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Research Article

EVALUATION OF COMMERCIAL PROBIOTIC (BIFILAC) AS A GROWTH PROMOTER FOR MURREL, *Channa striatus* FINGERLINGS

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A B S T R A C T

The present study was carried out to evaluate the influence of dietary supplementation of commercial probiotic, Bifilac (mixture of several strains of bacteria and yeast) on growth performance and feed utilization efficiencies of murrel fish, *Channa striatus*. *C. striatus* fingerlings with similar body weight (4±1gm) were distributed randomly into five treatment groups, which fed a feed containing Bifilac in five different concentrations such as 1.0 to 5.0 gm/kg. The control group was fed without probiotics for the same period. The fishes were fed twice a day at a rate of 5% of their body weight. The feeding trial was conducted for 60 days. At the end of the feeding trial, maximum weight gain, length gain and specific growth rate (SGR) were observed ($P < 0.05$) in the 5.0 gm/kg probiotic diet fed fishes. FCR was highest in control group and PER and FE values were maximum ($P<0.05$) in 5.0 gm/kg. Bifilac supplemented group, which was significantly different from other feeding groups. These results clearly suggest that the inclusion of Bifilac at 5.0 gm/kg level can improve growth performance and feed utilization efficiencies in *C. striatus* fingerlings and it can be used effectively as a probiotics for the use in aquaculture.

INTRODUCTION

Aquaculture is one of the fastest growing food production activities in the world rapidly during the last decade. It has been recognized as a growth area of economic importance in countries and has attracted the attention of both public and private sectors.

Presently the world is facing numerous interrelated challenges because of the negative effects of the ongoing economic crisis caused by the remarkable climate change. Simultaneously, another momentous anxiety is the requirement to meet up the nutrition needs of the progressively growing global population. Globally, the fisheries sector provides immense opportunities to accomplish food security, create economic growth to lessen poverty, as well as to confirm better utilization of all types of fisheries assets. Generally, world aquaculture production has grown more rapidly compared to the world population growth and aquaculture has been considered as the most significant food production sectors (Akter, 2019).

The use of antibiotics as disease controllers and growth promoters is currently restricted or forbidden in many countries and a growing concern about the high consumption of antibiotics in aquaculture has initiated a definite need in which both consumer and manufacturer are looking for the alternative health management strategy, which can be accomplished by microbial intervention (Panigrahi, 2005). Many countries have banned the aquaculture products due to the presence of antibiotics residual. For this reason probiotics have been developed for use in aquaculture (Brunt and Austin, 2005).

Aqua feed accounts for about 50-60% of the variable operating costs in an aquaculture production cycle where proper nutrition is mandatory to produce an economically affordable, healthy, safe and a high quality product. Intensive aquaculture practices involved using high quality protein feeds along with other essential nutrients and complementary additives to keep organisms healthy and result in good growth performance (Ali *et al*., 2018). Probiotics are quite common in health promoting "functional foods" now a day for humans, as well as therapeutic, prophylactic and growth supplements in animal production and human health (Senok *et al*., 2005).

Probiotics are live microbial feed supplements that improve the health of host by modifying the gastrointestinal tract of the fish. Fish, being a hydrophilic animal rely solely on the environment, which filtering through the body and gill as fish performs it physiological function would benefit from use of probiotics. Probiotics enhance the nutrient utilization, modulate gut flora, inhibit the growth of pathogenic bacteria and improve growth and immune system of the fish (Ulukoy *et*

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al., 2017). Probiotics also produce protease, amylase and lipase enzymes, as well as growth factors such as vitamins, fatty acids and amino acids so that absorption of nutrients becomes more efficient (Kurniasih *et al.,* 2013; Lara-Flores and Olvera-Novoa, 2013). Rad *et al*., (2012) evaluated the effect of different levels of dietary supplementation of *S. cerevisiae* on growth performance, feed utilization and body biochemical composition of *O. niloticus* fingerlings. Pooramini *et al*., (2014) conducted a study on the effect of *S. cerevisiae* as a probiotic strain on survival, growth parameters and carcass quality of rainbow trout fry at start feeding. The growth promoting effect of a multi-strain probiotic on common carp (*C. carpio*) fingerlings was analysed by Asadian *et al*., (2015). Khatun and Saha (2017) conducted to evaluate the effect of dietary supplementation of commercial probiotics on growth and production of Nile tilapia (*O. niloticus*) in brackish water environment. Use of probiotic as growth promoter in African catfish, *C. gariepinus* (Burchell, 1822) juveniles was observed by Nwanna *et al*., (2017). With this background, the present study was undertaken in order to evaluate the influence of probiotics on growth performance and feed utilization efficiencies of murrel fish, *Channa striatus.*

