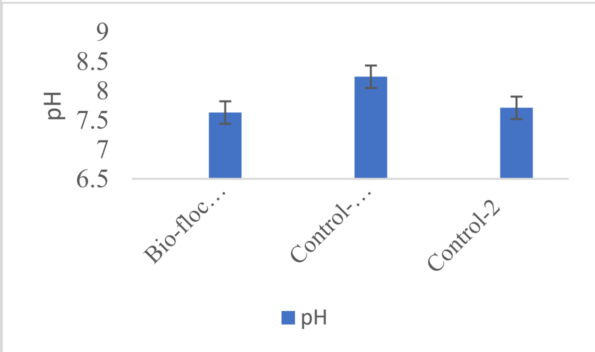
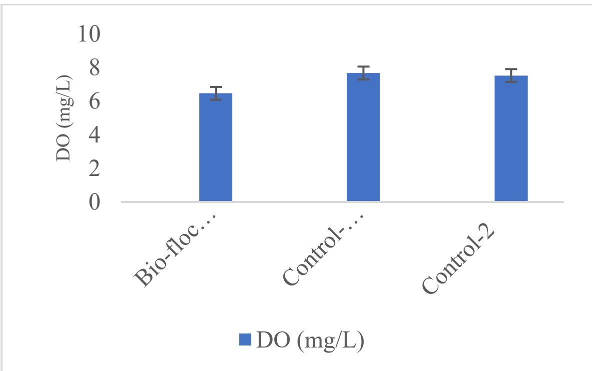


Fig. 1 Showing the variation of temperature. period.

Fig. 2 Showing the variation of pH during the study during the study period.



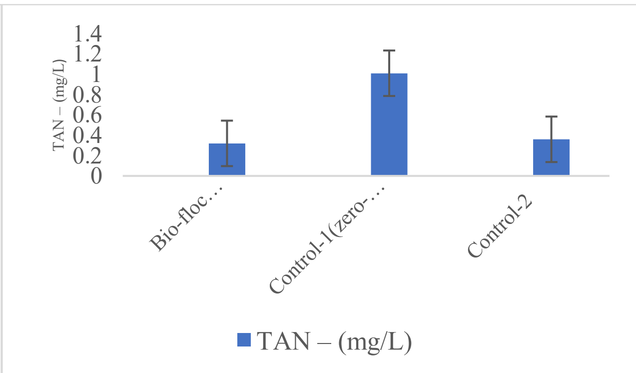


Fig. 3 Showing the variation of DO during the

Fig 4 Showing the variation of TAN during the study period. study period.

Fish growth and feeding performance:

The highest mean body weight gain was recorded in the biofloc treatment group (17.97 ± 1.35 g), followed by goldfish reared in the non-biofloc control tank with water exchange (Control-2; 12.10 ± 0.50 g), and the lowest in the non-biofloc

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control tank without water exchange (Control-1; 11.11 ± 0.60 g). Goldfish reared in the biofloc system exhibited significantly better weight gain compared to those in both control groups (Fig.5)

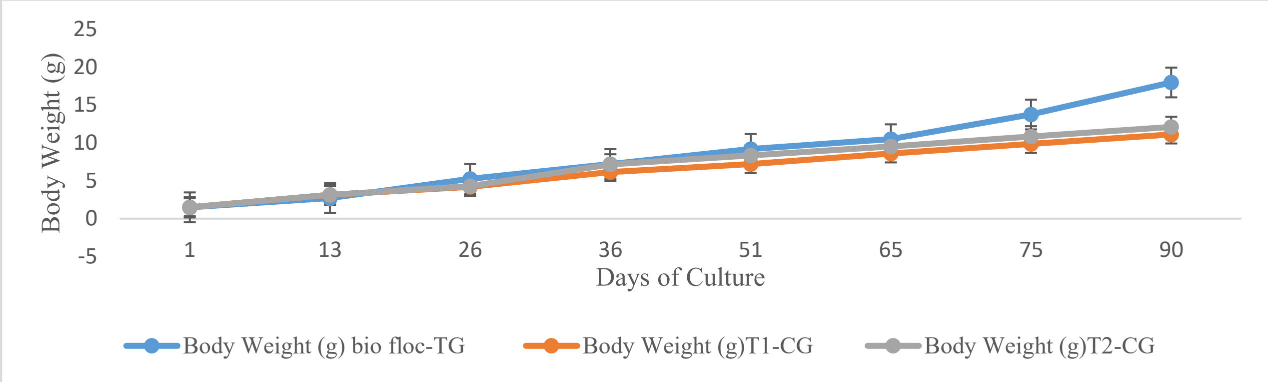

Fig-5 Showing the Average body weight of *C.auratus* (Goldfish) in bio-floc and non-biofloc experimental tanks

The highest mean body length recorded was 98.30 ± 0.85 mm in the biofloc group, followed by goldfish reared in the non-biofloc control tank with water exchange (Control-2), while the lowest lengths were observed in the non-biofloc control tank without water exchange (Control-1), at 85.20 ± 2.90 mm and 83.20 ± 1.90 mm, respectively. Fish reared in the biofloc system exhibited the greatest body length gain among all experimental groups, as shown in Fig. 6.

