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PERFORMANCE OF OUTDOOR BIOFLOC MEAL IN THE DIET OF *CATLA CATLA*, (HAMILTON, 1822)

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ABSTRACT

The present study aimed to evaluate the effect of the gradual replacement of fishmeal with outdoor biofloc meal in the diet of Catla catla. Four diets were formulated, and these replaced 0 (control), 20, 30 and 40% (C, T2, T3 and T4 respectively) of the fishmeal. The results of the present study revealed that Catla fed with Control diet exhibited higher growth of 0.084 g/day.Similarly, growth performance of Catla in T2 and T3 is 0.069 g/dayand 0.074 g/day performed better after control. And FCR is less in control, T3 and T4 is 1.65, 1.76 and 1.76 percent respectively. Hence fish meal could be replaced in the carp diet successfully by 20 and 30 percent with outdoor biofloc meal.

INTRODUCTION

The essential nutrient requirements of fish are proteins, lipids, carbohydrates, vitamins and minerals. It should be noted that knowledge of the protein requirement of fish is essential for the formulation of a well-balanced artificial diet for economical fish feeding (Lovell, 1989; De Silva, 2001; Omoniyi and Fagade, 2003,Nalawade, 2011). Fish meal is the first choice as a raw material in aquafeed production for its high quality of protein with a well-balanced amino acid proûle (Gatlin *et al*., 2007,Lende, S *et al*., 2015). But one of the greatest challenges for the aqua feed industry is to reduce use of fishmeal levels in feed through successive replacement by other available and cheaper protein sources. Bioflocs harvested from a suspended growth biological reactor that treats fish effluent water can be successfully used in shrimp diets as rich protein ingredients (Kuhn *et al*., 2016). Various researches also reported that dietary inclusion of biofloc enhanced the growth performance of *Litopenaeousvannamei* (Dorothy, 2015; Bauer *et al*., 2012; Kuhn *et al*., 2010; Ju *et al*., 2008,). Microbial protein has been used to replace fishmeal or other protein sources in fish and shrimp feed due to the good nutritional value and appropriate amino-acid profile which make it suitable for feeding omnivorous cultured species (Kuhn *et al*., 2016). The species has been selected for the study based on the feeding nature of the fish. Since it is omnivorous, the fish can effectively utilize the protein rich microbial flocs. Bioflocs has also been projected as a source of live feed for farmed organisms that may allow partial substitution of formulated feeds for fish (Tacon *et al*., 2002; De Schryver *et al*., 2008). The present study has been proposed to fill the research gap of replacing fish meals with biofloc in the diet of *Catla catla*.

MATERIALS AND METHODS

Experimental fish

Catla *(Catla catla)* young ones were procured from private fish seed farm, Karampai, Tirunelveli. The fishes were treated with vitamin C and antibiotics in a cemented tank for two hours upon reaching the experimental site in-order to revive the fishes from transportation stress and possible pathogen intrusion. Then, the fishes were kept for acclimatization in the net cages in reservoir for one monthand fed with commercial carp feed in *ad libitum*.

Experimental setup

The experiment was carried out in Wet laboratory, Department of Inland Aquaculture. The main fish culture experimental setup comprises of total 15 plastic troughs with 4 treatments and 1 control in triplicates. Before starting the experiment, the troughs were cleaned and disinfected using soap oil and dried under sunlight. Water was filled in the troughs up to ¾th of its volume. All the troughs were connected with proper aeration facilities.

Experimental design

Initially the length and weight of the fishes were measured and recorded before the start of the experiment. The fishes were equally distributed as 5 fishes per trough following Completely Randomized Design (CRD) and kept devoid of feed for a day. The initial recorded average body length of the fishes was 6.21 ± 0.071 cm while the average body weight was 2.47 ± 0.036 g. The treatment codes used in the experiment are given below in Table 1 and each replicates have been labeled as R1, R2 and R3.

Experimental fish feed ingredients

Feed ingredients such as dried outdoor biofloc meal, fish meal, ground nut oil cake (GNOC), tapioca flour, and rice bran were used for the study. Outdoor biofloc meal was collected from Hi-Tide sea farm located at Mahendrapally, Nagapattinam district. using nylon net. The collected flocs were dried under shade on a polythene sheet followed by drying in hot air oven at 45ºC. The dried flocs were powdered into fine particles of ÂÙ200 μ size and stored in air tight container under refrigerator. Fish meal (prepared using dried anchovies), ground nut oil cake, tapioca flour and rice bran were procured from local market in Thoothukudi. Vitamins and mineral mixture, fish oil, soya lecithin and guar gum were procured from farm chemical suppliers and used as feed additives.