MATERIALS AND METHODS

Experimental Fish and Husbandry

Commercially important freshwater edible fish murrel, *Channa striatus* (Bloch, 1793) was selected for the present investigation. *C. striatus* is an important food fish and preferred source of protein for rural and urban populations traditionally. Healthy *C. striatus* (mean initial weight, 4±1g) fingerlings were collected from hatchery farm at Bavanisagar Reservoir, Erode, Tamil Nadu, India. Fingerlings were immediately examined to find out their health status and acclimatized, transferred into in the quarantine tank (50 L) with aerated water for two weeks in the laboratory. Continuous aeration was provided to maintain the dissolved oxygen level, waste materials were removed by siphoning and one third of the aquarium water was exchanged daily. Fishes were provided with normal basal feed at the rate of 5% of their body weight twice a day at 9:00 and 17:00 hour for two weeks but no feed was provided at the first day of their arrival. The fishes were maintained as stock for further experimental trials.

Selection of Probiotics

The commercially available probiotic strain Bifilac was selected and tested for their efficacy in the experimental fishes. Bifilac (dietary probiotic) was purchased from local pharmaceutical shop at Coimbatore, Tamil Nadu, India. Bifilac contains mixed culture of *Streptococcus faecalis* T-HOJPC-30 million spores, *Clostridium butyricum* TO-A-2 million spores, *Bacillus mesentericus* TOA-JPC-1 million spores and *Lactobacillus*-50 million spores in each capsule. Bifilac was manufactured by UNI – SAN pharmaceuticals, Hyderabad (India) and Allianz Biosciences Pvt. Ltd. Pondicherry.

Experimental Diet Preparation

The probiotic tablets (Bifilac) collected from the local pharmaceutical store were ground well using mortar and pestle and made into a fine powder. The feed ingredients used in fish feed were fish meal, rice bran, chicken waste, vitamin premix, mineral premix, powdered probiotics and tapioca flour (as a binder). All the ingredients except probiotics were mixed thoroughly in a mix blender. The required amount of water was added to mixed ingredients to form soft dough. Then the dough was kept in an airtight polyethylene packet for one hour for proper conditioning followed by steam cooking for 20 minutes. Five different experimental pellet diets were prepared which contained five different mixtures of probiotics Bifilac such as 0 g (control), 1.0, 2.0, 3.0, 4.0 and 5.0 gm/kg (T_1 to T_5). Pellets were prepared using an extruder with 0.8 mm diameter holes**.** Pellets thus obtained were dried in hot sun and stored until use in an airtight polyethylene container to prevent fungal contamination.

Feeding Trial

Feeding trial was conducted for 8 weeks with dietary commercial probiotic, Bifilac and control diet (not supplemented with probiotics). Three replicate groups of fish were raised on treatment diets along with the control in 16 indoor cement tanks (50 L capacity).

Water temperature and pH were measured daily (morning and late afternoon); although these two parameters did not change significantly because of the indoor, closed, noncirculating, continuously aerated water environment and care was taken to monitor the cleanliness of the aquaculture tanks.

During the experimental period, fishes in control and Bifilac supplemented treatments were initially fed at a rate of 5% of body weight per day (dry-matter basis), which approached apparent satiation. The feeding rate was gradually reduced among all dietary treatments over the course of the experiment to ensure a rate close to apparent satiation without over feeding. The unutilized feed and faecal matter were collected before each morning feeding and stored for further analysis. Half of the water in the tanks was replaced daily throughout the experimental period after siphoning out the leftover feed and faecal matter. Culture tanks were thoroughly cleaned every two weeks when the fish were removed for weighing and mortality was checked daily.