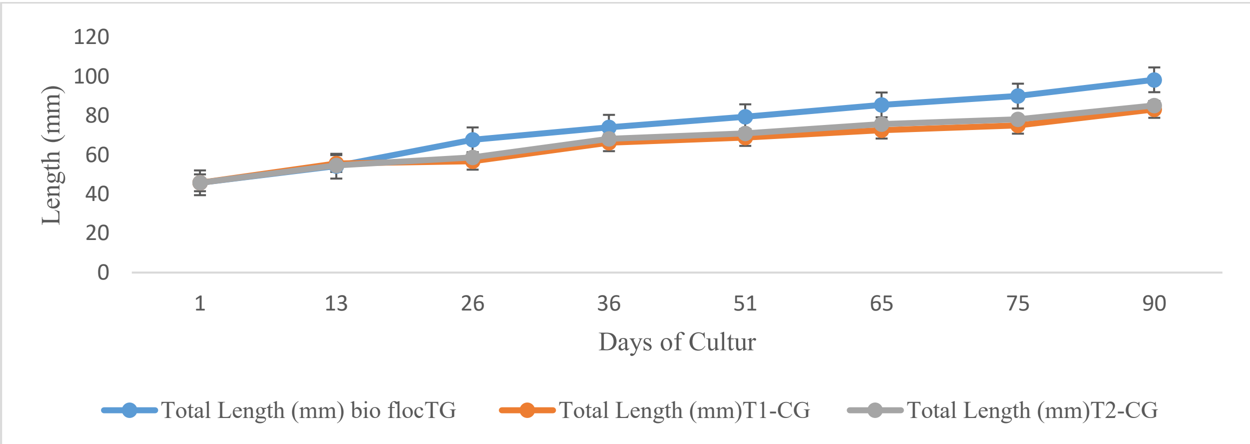

Fig 6 Showing the Average body length of *C.auratus* (Goldfish) in bio-floc and non-biofloc experimental tanks.

The maximum Specific Growth Rate (SGR) was recorded in the biofloc treatment group (25.98 ± 0.51), followed by goldfish reared in the non-biofloc control tank with water exchange (Control-2, 22.89 ± 0.45). The lowest SGR was observed in goldfish reared in the non-biofloc control tank without water exchange (Control-1, 20.77 ± 0.45). Overall, goldfish reared in the biofloc system exhibited superior specific growth rates compared to both control groups, as shown in Figure 7.

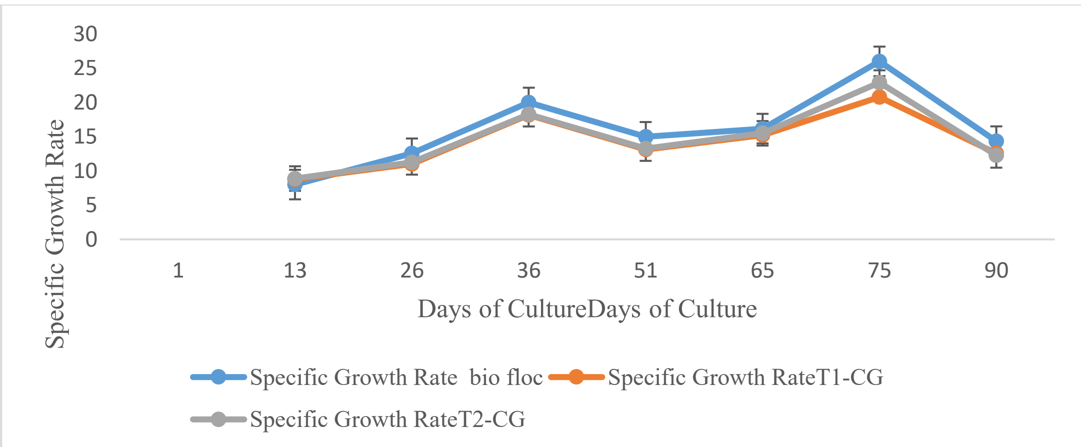

Fig.7 Showing Specific Growth Rate of *C.auratus* (Goldfish) in bio-floc and non-biofloc experimental tanks.