Formulation of experimental diets

The experimental diets were formulated and prepared from the above procured experimental fish feed ingredientsThe outdoor biofloc meal was used to replace fish meal at different compositions levels such as 10, 20, and 30% while the control common diet was prepared using fish meal, GNOC, rice bran and tapioca flour. The ingredient composition of experimental feeds used in the study is presented in Table 2.

Proximate analysis ofexperimental diets

The proximate analysis of all the experimental diets such as control diet, commercial diet, and diets prepared with outdoor biofloc meal at 20, 30, and 40% of diets were estimated proximate analysis following the standard protocols (AOAC, 1995).

Feeding

The experimental fishes were fed with the experimental treatments, control diet and commercial diets twice a day at 9.00h and 17.00h at the rate of 10% average body weight. Feeding charts were prepared based on the growth observed on periodical growth sampling and the weights of feed offered were accurately recorded.

Water quality analysis

The water quality parameters such as pH, Temperature, Dissolved oxygen and Total Ammonia Nitrogen (TAN) were estimated throughout the whole experimental period using the standard procedures (APHA, 2005) once in fortnight and the recorded values are given in Table 3. Water temperature was recorded using digital thermometer (TC-902, Agrawal Electronics, India). Water pH was measured using pH meter (Hanna Instrument, Italy). Dissolved oxygen content of the water was estimated using modified Winkler's titrimetric method (APHA, 2005).

To maintain optimum water quality, the faecal matter of the fish and the uneaten feeds were siphoned out and water exchange was done at the rate of 20 percent daily.

Sampling

The performance and health of the Catla was checked regularly for any deformities or abnormalities. Growth sampling was done once in a week with all the stocked animals from each treatment units by taking length and weight.

Growth Parameters

Growth assessment was done by taking body length and weight of the fish at a regular interval of 7 days for the whole culture period of 64 days. All the animals from each treatment tanks were taken for measurement of body length and weight. The body weight was taken using electronic balance while the body length was by measurement scale. The growth performances were assessed by estimating the following growth parameters (Varghese, (2007); Raj *et al*. (2008); Zaid and Sogbesan, 2010).

$$\text{Total weight gain (g)} = \text{Final weight (g)} - \text{Initial weight(g)}$$

$$\text{Total Percentage weight gain(\%)} = \frac{\text{Final weight(g) - intial weight(g)}}{\text{Initial weight (g)}} \times 100$$

$$\text{Daily Growth rate (g/day)} = \frac{\text{Final Length (cm) - Intitial Length(cm)}}{\text{Number of days}}$$

$$\text{SGR(\%)} = \frac{\text{ln final weight(g) - ln intial weigth 9g)}}{\text{Number of days}} \times 100$$

Where, ln = natural logarithm

Total Length gain (cm) = Final Length (cm) – Initial Length (cm)

$$\text{Total Percentage Lenght gain(\%)} = \frac{\text{Final Length (cm) - Initial Length(cm)}}{\text{Initial Length(cm)}} \times 100$$

$$\text{FCR} = \frac{\text{Feed given in dry weight (g)}}{\text{Body weight gain in wet weight(g)}}$$

$$\text{FER} = \frac{1}{\text{FCR}}$$

$$\text{PER} = \frac{\text{Net weight gain in wet weight(g)}}{\text{Protein consumed(g)}}$$

Length-weight relationship

The length weight relationship of *C.catla*reared in the experimental tanks were assessed using regression analysis (Dastagiri*et al.,* 2013).

Length weight relationship

$W = a. L^{b}$

Where, W = Body weight

L = Standard length

a and b are constants

a = intercept

b = slope value

Statistical analysis

Statistical analysis of different growth parameters was analyzed by using one-way analysis of variance and significance differences between treatments was assessed by Duncan multiple range test (Duncan, 1995). The level of significance was accepted at 5% level. All statistical analyses were performed using SPSS, Release 22, software (SPSS Inc., USA).

