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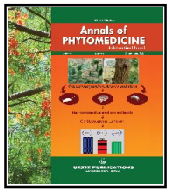

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Effect of turmeric supplemented feed on various growth parameters of *Pangasius hypophthalmus*

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Abstract

The use of non-specific plant products is gaining attention in aquaculture all over the world, for enhancing growth performance and to improve immunity to control bacterial and viral diseases in fishes. One of such herbs is turmeric (*Curcuma longa* L.), belonging to Zingiberaceae family. *Pangasius* is fast-growing fish species for culture fisheries and has great potential to meet the growing aquaculture production demand. The main aim of present study was to evaluate the effect of turmeric (*C. longa*) supplemented feed on growth performance parameters of *Pangasius hypophthalmus*. The experiment was conducted for 90 days, using glass aquaria of 48 × 15 × 18" and 240 finger lings were randomly divided in to 3 treatment groups in triplicates along with a control group. Three isoenergetic experimental diets were prepared by supplementing turmeric @ 3 gm/kg (T1), 6 gm/kg (T2) and 9 gm/kg (T3) with basal diet (mustard oil cake and rice bran) and control diet without turmeric. After 90 days of feeding trial, fishes fed with 6 gm/kg turmeric (T2) exhibited significant (p<0.05) increase in length in cm, weight in grams, specific growth rate (SGR), feed conversion ratio (FCR) or efficiency, average daily weight gain (ADG) and best survival rate. The results revealed that supplementation of turmeric can improve the growth performance parameters of *P. hypophthalmus*

1. Introduction

Aquaculture is low cost quality food producing sector, emerging rapidly and producing nearly 50% of the world's fish food for ever growing human population and all time high aquaculture production has reached up to 114.5 million tons in the world during 2018 including 82.1 million tones fish, 32.4 million tons of aquatic algae and 26,000 tons of ornamental sea shells and pearls (FAO, 2020). Aquaculture has contributed 46.0 per cent to global fish production in 2018, whereas it was 25.7% in 2000. The share of aquaculture in Asian fish production (excluding China) increased up to 42.0 % in 2018, from 19.3% in 2000. Fish production in India has increased from 3.84 MMT in 1990-91 to 13.76 MMT during 2018-19 with an annual growth rate of 4.05% (Kumar *et al*., 2020). The fish farming has increased manifold in Haryana in recent years and more than 80% of the village ponds available are under fish culture. Village Panchayats in Haryana are earning more than Rs. 125 crores every year through leasing the village ponds for fish farming. Haryana ranks 2nd for per hectare fish production in the whole country.

The catfish is the major group of fishes among freshwater fishes being cultivated all over the country. India consists of 197 catfish species from 52 genera and *Pangasius* is relatively new and fast-growing fish species that has great potential for production and export (Khan *et al*., 2018). Moreover, *Pangasius* is a type of catfish that is endemic to the waters of Mekong basin in Southeast Asia and belongs to the family Pangasiidae. This fish species is also known as *Pangasianodon hypophthalmus*, Sutchi catfish, striped catfish or Tra fish (Guimaraes *et al*., 2016; Rathod *et al*., 2018). *Pangasius* has unique qualities like fast growth, air breathing, and tolerance to low dissolved oxygen and compatibility to polyculture, so it has gained popularity in many Asian countries (Mugaonkar *et al*., 2019). This species can grow up to 1 to 1.5 kg in 6-8 months and annual yield is around 10 to 15 tons per hectare (Mugaonkar *et al*., 2017). The major cultivated areas in India are Andhra Pradesh (24,000 ha), followed by Bihar (8,000 ha) and West Bengal with 6,400 hectares (Mohan *et al*., 2019). Diseases are one of the major constraints and limiting factor in the field of aquaculture in India and other countries of the world (Bagum *et al*., 2013). Aquaculture growth is often linked to culture intensification, leading to overcrowding and poor water quality parameters, facilitating the spread of pathogens and disease outbreaks and mortality (Bondad-Reantaso *et al*., 2005; Reverter *et al*., 2017). The chemicals and antibiotics used to control bacterial load are expensive and somehow leave residual effects (Adeshina *et al*., 2017). Thus, the use of antibiotics has been criticized all over the world (Baruah *et al*., 2008; Shakaya, 2017). It not only affects the non-target species, but also poses serious health hazards for the consumers. Hence, more attention to formulate eco-friendly alternatives (organic immune-stimulants, vaccines and probiotics) has attracted the intention of researchers for health management in aquaculture in the recent years (Kaur and Ansal, 2020). The use of medicinal and herbal plants belonging to different families in the management practices of aquaculture ponds is gaining momentum, as they are safe, effective, widely available and cost effective to produce fishes

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free from chemicals (Mousa *et al*., 2008). The herbal plants are not only used as remedies, but also as growth promoters and immuno-stimulants (Aly *et al*., 2016; Hodar *et al*., 2021). The advantage of the herbs is that most of these plants do not pose threat for human health, because of their natural origin (Stratev *et al*., 2018). Therefore, there is urgent need for some alternate to replace chemicals with the use of botanicals which have antibacterial potential like *C. longa* (Abdel-Tawwab and Abbass, 2017).