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Table-3. Length, weight and other growth parameters during goldfish, *C. auratus* rearing in bio floc treatment experimental tank (Goldfish).Tank-TG

Days of Culture	Total Length (mm)	Body Weight (g)	Length Gain (mm)	Weight Gain (g)	Mean Length Gain (mm)	Mean Weight Gain (g)	Specific Growth Rate	Gross body and fin color
1	45.78 ± 1.02^{a}	1.50 ± 0.08^{a}						More intense bright red color
13	54.25 ± 2.81^{b}	2.74 ± 0.46^{b}	$8.47 \pm .16^{def}$	1.24 ± 0.02^{ab}	0.63 ± 0.01^{de}	0.1 ± 0.006^{a}	8.0 ± 0.16^{a}	
26	67.70 ± 1.72^{c}	$5.25 \pm .39^{abc}$	13.45 ± 0.25^{g}	2.51 ± 0.04^{abc}	0.97 ± 0.01^{g}	0.15 ± 0.01^{a}	12.57 ± 0.24^{b}	
36	74.10 ± 4.31^{cd}	$7.23 \pm .90^{abcd}$	6.4 ± 0.10^{ab}	1.98 ± 0.05^{abc}	0.55 ± 0.01^{cd}	0.23 ± 0.01^{a}	19.98 ± 0.39^{e}	
51	79.48 ± 1.26^{de}	$9.20 \pm 0.55b^{cde}$	5.38 ± 0.08^{a}	1.97 ± 0.23^{abc}	0.28 ± 0.005^{a}	0.14 ± 0.01^{a}	14.97 ± 0.29^{c}	
65	85.50 ± 3.36^{ef}	10.48 ± 0.52^{cdef}	6.02 ± 0.12^{abc}	1.28 ± 0.02^{a}	0.45 ± 0.005^{abc}	0.07 ± 0.01^{a}	16.17 ± 0.33^{d}	
75	90.00 ± 3.78^{ff}	13.74 ± 1.28^{def}	5.4 ± 0.13^{abcde}	3.26 ± 0.05^{abc}	0.68 ± 0.01^{def}	0.25 ± 0.01^{a}	25.98 ± 0.51^{f}	
90	98.30 ± 0.85^{g}	17.97 ± 1.35^{f}	8.3 ± 0.12^{abcd}	4.23 ± 0.54^{c}	0.32 ± 0.005^{ab}	0.20 ± 0.01^{a}	14.34 ± 0.28^{c}	

Values with different superscript letters (a, b, c, d, e, f, g) differ significantly at $P < 0.05$ and $P < 0.01$

Table 4. Length, weight, and other growth parameters of goldfish reared in the control experimental tank (Non-biofloc Control Tank-1; zero water exchange). T1-CG

Days of Culture	Total Length (mm)	Body Weight (g)	Length Gain (mm)	Weight Gain (g)	Mean Length Gain (mm)	Mean Weight Gain (g)	Specific Growth Rate	Gross body and fin color
1	45.78 ± 1.02^{a}	1.50 ± 0.08^{a}						**Least intense red color**
13	55.60 ± 3.40^{b}	3.15 ± 0.41^{ab}	9.82 ± 0.17^{f}	1.65 ± 0.03^{a}	0.75 ± 0.01^{f}	0.13 ± 0.02^{a}	8.78 ± 0.17^{a}	
26	56.78 ± 4.03^{bc}	4.22 ± 0.74^{abc}	1.18 ± 0.22^{g}	1.07 ± 0.02^{a}	0.05 ± 0.01^{a}	0.07 ± 0.01^{a}	11.00 ± 0.22^{b}	
36	66.20 ± 4.31^{d}	6.15 ± 1.16^{abcd}	9.42 ± 0.20^{f}	1.93 ± 0.03^{a}	0.90 ± 0.01^{f}	0.17 ± 0.01^{a}	$18.1\ 4\pm 0.36^{e}$	
51	$68.90 \pm 2.56d^{c}$	7.19 ± 0.32^{abcd}	2.7 ± 0.15^{bc}	1.04 ± 0.02^{a}	0.21 ± 0.01^{abc}	0.05 ± 0.01^{a}	$13.1\ 2\pm 0.26^{c}$	
65	72.64 ± 1.75^{ef}	8.61 ± 0.39^{bcd}	3.74 ± 0.24^{bcd}	1.42 ± 0.02^{a}	0.28 ± 0.01^{abcd}	0.11 ± 0.01^{a}	15.21 ± 0.30^{d}	
75	75.12 ± 1.00^{fg}	9.87 ± 0.29^{cd}	2.48 ± 0.25^{ab}	1.26 ± 0.02^{a}	$0.30 \pm 0.01b^{cde}$	0.10 ± 0.01^{a}	20.77 ± 0.45^{f}	
90	83.20 ± 1.90	11.11 ± 0.60^{d}	8.08 ± 0.78^{bcde}	1.24 ± 0.02^{a}	0.19 ± 0.01^{ab}	0.04 ± 0.01^{a}	$12.5\ 3\pm 0.24^{b}$	

Values with different superscript letters (a, b, c, d, e, f, g) differ significantly at $P < 0.05$ or $P < 0.01$

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Table 5. Length, weight, and other growth parameters of goldfish reared in the control experimental tank (Non–biofloc, Control Tank-2, with water exchange) — Tank T2-CG