RESULTS

Proximate composition of the experimental diets

The crude protein (CP) content of rice bran, GNOC, tapioca flour, fishmeal, outdoor dry biofloc meal and commercial carp

Table 1 : Details of an experimental treatments with respective to treatment codes

Treatment Codes	Treatments
C	Control diet
T1	Commercial diet
T2	20% outdoor dry biofloc meal incorporated diet
T3	30% outdoor dry biofloc meal incorporated diet
T4	40% outdoor dry biofloc meal incorporated diet

feed was 10.04%, 39.37%, 2.80%, 63.31%, 16.61% and 18.23% respectively. The crude protein level in the experimental diets was highest in control (27.52%) followed by T3 (25.96%)and which is shown in table 4.

Growth performance

The daily growth ratewas highest in C (0.084 g/day) followed by T3 (0.074 g/day), T1 (0.071 g/day) which is shown in Fig.1 whereas the highest SGRwas obtained in Control (1.79 g) followed by T1 (1.75 g), T3 (1.66 g) which is shown in Fig.2. The lowest FCR of Catla was obtained in C (1.65%) and followed by T1 (1.67%), T2 (1.76%), T3 (1.76%).The highest FERwas found in C (0.61%) followed by T1 (0.60%), T2 (0.57%), T3 (0.57(%). The highest PER was attained in commercial diet T1 (3.28%) followed by T2 (2.22%), C (2.20%), T3 (2.19%) is shown in Fig.3.

The highest mean body weight was recorded in control (7.88 ± 0.859) followed by T2 (7.25 ± 0.43) and T3 (6.91±1.31) which were not statistically significant as shown in Table.5 and Fig.4. As per Table 6. the highest total weight gain obtained in Control was 5.37 g followed by T3 (4.74 g).The highest total percentage weight gain were obtained in Control (213.94%) followed by T3 (188.98%).The highest mean body length was observed in C (9.89 ± 0.520^{b}) followed by Catla fed with T4 (8.58±0.199) diets shown in Table 5 and Fig 5.As shown in Table 6. The maximum total length gain were obtained in C (3.68 cm) followed by T8 (2.34 cm).The maximum total percentage length gain obtained in control was (59.14%) followed by T4 (37.46%), T2 (36.03%).

All the regression coefficient are highly significant ($P<0.01$) and length weight relationship in all experimental treatments showed „b value above 2.2 and which confirms good growth performance and which is shown in Fig.6.

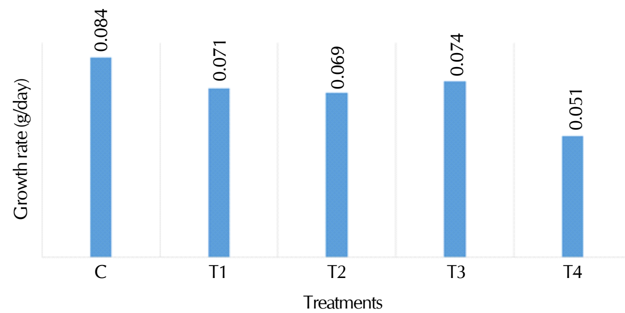


Figure 1: Daily growth rate of *C.catla* recorded in different treatment groups during the rearing experiment

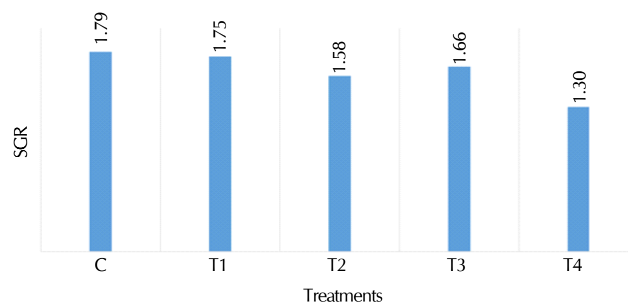


Figure 2: Specific Growth Rate of *C.catla* recorded in different treatment groups during the rearing experiment