2. Materials and Methods

2.1 Feed preparation and formulation

(a) Proximate analysis of feed ingredients

This was done by using standard method as described in AOAC (2019). The proximate composition of mustard oil cake and rice bran used for different diets is shown in Table 1.

Table 1: Proximate composition of mustard oil cake and rice bran used in different diets (% on dry matter basis)

Ingredients	Dry matter	Crude protein	Crude lipid	Ash	Crude fiber	Moisture content
Mustard oil cake	84.11	26.98	13.86	9.58	11.96	11.23
Rice bran	88.22	11.89	7.92	10.52	15.83	10.06

(b) Experimental diet preparation

Dry turmeric rhizome/root and mustard oil cake were procured from the local market and then grinded using grinding machine and rice bran was bought from the rice mill (from Tohana). Turmeric powder was incorporated in the basal diet (mustard oil cake and rice bran, 1:1) at different concentrations @ 3 gm/kg, 6 gm/kg and 9 gm/kg basal diet (Talpur and Ikhwanuddin, 2013). Sinking pellets of different experimental feeds were prepared using hand pelletizer machine. Molasses was added as binder @2% of formulated feed and thereafter, 10% moisture contents were maintained in the experimental feed through autoclaving for making the pellets. Pellets were then oven dried at 40^0C for 8 h and stored in air tight plastic containers at room temperature.

2.2 Experimental design

Under laboratory condition, the 500 finger lings of *P. hypophthalmus* (procured from the certified farmer) were acclimatized for one week with mustard oil cake without turmeric supplementation under laboratory conditions. Thereafter, 240 healthy fingerlings were selected and transferred to glass aquaria of 48×15×18" size and 12 groups (20 fishes/aquaria) under three feeding groups in triplicate were made with one control. One-third of water was replaced regularly and $KMNO_4$ was used as an oxidizing agent for disinfection. Total 4 feeding groups were maintained, group 1 (control): fingerlings were fed on basal diet without any additive, group 2 (T1): Fish basal diet + 3 gm/kg *C. longa*, group 3 (T2): Fish basal diet + 6 gm/kg *C. longa* and group 4 (T3): Fish basal diet + 9 gm/kg *C. longa*. All the fingerlings of all the feeding groups were fed @5% of their body weight in morning, noon and evening. Various growth parameters were recorded every fortnightly up to 90 days and ration was adjusted accordingly.

2.3 Evaluation of growth performances

Growth parameters were recorded fortnightly in terms of gain in length (cm) and weight (gm), average daily weight gain (ADG), food conversion ratio (FCR), survivability, specific growth rate (SGR) and per cent increase in length and weight using prescribed standard formulae as given below:

(a) Weight gain (%)

$$= \frac{\text{Mean final weight - Mean initial weight}}{\text{Mean initial weight}} \times 100$$

(b) % increase in length

$$= \frac{\text{Mean final length - mean initial length}}{\text{Mean initial length}} \times 100$$

(c) ADG $$= \frac{\text{Mean final Weight - Mean initial weight (g)}}{\text{Number of culture days}} \times 100$$

(d) FCR $$= \frac{\text{Amount of dry feed consumed}}{\text{Live weight gain}}$$

(e) SGR $$= \frac{\text{Log final body weight - Log initial body weight}}{\text{Number of Days}} \times 100$$

(f) Survival Rate $$= \frac{\text{Final number of fish}}{\text{Initial number of fish}} \times 100$$

2.4 Statistical analysis

The data were analyzed (means ± SD) by one-way analysis of variance (ANOVA) using OPSTAT; and differences between means were determined and compared by using Duncan's test and considered significant at $p<0.05$.

3. Results

3.1 Growth parameters

The observations on all the growth parameters are presented below and compared with control.

(a) Weight gain (%)

The observations recorded for the growth performance in terms of weight gain (%) are presented in Tables 2 and 3. The fingerlings of *P. hypophthalmus* exhibited weight gain in the range of 382.49 to 528.91% after feeding trials of 90 days and maximum gain in weight was 528.91 ± 5.07 %, recorded in fingerlings of T2 treatment, which was significantly higher ($p<0.05$) than T1. Weight gain was 422.41 ± 1.13% and 383.79 ± 2.91% in T3 and T1, respectively.