Days of Culture	Total Length (mm)	Body Weight (g)	Length Gain (mm)	Weight Gain (g)	Mean Length Gain (mm)	Mean Weight Gain (g)	Specific Growth Rate	Gross body and fin color
1	45.78 ± 1.02^{a}	1.50 ± 0.08^{a}						**Lesser intense red color**
13	54.60 ± 3.40^{b}	3.15 ± 0.41^{ab}	10.82 ± 0.17^{f}	1.65 ± 0.03^{a}	0.78 ± 0.01^{f}	0.12 ± 0.01^{a}	8.88 ± 0.17^{a}	
26	58.70 ± 4.13^{bc}	4.3 ± 0.74^{abc}	4.1 ± 0.52^{g}	1.15 ± 0.12^{a}	0.09 ± 0.01^{a}	0.09 ± 0.01^{a}	11.24 ± 0.22^{b}	
36	68.20 ± 4.31^{d}	7.15 ± 1.27^{abcd}	9.5 ± 1.19^{f}	2.85 ± 0.03^{a}	0.94 ± 0.01^{f}	0.18 ± 0.01^{a}	18.27 ± 0.36^{e}	
51	70.90 ± 1.276^{d}	8.35 ± 0.45^{abcd}	2.70 ± 0.27^{bc}	1.2 ± 0.01^{a}	0.25 ± 0.01^{abc}	0.09 ± 0.01^{a}	13.25 ± 0.26^{c}	
65	75.64 ± 1.845^{ef}	9.54 ± 0.39^{bcd}	4.74 ± 0.98^{bcd}	1.19 ± 0.02^{a}	0.29 ± 0.01^{abcd}	0.15 ± 0.01^{a}	15.48 ± 0.30^{d}	
75	78.12 ± 1.01^{fg}	10.85 ± 0.29^{cd}	2.48 ± 0.23^{ab}	1.31 ± 0.02^{2}	$0.37 \pm 0.01b^{cde}$	0.12 ± 0.01^{a}	22.89 ± 0.45^{f}	
90	85.20 ± 2.90	12.10 ± 0.50^{d}	7.08 ± 0.19^{bcde}	1.25 ± 0.03^{a}	0.22 ± 0.01^{ab}	0.07 ± 0.01^{a}	12.25 ± 0.24^{b}	

Values that have a different superscript letter (a,b,c,d,e,f,g) differ significantly P < 0.05 and P < 0.01 each other.

Discussion

The current study demonstrates that the use of biofloc systems has a considerable impact on water quality and growth performance in ornamental fish culture. Toxic nitrogen metabolites (NH_4^+ and NO_2^-) in intensive aquaculture systems are a major issue for water quality (Avnimelech, 1999). Several studies have reported the negative effects of ammonia (> 0.1 mg/l) and nitrite (> 5 mg/l) on farmed fish and prawns (Wang *et al.,* 2015b). As a result, ammonia and nitrite nitrogen are more susceptible to intensive aquaculture systems (Tovar *et al.,* 2000).

Water quality characteristics are extremely important in the cultivation system. Water quality must be maintained for fish to grow and survive successfully. Water quality is critical for the nutritional balance and healthy environment of developing fish. The current study gathered data on temperature, pH, DO, TAN, and EC.

Maintaining water temperature within the optimal range is crucial for effective ornamental fish culture. The temperature in this investigation ranged from 27.45 to 27.82 °C. Despite the fact that the temperatures in the testing tanks did not vary significantly. Earlier research revealed that temperatures between 24 -32°C are favourable for the growth of *L.vannamei* (Ogle *et al.,* 1992), as well as 28-32°C (Hirono, 1992; Boyd 1995). According to Jesus *et al*. (1997), the optimal temperature for *L.vannamei* survival is 20-30°C at 20 ppt salinity, with better post-larval development in the temperature range of 28-30°C and salinity of 33-40 ppt. Das and Saksena (2001) reported that temperature has pervasive controlling effect on the growth of shrimp. The observations relating to temperature in this study are in complete agreement with those of earlier workers mentioned above.

The pH affects the metabolism and other physiological processes of fishes.The pH values ranged from 7.63 to 8.24. The control-1 had a considerably higher pH (8.24 ± 0.19) than the biofloc treatment (7.64 ± 0.26) and the control-2 (7.71 ± 0.36), indicating the inability to maintain optimal water quality with 0% water exchange in *C.auratus* (Goldfish) culture systems.Researchers frequently emphasise the importance of pH in culture systems because it influences metabolic and physiological processes.At low pH, ammonia is transformed to ammonium, which is less hazardous. Many researchers have suggested that the optimal pH for *L.vannamei* development is 7.5-8.8 (Chen *et al.,* 2015). The optimum pH range varies slightly, as shown below.Wang *et al.,*(2004) reported that the favorable pH range is 7.6-8.6 for *L.vannamei*. Zhang (2006) suggested pH 7.56 for *L.vannamei* during the hypoxia condition.Wasielesky *et al.,* (2006); and Kim *et al.,* (2014 and 2015) reported that the pH levels were significantly lower in bio-floc treatments, which may be the result of carbon dioxide released by the ornamental fishes and heterotrophic bacteria during respiration.