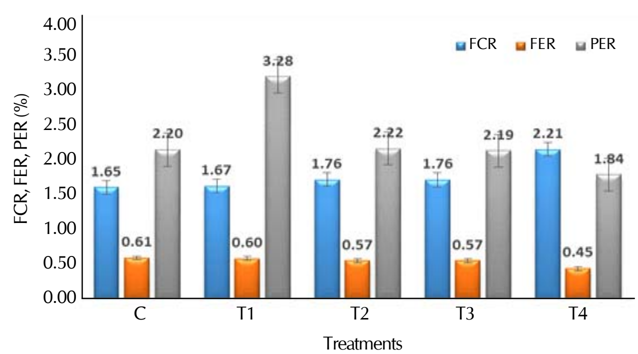


Figure 3: Feed Conversion Ratio, Feed Efficiency Ratio, Protein Efficiency Ratio PER of*C.catla* assessed in different treatment groups during the rearing experiment

DISCUSSION

Kuhn *et al*. (2009 and 2010) reported the use of biofloc as dietary ingredient for aquaculture species diet which enhances the growth rate of the cultured species. The present study illustrates the role of biofloc meal as a dietary supplement on the growth performance of *C.catla*.The aim was to drive down the cost of carp feed by reducing use of fishmeal with biofloc meal incorporation. Few studies have used biofloc as ingredients in aquaculture diets. Inclusion of biofloc as a dietary ingredient in shrimp diet found to improve the growth performance of L. vannamei (Ju *et al*., 2008b; Kuhn *et al*., 2009, 2010). The application of biofloc technology improved the feed conversion and protein retention indicating indirectly that the consumption of biofloc contributes to the growth of cultured organisms (Avnimelech, 2009; Gao *et al*., 2012; Hari *et al*., 2004; Wasielieskey *et al*., 2006; Xu *et al*., 2012).

Proximate composition

Nutritional composition of biofloc varies with type of carbohydrate source used microbial community structure, prevailing culture condition *etc*. Protein content of biofloc in the present study is in covenant with the findings of Magondu (2012), Soares (2004), Megahed (2014), Neto *et al*. (2015) and Hende et al., (2014) and the crude protein levels were 12.9%, 16-20%, 9.5-13.7% and 15.8-27% respectively. (Crab *et al*., 2010; Ekasari *et al*., 2010) recorded harvested biofloc with low crude protein (give data) in BFT system. The low crude protein level in the biofloc may be due to the differences in bacteria taking part in the floc formation (Rittmann and McCarty, 2001). For example, substrates like acetate and glycerol used in the previous studies of Crab *et al*. (2010)

Table 2: Formulated control and experimental treatment feed composition using outdoor biofloc meal treatment units by taking length and weight

Sl.No.	Ingredients	Control (g)	Level of incorporated outdoor biofloc meal (g)		
			20%	30%	40%
1	GNOC	27	27	27	27
2	Fish Meal	25	20	18	16
3	Rice bran	30	15	10	2
4	Tapioca powder	8	8	5	5
5	Biofloc meal	0	20	30	40
6	Fish oil	3.5	3.5	3.5	3.5
7	Calcium Phosphate	2.7	2.7	2.7	2.7
8	Soya lecithin	1	1	1	1
9	Vitamin Premix	0.4	0.4	0.4	0.4
10	Mineral Premix	0.2	0.2	0.2	0.2
11	Vitamin C	0.2	0.2	0.2	0.2
12	Guar gum	2	2	2	2
	Total	100	100	100	100
	Protein content	27.52%	25.50%	25.96%	24.63%

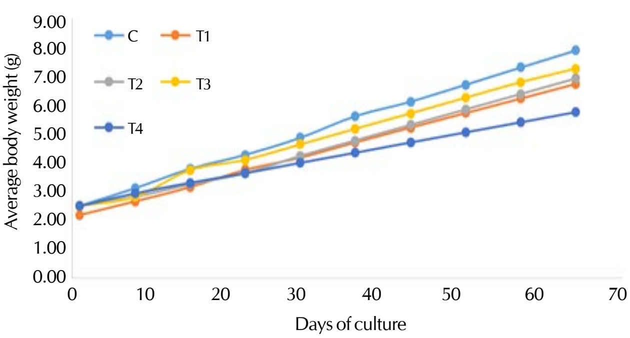


Figure 4: Mean body weight of *C. catla* observed in the rearing experiment with control and T1, T2, T3 and T4 treatments