Table 2: Effect of turmeric supplemented feed on mean weight (gm) of *P. hypophthalmus*

Treatment	0 day	15 days	30 days	45 days	60 days	75 days	90 day
Control	4.45 ± 0.03	7.13 ± 0.00	9.37 ± 0.05	11.78 ± 0.04	14.81 ± 0.07	17.91 ± 0.06	21.42 ± 0.12
T1	4.43 ± 0.04	7.06 ± 0.02	8.92 ± 0.00	11.23 ± 00.1	14.18 ± 0.06	19.61 ± 0.12	21.34 ± 0.24
T2	4.43 ± 0.01	8.02 ± 0.09	10.73 ± 0.03	13.49 ± 0.13	17.92 ± 0.08	22.43 ± 0.17	27.84 ± 0.26
T3	4.44 ± 0.00	7.61 ± 0.02	9.79 ± 0.04	12.45 ± 0.03	15.81 ± 0.03	19.38 ± 0.03	23.16 ± 0.03
C.D.($p \leq 0.05$)	N/S	0.17*	0.11*	0.28*	0.21*	0.37*	0.63*

Table 3: Effect of turmeric on % increase in weight of *P. hypophthalmus*

Treatments	After 90 days
Control	382.49 ± 5.34
T1 (3 gm/kg)	383.79 ± 2.91
T2 (6 gm/kg)	528.91 ± 5.07
T3 (9 gm/kg)	422.41 ± 1.13
C.D. ($p \leq 0.05$)	13.24*

(b) Percent increase in length

The gain in length measured in percentage increase in fingerlings of *P. hypophthalmus* was in the range of 74.02 to 95.02 % after feeding trials of 90 days (Tables 4 and 5). The observations recorded showed that maximum gain in length was 95.02 ± 1.90% in T2 treatment, followed by T1 and T3. Length gain in fingerlings of T2 treatment, was significantly higher (p<0.05) than control, T3 and T1.

(c) Average daily weight gain (ADG)

The changes in an average daily weight gain were recorded after 90 days of feeding trials, and the maximum ADG (0.26 ± 0.003 gm) was observed in T2, followed by T3 and T1 with gain of 0.21 and 0.19 gm, respectively (Table 6). But, maximum value of ADG (0.36 gm) was observed in T2 treatment between 75 to 90 days whereas; minimum value (0.12 gm) was recorded in T1 treatment during 15 to 30 days interval. When compared with other treatments, ADG of T2 was (p>0.05) during 15 to 45 days interval.

Table 4: Effect of turmeric supplemented feed on mean length (cm) of *P. hypophthalmus*

Treatment	0 day	15 days	30 days	45 days	60 days	75 days	90 days
Control	8.01 ± 0.003	9.89 ± 0.11	10.88 ± 0.05	11.78 ± 0.1	12.50 ± 00.1	13.13 ± 0.06	13.93 ± 0.15
T1	7.70 ± 0.05	10.35 ± 0.33	10.84 ± 0.02	11.74 ± 0.05	12.57 ± 0.19	13.14 ± 0.12	14.03 ± 0.05
T2	7.43 ± 0.04	10.02 ± 0.06	11.55 ± 0.04	12.38 ± 0.04	12.94 ± 0.11	13.68 ± 0.12	14.43 ± 0.07
T3	7.72 ± 0.05	9.87 ± 0.05	10.97 ± 0.07	12.08 ± 0.04	12.78 ± 0.07	13.43 ± 0.11	13.86 ± 0.14
C.D.($p \leq 0.05$)	0.13*	0.18*	0.17*	0.21*	0.21*	0.35*	0.36*

Table 5: Effect of turmeric supplemented feed on % increase in length of *P. hypophthalmus*

Treatment	Complete
Control	74.02 ± 1.76
T1	82.29 ± 0.50
T2	95.02 ± 1.90
T3	79.633 ± 2.45
C.D.($p \leq 0.05$)	5.96*

Table 6: Effect of turmeric supplemented feed on average daily weight gain (gm) in *P. hypophthalmus*.