Dissolved oxygen is one of the limiting factors in the intensive rearing of ornamental fish. DO levels govern a variety of water biochemical processes, including nitrification, de-nitrification, and organic matter decomposition.DO levels in this study ranged from 6.45 to 7.66 mg/L.The DO level in the biofloc treatment gradually fell over time and was much lower than in the two controls. Low DO in the treatment relative to the controls may have contributed to increased biofloc volume and faster microbial activity. Microorganisms consume a lot of oxygen during organic matter degradation to keep their metabolic activities going (Hargreaves, 2013).In some studies, the DO concentrations could not even be maintained at a desirable level in biofloc tanks until the end of the production cycle, especially in high concentrations of suspended

solids (Van Wyk *et al.,* 1999). However, the 24 hr aeration provided in the present experiment was sufficient to supply a favorable DO concentration to ornamental fishes and microorganisms in both treatment and controls.
TAN steadily increased in control-1 due to 0% water exchange, whereas it remained very low in both biofloc treatment and control-2. Despite the fact that biofloc treatment and control-1 had zero water exchange systems, only the treatment tanks might have shown a higher rate of carbon metabolism and nitrogen immobilisation by heterotrophic bacteria. This is demonstrated by significantly lower TAN and a larger floc volume in the treatment compared to control-2. Lim (2018) discovered that platy, Xiphophorus maculatus (Günther 1866) biofloc culture systems generated less nitrogenous waste than non-bio floc culture systems. Thus, it is clear that bio-floc technology is effective at lowering TAN levels. These results is well supported by Avnimelech (2012) who reported that the simple sugars decompose faster than the complex sugars and result in faster reduction of TAN from the water column. Our findings are strongly corroborated by Fabiane and his associates (2015). They loaded 0.024 0.01g weight post larvae (PL-25 stage) in green house nursery tanks at 1,200 prawns per square metre and reared them for 35 days. PL's were fed commercial feeds containing 40% protein. A variety of carbohydrate sources were used, including sugar-cane molasses and rice bran. The results of their investigation revealed that, ammonia concentrations reached high in the second week, and Nitrite values grew throughout the experiment and reached 20mg/L in all treatments. Similar results were reported in our investigation, with ammonia concentrations peaking in the second week and nitrate levels rising throughout the experiment. Fabiane and his associates (2015) concluded that both sugar-cane molasses and rice bran were effective in reducing the concentration of ammonia, even though their degradation levels were different and showed similarity with our results.
The survival rate of ornamental fishes in zero-water exchange culture (contro-2 of all ornamental fish) was significantly lower (64%) than that of biofloc treatment (89%) and control-2 (83%). The better fish survival in the biofloc treatment in the current study is consistent with the findings of Ekasari *et al.* (2015) and Wang *et al.* (2015), who also found high survival rates for fish grown in biofloc systems. Similarly, Harini *et al.