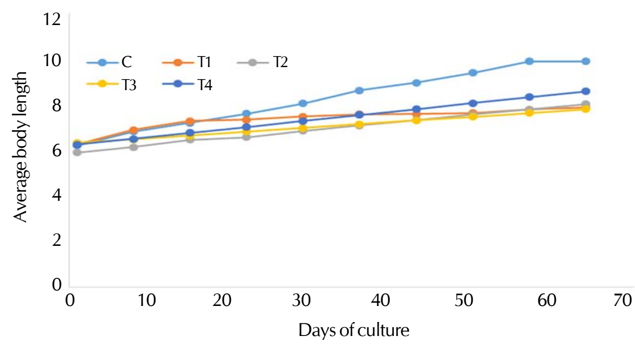


Figure 5: Mean body length of *C.catla* observed in the rearing experiment with control and T1, T2, T3 and T4 treatments

might have promoted the bacteria involved in cellular growth and increased the protein content in biofloc whereas wheat flour might have promoted bacteria that produce large amounts of exopolysaccharides. This further suggests that microbiota that constitutes biofloc is likely to affect the protein content of biofloc. These results differ from studies performed with microbial flocs produced in batch reactors using effluent from tilapia culture and sugar as a culture medium (Kuhn *et al.*, 2009). Ju *et al.* (2008a) reported that chlorophyll-dominated biofloc contained higher crude protein content (42%) than flocs dominated by diatoms (26–34%) and bacteria (38%). For example, Crab *et al.* (2010) observed that biofloc developed from glycerol inoculated with Bacillus contained higher protein (58% CP) than biofloc developed from glycerol, acetate (42–43% CP) and glucose (28% CP).

The ash content of biofloc in the present investigation was 46.21% from outdoor and 33.27% from indoor, which agreed with earlier studies (Soares, 2004, Maicá *et al.*, 2012, Magondu, 2012, Hende *et al.*, 2014, Suita *et al.*, 2015, Neto *et al.*, 2015). Tacon et al. (2002)suggested that the high ash content in the biofloc was probably related to the presence of acid insoluble oxides and mixed silicates. The lipid content of biofloc was 0.83% from outdoor and 0.47% from indoor, The value of crude lipid of biofloc produced in the present study was well within the range which had been previously reported (Harini,2015, Faizullah, 2014, Hargreaves, 2013, Emerenciano *et al.*, 2006, Wasielesky *et al.*, 2006).

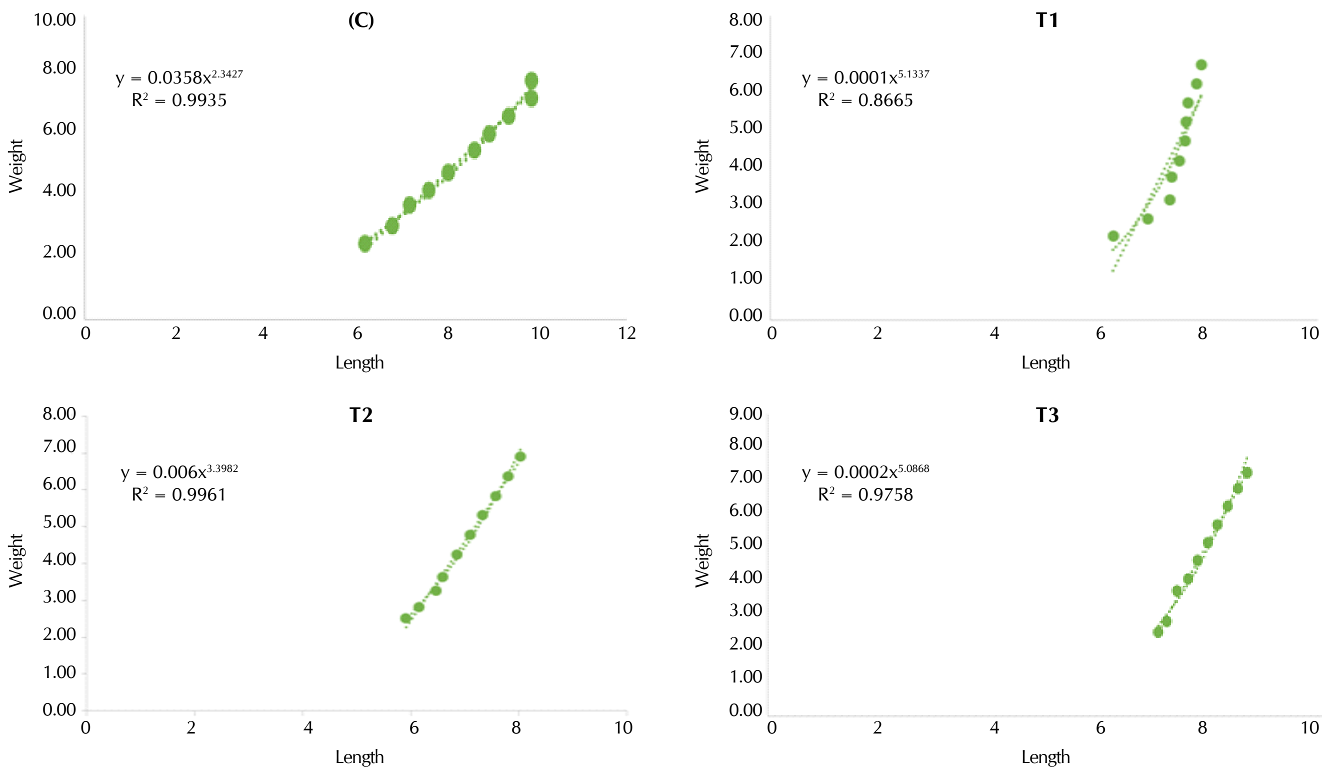
Table 3: The range of water quality parameters recorded in the experimental Catla rearing system