Effect of Bifilac on Growth Parameters

Weight and length of the control and experimental fishes were taken just before starting the experiment, followed by 15 days interval till the end of the experiment. The growth parameters in terms of weight gain, length gain and specific growth rate were evaluated as follows.

$$\text{Percentage weight gain} = \frac{\text{Final weight (gm)} - \text{Initial weight (gm)}}{\text{Initial weight (gm)}} \times 100$$

$$\text{Percentage length gain} = \frac{\text{Final length (cm)} - \text{Initial length (cm)}}{\text{Initial length (cm)}} \times 100$$

$$\text{Specific growth rate (weight) (\% day}^{-1}) = \frac{\ln \text{Final weight (gm)} - \ln \text{Initial weight (gm)}}{\text{Days of experiment}} \times 100$$

Estimation of Feed Utilization Efficiencies

Feed utilization efficiencies in terms of feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV) were estimated after 60 days of the experimental period in *C. striatus* fed with control and five different concentrations (T_1 to T_5) of probiotic supplements feeds.

Feed Conversion Ratio (%)

$$\text{Feed conversion ratio} = \frac{\text{Feed given*}}{\text{Weight gain**}} \times 100$$

*As fed basis i.e., dry weight
* * Wet or fresh weight gain

Protein Efficiency Ratio (%)

$$\text{Protein efficiency ratio} = \frac{\text{Weight gain (gm)}}{\text{Protein intake (gm)}} \times 100$$

Protein Productive Value (%)

$$\text{Protein productive value} = \frac{Pb - Pa}{Pi} \times 100$$

Where,
P_b = Total body protein at the end of the feeding trial
P_a = Total body protein at the beginning of the feeding trial
P_i = Amount of protein consumed over the feeding trial

Statistical Analysis

Significant difference among treatment groups were tested by one-way analysis of variance (ANOVA; SPSS, 13.0). Differences between means were determined and compared by post hoc multiple comparison test (DMRT). All the tests used a significance level of $P<0.05$. Data are reported as means of three replicates ± standard error.

RESULTS

Growth Parameters

Weight gain, length gain and specific growth rate of the control and experimental fishes during different days (15, 30, 45 and 60 days) of the experimental period are given in Tables 1 to 3.

Weight Gain

Table 1 revealed that the percentage weight gain in *C. striatus* during 15 days intervals upto 60 days of the experiment. The results showed that of all the different treatments (T_1-T_5) and control, maximum weight gain (15.73±0.24, 20.81±0.82, 26.43±0.48 and 30.85±0.04%) was recorded in *C. striatus* fed with T_5 diet and minimum weight gain (10.87±0.83, 16.70±1.00, 20.46±0.02 and 22.77±0.82%) was recorded in the control fishes. The difference in weight gain observed in *C. striatus* fed with Bifilac supplemented diets during different days of the experiment was found to be statistically significant ($P<0.05$) when compared with control.

Length gain

During different days of the experiment, there was significant ($P<0.05$) increase in net length gain in all the Bifilac supplemented diet fed fishes than the control fishes. However, maximum length gain (13.80±0.16, 15.06±0.74, 18.26±0.78 and 23.16±0.07%) was obtained in 5.0g/Kg Bifilac incorporated diet fed fishes and minimum length gain was recorded in the control fishes on 15, 30, 45 and 60 days of the experiment. The minimum values recorded were 10.46±0.71, 12.76±1.00, 16.30±0.63 and 19.30±0.20%.

Specific growth rate (SGR)

Specific growth rate on 15, 30, 45 and 60 days of the experiment was maximum (0.63±0.21, 1.21±0.86, 1.39±1.00 and 1.69±0.23% respectively) in *C. striatus* grown in T_5 feed and minimum values (0.63±0.02, 1.21±0.23, 1.39±0.38 and 1.69±0.51%) were observed in fishes fed with control feed. SGR noticed in *C. striatus* fed with different probiotic feed showed significantly ($P<0.05$) higher values during different days of the experiment (Table 3).

Feed Utilization Efficiencies

Feed utilization efficiencies in terms of feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV) of *C. striatus* fingerlings grown in the control and Bifilac supplemented diets were analyzed after 60 days of the experimental period and are summarized in table 4. Feed conversion ratio in *C. striatus* fed with different probiotic supplementation at the end of the experimental period showed a variation between 1.58±0.84 to 2.10±0.03%. Among the different treatments and control, maximum feed conversion ratio (2.10±0.03%) was recorded in *C. striatus* grown in the control and minimum (1.58±0.84%) was recorded in fishes fed with 5.0 gm/Kg Bifilac supplemented diet. Feed conversion ratio recorded in all the treatments (T_1-T_5) was lower than the control and the values were found to be statistically significant ($P<0.05$). Similarly, highest protein efficiency ratio (2.70±1.00%) was recorded in T_5 fishes and lowest (2.32±0.26%) was noticed in fishes grown in control feed.