* (2016) found that blue morph cichlids, Pseudotropheus saulosi (Konings 1990), raised in a biofloc culture system had higher survival and production rates. The significantly lower survival of ornamental fish in control-1 could be attributed to the higher TAN and pH values detected in the tank water. The presence of unionised ammonia, the poisonous form, increases when pH rises, causing ammonia to become more ionised (Schneider *et al.,* 2005). Furthermore, the greater temperature of tank water could have caused a large increase in ammonia toxicity (Ip and Chew, 2010). Thus, the current study demonstrates the impossibility to maintain a culture system of brackish water fancy guppy with nil water exchange without including any technique to decrease nitrogenous waste products. In this study, weight gain, specific growth rate (SGR), survival rate, final weight, final standard length, and body colour were all higher in the biofloc treatment. The positive effects of the application of biofloc technology on growth performance and FCR of cultured organisms have been reported for O. niloticus (Azim and Little, 2008), L. vannamei (Khanjani *et al.,* 2017), Labeo rohita (Hamilton 1822) (Mahanand *et al.,* 2013;, *Carrasius auratus* (Linnaeus 1758) (Wang *et al.,* 2015) and Cyprinus carpio (Linnaeus 1758) (Bakhshi *et al.,* 2018). However, Bakhshi *et al.* (2018) found no significant difference in the ultimate weight, productivity, weight increase, and SGR of common carp fingerlings between the control and biofloc treatments with different carbon sources. Dauda *et al*. (2018) found that the biomass gain, SGR, and FCR of *Clarias gariepinus* (Burchell 1822) were comparable between the control and biofloc treatments with varying C:N ratios. These findings are most likely related to the species' failure to successfully extract bioflocs produced in culture systems. Fish consume bioflocs primarily based on their species and eating patterns, as well as floc size and density (Deocampo *et al.,* 2021). The increased growth of ornamental fish in biofloc treatment may be ascribed to the microbial flocs, which might serve as a supplemental food source at any time. Once ingested, bacterial flocs offer fish with protein (essential amino acids), polyunsaturated fatty acids, and various vitamins and minerals (Azim and Little, 2008). Bioflocs may reduce FCR by supplying bioactive components like amino sugar, carotenoids, phytosterol, chlorophyll, and bromophenols (Ju *et al.,* 2008; Crab *et al.,* 2010). Furthermore, by creating microbial flocs, residual feeds and wastes can be recycled and feed nutrients reutilised by fish, resulting in better growth and feeding performance in biofloc systems (Avnimelech, 2006, & Hargreaves, 2013). According to Michaud *et al.* (2006), Crab *et al*. (2007), Emerenciano *et al.* (2013), Bakhshi *et al.* (2018), the bacteria in bioflocs produce poly-β-hydroxybutyrate, a biodegradable polymer, and exogenous enzyme sources that stimulate and improve intestinal digestibility. This improves fish growth and increases nutrient digestibility. The growth of *C. reticulata* may have been further enhanced by directly ingesting rice bran that contained ferulic acid, γ oryzanol, and dietary fibre (β-glucan, pectin, and gum) (Jayadeep *et al.,* 2009). According to the findings of the current study, ornamental fish, such tilapia and prawns (Hargreaves, 2013), are very efficient in using bioflocs as supplementary feed in aquaculture systems. In the current study, the fish in the biofloc tanks showed more intense colour in their skin and fins than the fish in the two control tanks. The highest intensity of fish skin colour in biofloc treatment might be attributed to the diet that the fish ingested during the testing period. The bioflocs included a variety of beneficial chemicals, including carotenoids (Ju *et al.,* 2008; & Deocampo *et al.,* 2021), which may have contributed to the high skin colour intensity observed in ornamental fish in the biofloc production method. Previous research employing biofloc technology to improve the skin pigmentation of *X. maculatus* (Lim, 2018), *C. auratus* (da Cunha *et al.,* 2020), and pink prawns (Emerenciano *et al.,* 2013) has yielded similar findings. According to Sefc *et al.* (2014), dietary carotenoids created by biofloc intake can enhance fish's red, orange, and yellow colouration. Biofloc technology with zero water exchange can be used in place of conventional water exchanged culture systems in brackish