Parameters	Range
Temperature	27-30°C
pH	7.8-8.2
Dissolved oxygen	3-4 mg/l
Total Ammonia Nitrogen(TAN)	0-0.01mg/l

Emerenciano *et al.*, (2013), stated that protein (12 to 49), carbohydrates (18 to 36), fiber (0.8 to 16.2) and ash content (13 to 46%) in biofloc particles could vary substantially.

Growth characteristics of Catla

In the present study, highest mean body weight were recorded in control (7.88 ± 0.859) followed by T3 (7.25 ± 0.43) which were not statistically significant. The highest total weight gain obtained in Control was 5.37 g followed by T3 (4.74 g). The highest total percentage weight gain were obtained in Control (213.94%) followed by T1 (206.06%) and T3 (188.98%).The highest mean body length was observed in C (9.89 ± 0.520^b) followed by T4 (8.58 ± 0.199) diet. The maximum total length gain were obtained in C (3.68 cm) followed by T8 (2.34 cm).The maximum total percentage length gain obtained in control was (59.14%) followed by T4 (37.46%), T3 (36.03%).In this study, T3 and T4 treatment performed a significantly better than all other treatments same as Control. Partial replacement



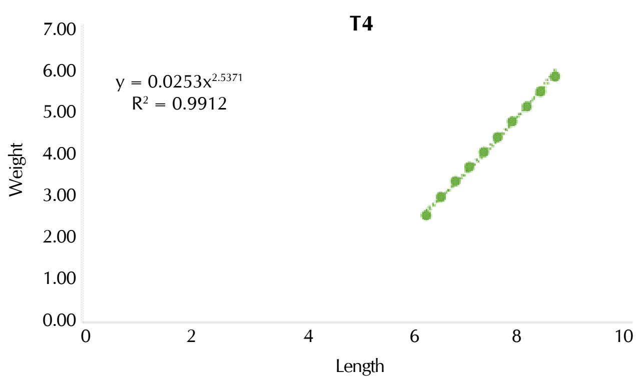


Figure 6: Length- weight relationship of *C. catla* assessed in the rearing experiment with different treatment groups

of fishmeal with biofloc meal does not appear to affect growth.Results obtained in present study was within the range of those which had been previously reported by Dantas *et al*., (2014), and thus further suggested regression analysis indicated that a fish meal replacement by biofloc meal at level over 20% may actually improve growth of shellfish. As per the Valle. (2015) regression test indicated that the ideal fishmeal substitution level is between 15.16 and 16.5%. Kuhn *et al*. (2010) reported no deleterious effects on growth when L. vannamei were fed with diet containing biofloc inclusion from 10 to 30%, regardless of fishmeal substitution at 0–67%.However,Kuhn *et al*. (2009)replaced 37% of fishmeal in shrimps using biofloc meal, achieved similar performance as diets containing lower replacement levels.