Treatments	0 to 15	15 to 30	30 to 45	45 to 60	60 to 75	75 to 90	After 90 days
Control	0.18 ± 0.00	0.15 ± 0.00	0.16 ± 0.00	0.21 ± 000	0.20 ± 0.04	0.23 ± 0.00	0.19 ± 0.00
T1 (3 gm/kg)	0.18 ± 0.00	0.12 ± 0.00	0.15 ± 0.01	0.20 ± 0.00	0.23 ± 0.00	0.24 ± 0.00	0.19 ± 0.00
T2 (6 gm/kg)	0.25 ± 0.01	0.17 ± 0.01	0.18 ± 0.01	0.29 ± 0.01	0.30 ± 0.01	0.36 ± 0.01	0.26 ± 0.00
T3 (9 gm/kg)	0.21 ± 0.00	0.15 ± 0.00	0.18 ± 0.00	0.22 ± 0.00	0.24 ± 0.00	0.21 ± 0.05	0.21 ± 0.00
C.D. ($p \leq 0.05$)	0.01*	0.02*	0.02*	0.02*	0.06*	0.08*	0.01*

(d) Feed conversion ratio (FCR)

Feed conversion ratios in fingerlings of *P. hypophthalmus* are shown in Table 7. The minimum FCR (2.49 ± 0.03) was recorded in T2 treatment, whereas the maximum FCR (3.34 ± 0.06) was calculated in control, followed by T1 and T3 with values 2.91 ± 0.08 and 2.88 ± 0.02, respectively. Lowest FCR (0.88 ± 0.03) was observed in T2 treatment after 15 days of trial interval whereas highest FCR (4.22 ± 0.44) was recorded in T1 treatment between 75 to 90 days interval.

Table 7: Feed conversion ratio in fingerlings of *P. hypophthalmus* fed with turmeric supplemented feed

Treatments	0 to 15	15 to 30	30 to 45	45 to 60	60 to 75	75 to 90	After 90 days
Control	1.28 ± 0.06	2.36 ± 0.03	2.98 ± 0.07	3.03 ± 0.03	3.36 ± 0.13	3.89 ± 0.16	3.34 ± 0.06
T1 (3 gm/kg)	1.25 ± 0.02	2.84 ± 0.04	2.92 ± 0.11	2.95 ± 0.14	3.31 ± 0.17	4.22 ± 0.44	2.91 ± 0.08
T2 (6 gm/kg)	0.88 ± 0.03	2.45 ± 0.15	3.12 ± 0.09	2.29 ± 0.06	2.98 ± 0.10	3.12 ± 0.07	2.49 ± 0.03
T3 (9 gm/kg)	1.04 ± 0.01	2.6 ± 0.02	2.77 ± 0.03	2.81 ± 0.03	3.29 ± 0.04	3.93 ± 0.05	2.88 ± 0.05
C.D. ($p \leq 0.05$)	0.12	0.26*	N/S	0.27*	N/S	0.77*	0.19*

(e) Specific growth rate (SGR)

The values of SGR were calculated for the fishes fed with turmeric supplemented feed for 90 days (Table 8). The maximum SGR (0.89 ± 0.01%) was observed in T2 treatment while minimum values were significantly similar in control and T1, *i.e.*, 0.76 ± 0.00. The fingerlings exhibited significantly higher ($p<0.05$) SGR in T2 as compared to other treatments. However, maximum SGR (1.78 ± 0.04%) was observed in T2 treatment during 0 to 15 days interval whereas minimum value (0.51 ± 0.01%) of SGR was recorded in control and T3 between 75 to 90 days interval.

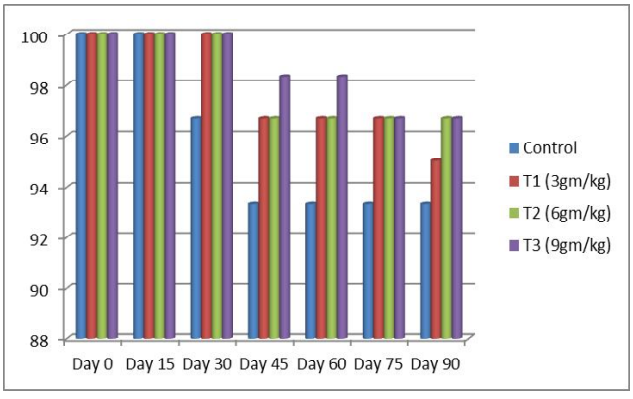
Table 8: Effect of turmeric supplemented feed on specific growth rates (%) of *P. hypophthalmus*