water fancy guppy farming because the water quality in the biofloc treatment in the current study was within the allowable range without having any limiting effects on the performance of ornamental fishes. Biofloc technology is an environmentally friendly aquaculture method that has promise for future ornamental fish farming applications, with sustainability and efficiency at its core.

Conclusion

The study reveals that biofloc technology can enhance *C.auratus* (Goldfish) culture by lowering feed conversion ratios and increasing growth, body color, and survival rates. Biofloc treatment led to higher SGR values for ornamental fish compared to the control. This environmentally friendly aquaculture method benefits unemployed youth and rural farmers by creating jobs and supporting sustainable practices. With proper training and market research, anyone can thrive in this growing industry, making biofloc an efficient and sustainable aquaculture method with potential for future applications.

References

1. Asaduzzaman M., Wahab M.A., Verdegem M.C.J., Mondal M.A., Azim M.E. (2009). Effects of stocking density of freshwater prawn Macrobrachium rosenbergii and addition of different levels of tilapia Oreochromis niloticus on production in C:N controlled periphyton based system. *Aquaculture*, 286: 72-79.
2. Avnimelech Y.(1999). Carbon/Nitrogen ratio as a control element in aquaculture systems. Aquaculture. 176(3–4):227–235.
3. Avnimelech Y., Kochba M. (2009). Evaluation of nitrogen uptake and excretion by tilapia in bio floc tanks, using 15N tracing. *Aquaculture,* 287: 163-168.
4. Avnimelech, Y. (2012). Bio-floc technology – A practical guide book. The World Aquaculture Society, Baton Rouge, *Louisiana,* USA. 1-594.
5. Azim M.E., Little D.C. (2008). The biofloc technology (BFT) in indoor tanks: water quality, biofloc composition, and growth and welfare of Nile tilapia (Oreochromis niloticus). *Aquaculture,* 283: 29-35.
6. Bakhshi F., Najdegerami E.H., Manaffar R., Tukmechi A., Farah K.R. (2018). Use of different carbon sources for the biofloc system during the grow-out culture of common carp (Cyprinus carpio) fingerlings. *Aquaculture*, 484: 259-267.
7. Boyd, C.E. (1985). Chemical budget for channel catfish ponds. *Transactions of the American Fisheries Society. 1*14: 291 - 298.
8. Chen, K., Erhao, L., Chang. X. & Che, L. (2015). Evaluation of different lipid sources in diet of pacific white shrimp Litopenaeus vannamei at low salinity. *Aquaculture Reports,* 2: 163-168.
9. Crab R., Chielens B., Wille M., Bossier P., Verstraete W. (2010). The effect of different carbon sources on the nutritional value of bioflocs, a feed for Macrobrachium rosenbergii postlarvae.*Aquaculture Research*, 41: 559 567.
10. da Cunha L., Bese, K.P., Ha N., Uczay J., Skoronski E., Fabregat T.E.H.P. (2020). Biofloc technology (BFT) improves skin pigmentation of goldfish (*Carassius auratus*). *Aquaculture*, 522: 735132.
11. Daniels, H.V.,& Boyd, C.E.(1989). Chemical budgets for polyethyl ene-lined brackish water ponds. *Journal of the World Aquaculture Society*.20(2):53–60.
12. Das, K. & Mandal, A. (2021). Supplementation of biofloc in carp (Cyprinus carpio var. Communis) culture as a potential tool of resource management in aquaculture. *Aquatic Living Resources.* 34. 10-20.
13. Dauda A.B., Romano N., Ebrahimi M., Teh J.C., Ajadi A., Chong C.M., Karim M., Natrah I., Kamarudin M.S. (2018). Influence of carbon/nitrogen ratios on biofloc production and biochemical composition and subsequent effects on the growth, physiological status and disease resistance of African catfish (*Clarias gariepinus*) cultured in glycerol-based biofloc systems. *Aquaculture,* 483: 120-130.
14. Deocampo Jr. J.E., Fenol J.T., Yerro E.B.S., Pakingking Jr. R.V., Caipang C.M.A. (2021). Biofloc technology (BFT): a promising approach for the intensive production of ornamental fish. *Poeciliid Research*, 11: 18-24.
15. Ekasari J., Zairin J.M., Putri D.U., Sari N.P., Surawidjaja E.H., Bossier P. (2015). Biofloc-based reproductive performance of Nile tilapia Oreochromis niloticus broodstock. Aquaculture Research, 46: 509-512.
16. Emerenciano M.G.C., Martínez-Córdova L.R., Martínez Porchas M., Miranda-Baeza. (2017). Biofloc technology (BFT): a tool for water quality management in aquaculture. *Water quality,* 5: 92-109.
17. Export Development Board (EDB) (2023). Aquarium Fish Export Performance, Sri Lanka 2013-2023. https://www.srilankabusiness.com/aquarium-fish/ aquarium-export-performance.html.
18. Fabiane, S., Gaona, Carlos, F., Plínio & Poersch, Luís & Wasielesky, W. (2015). Use of different carbon sources for the biofloc system adopted during the nursery and grow-out culture of Litopenaeus vannamei. *Aquaculture International*, 23
19. Hargreaves J.A. (2013). Biofloc production systems for aquaculture. Stoneville, MS: Southern Regional *Aquaculture Center*. 11 p.
20. Harini, C., Rajagopalasamy ,C.B.T., Kumar, J.S.S., & Santhakumar, R. (2016). Role of biofloc in the growth and survival of blue morph, Pseudotropheus saulosi. *Indian Journal of Science and Technology*, 9: 1-7.
21. Harini, C., Rajagopalasamy ,C.B.T., Kumar, J.S.S., & Santhakumar, R. (2016). Role of biofloc in the growth and survival of blue morph, Pseudotropheus saulosi. *Indian Journal of Science and Technology*, 9: 1-7.