Probiotics incorporated diet fed fishes showed significantly ($P<0.05$) higher protein productive value ranged between 4.82±1.00 to 6.21±0.42% than the control fishes (4.60±1.12%). Of all the different treatments maximum protein productive value (6.21±0.42%) was recorded in *C. striatus* grown in T_5 feed and lowest (4.60±1.12%) was obtained in the control fishes. The difference in feed utilization efficiency among fishes of different treatments was found to be statistically significant ($P<0.05$).

Table 1 Weight gain (%) in *Channa striatus* during different days of the experiment in the control and Bifilac supplemented feeds.

Feed	Treatments	Concentration of Bifilac (gm/Kg)	No. of days during experiment			
			15	30	45	60
Control	C	-	10.87±0.83	16.70±1.00	20.46±0.02	22.77±0.82
Bifilac	T_1	1.0	12.40± 0.21	16.89±0.50	23.38±0.71	25.04±0.06
	T_2	2.0	13.39±0.80	18.22±0.52	24.30±0.84	27.46±0.92
	T_3	3.0	14.89±0.90	18.82±0.46	25.15±0.08	28.22±0.38
	T_4	4.0	15.41±0.32	19.31±0.08	26.21±0.71	29.36±0.12
	T_5	5.0	15.73±0.24	20.81±0.82	26.43±0.48	30.85±0.04

Values are the mean of three replicates± Standard Error

Table 2 Length gain (%) in *Channa striatus* during different days of the experiment in the control and Bifilac supplemented feeds.

Feed	Treatments	Concentration of Bifilac (gm/Kg)	No. of days during experiment			
			15	30	45	60
Control	C	-	10.46±0.71	12.76±1.00	16.30±0.63	19.30±0.20
	T_1	1.0	11.06±1.20	13.10±0.12	16.20±0.32	20.03±0.30
Bifilac	T_2	2.0	11.40±0.08	13.60±0.26	16.70±1.20	20.50±0.06
	T_3	3.0	12.50±1.00	14.40±0.18	17.200±1.00	21.60±0.10
	T_4	4.0	13.26±0.78	14.80±0.00	17.66±0.08	22.30±0.00
	T_5	5.0	13.80±0.16	15.06±0.74	18.26±0.78	23.16±0.07

Values are the mean of three replicates ± Standard Error

Table 3 Specific growth rate (%) in *Channa striatus* during different days of the experiment in the control and Bifilac supplemented feeds.

Feed	Treatments	Concentration of Bifilac (gm/Kg)	No. of days during experiment			
			15	30	45	60
Control	C	-	0.63±0.02	1.21±0.23	1.39±0.38	1.69±0.51
	T_1	1.0	0.77±1.00	1.22±0.26	1.52±0.00	1.76±0.04
	T_2	2.0	0.87±1.24	1.25±0.14	1.55±1.20	1.82±0.91
Bifilac	T_3	3.0	0.75±0.06	1.23±0.32	1.40±1.12	1.78±1.20
	T_4	4.0	0.86±0.46	1.28±0.64	1.54±0.64	1.83±0.62
	T_5	5.0	0.63±0.21	1.21±0.86	1.39±1.00	1.69±0.23

Values are the mean of three replicates ± Standard Error

Table 4 Feed utilization efficiencies (%) of *Channa striatus* fed with control and Bifilac supplemented feeds.

Feed	Treatments	Concentration of Bifilac (gm/Kg)	FCR (%)	PER (%)	PPV (%)
Control	C	-	2.10±0.03	2.32±0.26	4.60±1.12
	T_1	1.0	1.80±0.10	2.44±0.14	4.82±1.00
	T_2	2.0	1.68±0.23	2.5±0.62	5.74±0.51
Bifilac	T_3	3.0	1.62±0.36	2.5±0.20	5.82±0.12
	T_4	4.0	1.60±0.14	2.54±0.11	6.02±0.30
	T_5	5.0	1.58±0.84	2.70±1.00	6.21±0.42

DISCUSSION

Supplementation of commercial probiotic Bifilac into the feed of *C. striatus* significantly increased the weight, length and SGR of experimental fishes (T_1-T_5) compared to the control group. The highest attainment in fish body weight, length and SGR was recorded in group of fishes fed with 5.0 g/Kg Bifilac incorporated diet, however all the experimental fishes showed higher growth performance than the control diet.