The studies which were antagonistic to this investigation were reported by Anand *et al*.(2014) suggested that 4% level of inclusion of biofloc in shrimp diets enhanced better growth. Bauer *et al*., 2012 said that 14% biofloc meal inclusion showed significant growth in *L.vannamei*. As per Hende *et al*., 2014, 0.8% biofloc meal replacement with wheat flour performed good growth of *L.vannamei*. . The present finding agree in general with those of Wang (2007) and Anand *et al*.(2013b) who reported that increase in dietary supplementation of probiotic or periphytic algae in shrimp diet do not increase proportionately the digestive enzyme activities and growth of shrimp. Moreover, reduction in growth rate of fishes was recorded at higher level of microbial supplementation (Ajiboye *et al*., 2012; Kiessling and Askbrandit, 1993) as microbial products at higher level tend to reduce the feed palatability and digestibility (Kiessling and Askbrandit, 1993).

In the present study the daily growth ratewas highest in C (0.084 g/day) followed by T4 (0.074 g/day), T1 (0.071 g/day). The highest specific growth ratewas obtained in Control (1.79 g) followed by T1 (1.75 g), T4 (1.66 g). The lowest FCR was obtained in C (1.65%) followed by T1 (1.67%), T3 (1.76%) and T4 (1.76%).The highest Feed Efficiency Ratiowas found in C (0.61%) followed by T3 (0.61%), T1 (0.60%), T6 (0.57%), T7 (0.57(%).The highest Protein Efficiency Ratio was attained in commercial diet T1 (3.28%) followed by T3 (2.22%), C (2.20%), T4 (2.19%). In the present experiment, biofloc meal at 20, 30, 40% level significantly enhanced the daily growth rate, SGR, FER, PER and reduced the FCR in Catla. The better FCR obtained in this study were in the line with Moss *et al*., 2006, Samocha *et al*.(2007),Taw *et al*.(2009), Zhao *et al*.(2012), Xu *et al*.(2012), Hussain *et al*. (2015), Dantas *et al*. (2015) whose FCR values ranged from 1.60-1.70%. The PER value assessed in this study was related to the studies by Hussain *et al*. (2015), Anand *et al*. (2014), Dantas *et al*.

Table 4: Proximate composition of experimental treatment diets, indoor and outdoor dry biofloc

Sl. No.	Proximate Composition	Control (C)	Commercial Diet (T1)	Outdoor Dry Biofloc	Outdoor Biofloc Incorporated Diets 20% (T6)	30%(T7)	40%(T8)
1	Moisture (%)	7.62	8.64	11	10.87	10.37	10.77
2	Crude Protein (%)	27.52	18.23	16.61	25.5	25.96	24.63
3	Crude Fiber (%)	8.32	16.87	0.45	4.62	3.48	1.53
4	Crude Lipid (%)	13.07	8.77	0.83	11.2	10	8.59
5	Total Ash (%)	14.11	12.43	46.21	18.85	22.7	24.93
6	Gross Energy(Kcal/Kg	4297	3936		3842	3651	3407

Table 5: Mean body Weight and length of *C. catla* observed during the rearing experiment with different treatments