Treatments	0 to 15	15 to 30	30 to 45	45 to 60	60 to 75	75 to 90	After 90 days
Control	1.37 ± 0.02	0.79± 0.01	0.66± 0.01	0.66± 0.00	0.55± 0.01	0.52± 0.02	0.76± 0.00
T1 (3 gm/kg)	1.39 ± 0.01	0.68± 0.01	0.66± 0.02	0.68± 0.01	0.63± 0.01	0.53± 0.01	0.76± 0.00
T2 (6 gm/kg)	1.78 ± 0.04	0.78± 0.04	0.66± 0.03	0.82± 0.04	0.65± 0.02	0.63± 0.01	0.89± 0.00
T3 (9 gm/kg)	1.14 ± 0.30	0.73± 0.00	0.69± 0.01	0.69± 0.01	0.59± 0.01	0.51± 0.00	0.80± 0.00
C.D. ($p \leq 0.05$)	N/S	0.07*	N/S	0.07*	0.04*	0.04*	0.01*

(f) Survival rate

Observations on survival rate reveals that maximum survival rate was equal (96.67%) in the both (T2 and T3), the treatments where as it was 93.33% in control group.

Figure 1: Effect of turmeric supplemented feed on the survival rate of *P. hypophthalmus*.



4. Discussion

It is well established fact that changes take place in growth and metabolism of fishes besides physicochemical characteristics as a result of supplementary feeding. Major input cost in culture fisheries are the cost of commercial supplementary feed and synthetic drugs to enhance production and to minimize the losses due to various viral and bacterial diseases. Herbal plants extracts in the management practices of fish ponds is gaining popularity because they are safe, cost effective, easy and widely available to produce fish free from any residual effects of synthetic drugs. The data and observations made during present investigation on the fingerlings of *P. hypophthalmus* reveals that supplementation of curcumin in the fish feed resulted in the enhanced growth performance. Fingerlings fed upon supplementary diet containing turmeric @ 3 gm/kg, 6 gm/kg and 9 gm/kg in T1, T2 and T3, respectively exhibited better growth performance in terms of total weight and length gain in comparison to fishes fed with similar diets, but without turmeric. Significantly ($p<0.05$) better SGR, ADG and FCR were observed in T2 treatment. Similar results were observed by Sahu *et al.* (2008) in *L. rohita* where highest weight gains with lowest FCR were found with the diet supplemented with curcumin @ 5 gm/kg. Similarly, Mooraki *et al.* (2019) observed the positive effect of 0.3 per cent turmeric powder as an herbal additive on growth performance and FCR of Green Terror (*Adinocara rivulatus*). Adeshina *et al.* (2017) also got positive results, the level of *C. longa* in diet as an additive in the basal diet of *Clarias gariepinus*, and recorded significant increase ($p<0.05$) in total weight gain (g), percentage weight gain (%), specific growth rate (%) and protein efficiency ratio (PER) meanwhile feed conversion ratio decreased significantly ($p<0.05$). Maximum total weight gain (54.54 gm), SGR (0.96 gm/day), feed intake (68.98 gm), PER (1.36) and energy intake (300.40 kcal/fish) was noted in fishes

fed with the diet containing 3.0% *C. longa* (Adeshina *et al.*, 2017). Present study reveals that the maximum SGR (0.89) was observed in T2 treatment, whereas minimum SGR (0.76) was recorded in control. The best FCR with minimum value (2.49) was in T2 treatment and maximum FCR (2.91) in T1 treatment, minimum value of FCR in T2 may be because turmeric might have contributed in the digestion process or may have helped in enhanced secretion of digestive enzymes to better utilization of available nutrients (Dulbecco and Savarino, 2013). The maximum % increase in length (95.02%), weight (528.91%), and average daily weight gain (0.26 gm) were also observed in T2 treatment. This increase in growth parameters is due to curcumin content in turmeric which stimulates appetite and enhances the palatability of feed for fishes (Arief *et al*., 2015). No significant (p>0.05) variations in the survival rate of fishes were recorded in all treatments during present study. Red spots near pectoral and caudal fins along with some symptoms of tail rot type disease were observed in the fishes fed with control diet so antifungal, antiviral and antibacterial property of curcumin may have prevented the growth of harmful microorganisms in all treatment and this view is supported by Ashry *et al*. (2021), that fish (*Sparus aurata*) fed with turmeric supplemented diet stay healthy. Conclusively, it can be stated that turmeric improved growth in fingerlings of *P. hypophthalmus* through improved digestion.

5. Conclusion

In the present investigation, the effect of turmeric (*C. longa*) supplemented feed on growth performance, parameters of *P. hypophthalmus* was evaluated for 90 days, using 500 L capacity glass aquaria and 240 fingerlings. After 90 days, fishes (*P. hypophthalmus*) fed with 6 gm/kg turmeric (T2) exhibited significant (p<0.05) increase in length, weight, SGR, FCR, ADG and best survival rate. Hence, it can be concluded that supplementation of turmeric can improve and enhance various growth parameters of *P. hypophthalmus* through improved digestion.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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