One of the most expected consequence of using probiotic bacteria is the direct effect of probiotic on the growth performance of fish either by direct increment in nutrient uptake (Kesarcodi-Watson, 2008) or by providing the nutrients (Kolndadacha *et al*., 2011).

Probiotics that enter the fish stomach will attach to intestines and use large amounts of carbohydrates for growth and the production of digestive enzymes, so they will increase the digestibility of organic matters and protein. According to Lara-Flores and Olvera-Novoa (2013), an increase in fish growth performance may occur due to the balance of microflora in the gastrointestinal tract leading to the increase of the feed absorption quality and digestive enzymes, such as amylase, protease, lipase and cellulase. This will result in more nutrients that will convert into basal energy for growth. According to Hemaiswarya *et al*., (2013) probiotic can improve the fish growth through stimulation of appetite and increase the nutritional value by producing vitamins, detoxification compounds in the feed and simplifying those compounds, so they will be easier to be digested.

Commercial probiotic Bifilac used in this present study contains mixed cultures of bacteria including *Lactobacillus*. Several studies have demonstrated the positive effects of most vital group of probiotic bacteria such as *Lactobacillus* species on the growth response of Nile tilapia (Lara-Flores *et al*, 2003), freshwater prawn (Venkat *et al*., 2004), Persian sturgeon, beluga fry (Askarian *et al*., 2011). The reason of improved growth performance of cultured fish after feeding with probiotic diets might be due to improved quality and feed efficiency of diet, which ultimately stimulate the appetite of fish (Irianto and Austin, 2002).

A significant increase in growth performance was observed in rainbow trout fed diets containing *L. casei* and *L. plantarum* for 30 days (Andani *et al*., 2012). Improvement in growth performance could be related to better nutrient digestibility and absorption and increased enzyme activities by a proper balance of the intestinal microbial flora (Fuller, 1989) or exoenzyme secretion (Moriarty, 1998). Moreover, in previous studies lower levels of cortisol in fish fed the probiotic diet were shown, therefore lower stressor levels in these fish could result in better growth performance and nutrient efficiency (Al-Dohail *et al*., 2009). Our findings agree with those studies by other authors (Hernandez *et al*., 2010; Tung *et al*., 2010) where Kuruma shrimp, *Marsupenaeus japonicus* supplemented with *L. plantarum* at 1 g/ kg and showed enhancement in growth parameters and porthole livebearer fish, *Poecilopsis gracilis*, showed slightly higher body growth values after being fed a *L. casei* incorporated diet.

The best FCR values were observed in Bifilac supplemented diets (T_1 to T_5) suggesting that the addition of probiotics improved feed utilization, in practical terms this means that probiotic used can decrease the amount of feed necessary for the growth of experimental fishes, which could result in production cost reduction. Similar results have been reported by (Lara-Flores *et al*., 2003), who used *S. faecium, L. acidophilus* and yeast *S. cerevisiae* as growth promoters in Nile tilapia (*O. niloticus*). The present results are also in line with Wang (2011). The growth performance and nutrient utilization of *C. striatus* obtained in the current work also agree with Nwanna and Tope-Jegede (2017), who reported that *L. plantarum* when used in supplementation of fish diets improved growth performance and nutrient utilization.

The use of Bifilac which contains mixed cultures of *Lactobacillus*, *B. mesentericus, S. faecalis and C. butyricum* with a diet for eight weeks has exhibited significantly (P<0.05) improved specific growth rate

(SGR), protein efficiency ratio (PER), feed conversion ratio (FCR) and protein productive value (PPV) in *C. striatus* fingerlings. A parallel study with *C. gariepinus* showed increased growth performance, FCR, PER, PPV and energy retention when the fish feed was supplemented with a commercial probiotic strain of *Bacillus* (El-Haroun 2007). Fortified diet enriched with *L. plantarum* enhanced the growth, weight gain and FCR of cultured *C. gariepinus* fingerlings (Falaye *et al*., 2016).