	Mean body Weight of *C. catla* observed during the rearing experiment with different treatments					Mean body length of *C. catla* observed during the rearing experiment with different treatments				
Days Of Culture	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
1	2.51 ± 0.035^{a}	2.19 ± 0.31^{a}	2.52 ± 0.03^{a}	2.51 ± 0.02^{a}	2.5 ± 0.018^{a}	6.21 ± 0.154^{a}	6.12 ± 0.407^{a}	5.90 ± 0.182^{a}	6.34 ± 0.06^{a}	6.24 ± 0.069^{a}
8	3.116 ± 0.237^{a}	2.66 ± 0.25^{a}	2.82 ± 0.22^{a}	2.82 ± 0.13^{a}	2.94 ± 0.095^{a}	6.82 ± 0.131^{ab}	6.39 ± 0.288^{a}	6.14 ± 0.181^{a}	6.48 ± 0.190^{ab}	6.50 ± 0.074^{ab}
15	3.79 ± 0.34^{b}	3.15 ± 0.25^{ab}	3.25 ± 0.50^{ab}	3.74 ± 0.04^{b}	3.3 ± 0.092^{ab}	7.2 ± 0.192^{ab}	6.52 ± 0.257^{b}	6.46 ± 0.240^{a}	6.65 ± 0.145^{ab}	6.76 ± 0.083^{ab}
22	4.27 ± 0.462^{b}	3.75 ± 0.15^{b}	3.63 ± 0.45^{ab}	4.1 ± 0.085^{b}	3.63 ± 0.219^{ab}	7.61 ± 0.214^{b}	6.75 ± 0.271^{b}	6.57 ± 0.236^{a}	6.82 ± 0.256^{ab}	7.02 ± 0.096^{ab}
29	4.86 ± 0.539^{b}	4.17 ± 0.18^{b}	4.23 ± 0.64^{b}	4.63 ± 0.14^{b}	3.99 ± 0.368^{ab}	8.05 ± 0.331^{b}	6.36 ± 0.853^{ab}	6.85 ± 0.257^{ab}	6.98 ± 0.316^{ab}	7.28 ± 0.110^{ab}
36	5.61 ± 0.485^{b}	4.7 ± 0.252^{b}	4.77 ± 0.77^{b}	5.17 ± 0.2^{b}	4.34 ± 0.518^{ab}	8.62 ± 0.3786^{b}	6.68 ± 0.712^{ab}	7.09 ± 0.283^{a}	7.14 ± 0.381^{a}	7.54 ± 0.127^{ab}
43	6.1 ± 0.635^{b}	5.21 ± 0.34^{b}	5.31 ± 0.90^{b}	5.7 ± 0.264^{b}	4.7 ± 0.665^{ab}	8.96 ± 0.378^{b}	6.76 ± 0.826^{ab}	7.32 ± 0.310^{a}	7.31 ± 0.450^{a}	7.80 ± 0.144^{ab}
50	6.69 ± 0.709^{b}	5.71 ± 0.43^{b}	5.84 ± 1.04^{b}	6.24 ± 0.32^{b}	5.05 ± 0.816^{ab}	9.39 ± 0.422^{b}	6.85 ± 0.940^{a}	7.56 ± 0.339^{a}	7.47 ± 0.519^{a}	8.06 ± 0.162^{ab}
57	7.29 ± 0.785^{b}	6.21 ± 0.53^{b}	6.37 ± 1.17^{b}	6.78 ± 0.39^{b}	5.39 ± 0.965^{ab}	9.89 ± 0.480^{b}	6.93 ± 1.05^{a}	7.79 ± 0.369^{a}	7.63 ± 0.589^{a}	8.32 ± 0.180^{ab}
64	7.88 ± 0.859^{b}	6.72 ± 0.63^{b}	6.91 ± 1.31^{b}	7.25 ± 0.43^{b}	5.75 ± 1.112^{ab}	9.89 ± 0.520^{b}	7.02 ± 1.174^{a}	8.03 ± 0.399^{a}	7.79 ± 0.658^{a}	8.58 ± 0.199^{ab}

Table 6 : Growth parameters of *C.catla* assessed during the rearing experiment with different treatments

Treatments	Total Weight Gain(g)	Total Percentage Weight Gain(%)	Total Length Gain(cm)	Total Percentage Length Gain(%)	Daily Growth Rate (g)	SGR	FCR	FER	PER
C	5.37	213.94	3.68	59.14	0.084	1.79	1.65	0.61	2.20
T1	4.53	206.06	1.60	25.58	0.071	1.75	1.67	0.6	3.28
T2	4.39	174.34	2.13	36.03	0.069	1.58	1.76	0.57	2.22
T3	4.74	188.98	1.46	22.98	0.074	1.66	1.76	0.57	2.19
T4	3.25	129.70	2.34	37.46	0.051	1.30	2.21	0.45	1.84

(2015) whose PER values ranged from 2-3 percent.

Length- weight relationship

The length and weight relation of fin fish follows allometric growth pattern and slope „b value in the $W = a.L^{b}$ equation normally varies from 2 to 3 for fishes growing under optimum environmental condition. Karthikeyan, (2006) and Deepa Suman, (2007) assessed the length and weight of relationship in angel fish and rosy barb respectively. Karthikayan, (2006) observed „b value above 2 for angel fishes where as Deepa Suman, (2007) recorded „b value less than 2 for rosy barb during rearing experiment. In line with Karthikeyan, (2006) the present study also showed the b value above 2 in the length -Weight relationship of Catla both in control and all treatment.

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