22. Homer, G.H, Rosenthal, H., & Kruner, G.(1987). Fluctuation of water quality during the experimental rearing of juvenile Sarotherodon galilaeus. *J Aquac Trop*. 2:273–6.
23. Ip Y.K., Chew S.F. (2010). Ammonia production, excretion, toxicity, and defense in fish: A Review. *Frontiers in Physiology*, 4: 134.
24. Jesus,P, Carlos, A. Martinez, P., & Lindsay, G. (1997). The effects of salinity and temperature on the growth and survival rates of juvenile white shrimp Penaeus vannamei, Boone, 1931. *Aquaculture*. 157: 107-155.
25. Ju Z.Y., Forster I., Conquest L., Dominy W. (2008). Enhanced growth effects on shrimp (Litopenaeus vannamei) from inclusion of whole shrimp floc or floc fractions to a formulated diet. *Aquaculture Nutrition,* 14: 533-543.
26. Khanjani, M. H., & Sharifinia, M. (2020). Biofloc technology as a promising tool to improve aquaculture production. *Reviews in aquaculture*, *12*(3), 1836-1850.
27. Kim, M., Jeong, S.Y., Yoon, S.J., Cho, S.J., Kim, Y.H., Kim, M.J., Ryu, E.Y., Lee, S.J.(2008);. Aerobic denitrification of Pseudomonas putida AD-21 at different C/N ratios. *J Biosci Bioeng*. 106:498–502.
28. Kim, M., Jeong, S.Y., Yoon, S.J., Cho, S.J., Kim, Y.H., Kim, M.J., Ryu, E.Y., Lee, S.J.(2008);. Aerobic denitrification of Pseudomonas putida AD-21 at different C/N ratios. *J Biosci Bioeng*. 106:498–502.
29. Kishawy A.T.Y., Sewid A.H., Nada H.S., Kamel M.A., El Mandrawy S.A.M., Abdelhakim T.M.N., El-Murr A.E.I., Nahhas N.E., Hozzein W.N., Ibrahim D. (2020). Mannanoligosaccharides as a carbon source in Biofloc boost dietary plant protein and water quality, growth, immunity and Aeromonas hydrophila resistance in Nile tilapia (Oreochromis niloticus). *Animals,* 10: 1724.
30. Lim, Y.H.F. (2018). Performance of freshwater ornamental fish in a biofloc system reared at various stocking densities. Major Project Report, Diploma in Veterinary Technology, *Temasek Polytechnic, Singapore.*128 p.
31. Linnaeus C. System a naturae per regna trinaturae, secundum classes, ordines, genera, species, cum charac teribus, differentiis, synonymis, locis. Tomus 1. Holmiae (Stockholm): Laurentii Salvii; 1758.
32. Mahanand, S.S., Moulick, S. & Srinivasa Rao, P. Optimum formulation of feed for rohu, *Labeo rohita* (Hamilton), with biofloc as a component. *Aquacult Int* 21, 347–360 (2013).
33. Minabi K., Sourinejad I., Alizadeh M., Ghatrami E.R., Khanjani M.H. (2020). Effects of different carbon to nitrogen ratios in the biofloc system on water quality, growth, and body composition of common carp (*Cyprinus carpio*) fingerlings. *International,* 28: 1883-1898.
34. Ogle, J.T., Beaugez, K., Lotz, J.M., 1992. Effects of salinity on survival and growth of postlarval Penaeus vannamei. *Gulf Res. Rep.* 8, 415–421.
35. Panigrahi A., Sundaram M., Chakrapani S., Rajasekar S., Syama Dayal J., Chavali G. (2019). Effect of carbon and nitrogen ratio (C: N) manipulation on the production performance and immunity of Pacific white shrimp Litopenaeus vannamei (Boone, 1931) in a biofloc-based rearing system. *Aquaculture Research,* 50: 29-41.
36. Rajkumar M., Pandey P.K., Aravind R., Vennila A., Bharti V., Purushothaman C.S. (2016). Effect of different biofloc systems on water quality, biofloc composition, and growth performance in Litopenaeus vannamei (Boone, 1931). *Aquaculture Research,* 47: 3432-3444.
37. Sales ,J., Janssens, G.P.J.(2003). Nutrient requirements of ornamental fish. *Aquatic Living Resources*. 16(6):533–40.
38. Schneider O., Sereti V., Eding E.H., & Verreth J.A.J. (2005). Analysis of nutrient flows in integrated intensive aquaculture systems. *Aquacultural Engineering* 32: 379-401.
39. Tovar, A., Moreno, C., Mánuel-Vez, M. P., & García-Vargas, M. (2000). Environmental impacts of intensive aquaculture in marine waters. *Water Research*, *34*(1), 334-342.
40. Van Wyk P., Davishodgkins M., Laramore R., Main K.L., Mountain J., & Scarpa J. (1999). Farming marine shrimp in recirculating freshwater systems. Florida Department of Agriculture and Consumer Services, *Tallahassee*. 21 p.
41. Wang G., Yu E., Xie J., Yu D., Li Z., Luo W., Qiu L., Zheng Z. (2015). Effect of C:N ratio on water quality in zero-water exchange tanks and the biofloc supplementation in feed on the growth performance of crucian carp, Carassius auratus. *Aquaculture,* 443: 98 104.
42. Wang, X., Ermeng, Y.u, Jun, X., Deguang, Y.u, Zhifei, L.I, Wen Luo, L., Qiu, Zonglin Z.(2015b).Effect of C/N ratio on water quality in zero-water exchange tanks and the biofloc supplementation in feed on the growth performance of crucian carp, Carassius auratus, *Aquaculture,*443: 98-104.
43. Wang. X., Ma, M., Dong, S and Cao, M. (2004). Effects of salinity and dietary carbohydrate levels on growth and energy budget of juvenile L.vannamei. *Journal of Shell fish Research*.23: 231-236.
44. Wasielsky, J.r. W., Atwood, H., Stokes, A. and Browdy, C.L. (2006). Effect of natural production in a zero exchange suspended microbial floc based super-intensive culture system for white shrimp Litopenaeus vannamei. *Aquaculture*.258: 396- 403.
45. Zhang, P., Zhang, X., Li, J., & Huang, G. (2006). The effects of body weight, temperature, salinity, pH, light intensity and feeding condition on lethal DO levels of whiteleg shrimp, Litopenaeus vannamei (Boone, 1931). *Aquaculture*, *256*(1-4), 579-587.