Probiotic strains usually synthesize extracellular enzymes (e.g: proteases, amylases and lipases) and growth factors (e.g., vitamins, fatty acids and amino acids) which can stimulate the appetite and endorse fish nutrition by the detoxification of toxic substances and breakdown of indigestible components (Balcazar *et al*., 2006). Consequently, nutrients are more readily absorbed when the feed is supplemented with probiotics (Afrilasari *et al*., 2017). However, some probiotic strains may be a source of essential nutrients, such as fatty acids (Vine *et al*., 2006), biotin and vitamin B12 (Sugita *et al*., 1996), and their activity in the digestive tract may also stimulate the specific and total activities of digestive enzymes such as amylase, chitinase, lipase and protease (Newaj-Fyzul and Austin, 2015), thereby improving the whole digestive process and enhancing the digestibility of feed and the effective utilization of nutritive supplies, leading to improvement of FCR.

In the current study, the best FCR, PER and PPV and SGR values were observed in 5.0g/Kg Bifilac incorporated diet than the other diet fed groups. Probiotics may improve digestion by stimulating production of digestive enzymes or through other alterations in the gut environment, which could translate to improved growth performance (Welker and Lim, 2011). Growth improvement has been reported by feeding of *S. cerevisiae* in *O. niloticus* (Rad *et al.,* 2012), *O. mykiss* (Pooramini *et al.,* 2007), *E. coioides* (Chiu *et al.,* 2010), *C. striatus* (Dhanaraj and Haniffa, 2011) and *A. persicus* (Iranshahi *et al.,* 2011). Also the same results were reported by Lashkar Boloki *et al.,* (2011) on Persian sturgeon (*A. persicus*).

These present results are consistent with the study by Putra and Widanarni (2015), probiotic incorporation in the diet of tilapia can improve feed efficiency and specific growth rate. Maity *et al*., (2011) also reported that *B. subtilis* and *B. licheniformis* could increase the growth rate, nutrient digestibility, digestive enzyme activity and microbial populations in the gastrointestinal tract of barramundi fingerlings (*L. calcarifer*). Sanchez-Ortiz *et al*., (2015) reported that the probiotic isolated from blood clams (*A. tuberculosa*) could improve growth performance and immunity of white shrimp (*L. vannamei*). According to Widanarni *et al*., (2015) probiotics isolated from white shrimp could promote growth, protein digestibility and protein retention of white shrimp.

Probiotic diet fed for 21 days had significant effect on FE and FCR and FE of fish was also higher and significantly different as compared to that of control fish ($P<0.01$) in Sangkuriang catfish (Manoppo, 2019). A research by Mulyasari *et al.,* (2016) reported that probiotic originating from the gastrointestinal tract of gouramy (*Osphronemus goramy*) had the ability to increase the growth of Nile tilapia (*O. niloticus*). The results showed that tilapia fingerlings fed feed added with probiotic had better growth than control fish. Marlida *et al.,* (2014) also reported that probiotic isolated from humpback groupers (*Cromileptes altivelis*) digestive organ induced growth, protein and fat retention and reduced FCR. In shrimp, Widanarni *et al.,* (2015) reported that probiotics isolated from gastrointestinal tract of Pacific white shrimp (*L. vannamei*) could promote growth, protein digestibility and protein storage of shrimp.

CONCLUSION

In this present investigation, growth performance and nutritional indices were assessed in *C. striatus* orally supplemented with Bifilac (1.0 to 5.0g/Kg) for 60 days. All the experimental diet fed fishes showed better weight gain, length gain and specific growth rate and the nutritional indices such FCR, PER and PPV. However, maximum results were recorded in fishes fed with 5.0g/Kg Bifilac supplemented diet. Biochemical composition in muscle tissues of *C. striatus* were also in the same trend that is highest moisture, protein, carbohydrate, fat, ash and calorific contents were recorded in 5.0g/Kg Bifilac included diet fed fishes. The enhanced growth performance in all the experimental fish fed diets with commercial probiotics Bifilac suggests that the mixed culture of bacteria may be involved in optimizing the use of dietary protein and it could reduce the wastage since more than 70% of the cost of fish feeds.

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