

Assessment of Growth Performance in *Channa punctata* (Bloch, 1793) Fed Diets Supplemented with Differential Concentrations of Lycopene

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ABSTRACT

The current research work was undertaken to evaluate the impact of dietary lycopene supplementation in enhancing the growth performance of fresh water fish *Channa punctata*. The experimental fishes were fed diets containing five different lycopene concentrations (10, 12, 14, 16 and 18mg/kg) over an eight-week period. Growth performance was evaluated across seven treatment groups including controls. The study resulted in significant gain in weight (6.64 ± 0.08 g to 10.11 ± 0.12 g) and length (0.8 ± 0.05 cm to 3.03 ± 0.33 cm) among fishes treated with increasing concentrations of lycopene compared to control. Lycopene concentration of 14mg/kg displayed the minimum feed conversion ratio (FCR) value of 1.10 ± 0.06 . The lycopene supplementation of 14mg/kg exhibited the maximum ($1.98 \pm 0.08\%$, day^{-1}) specific growth rate (SGR). However, diets supplemented with 16mg/kg and 18mg/kg of lycopene showed a decline in SGR. A second order polynomial fit analysis between dietary lycopene level and SGR showed the optimal dietary concentration of lycopene for maximum growth (14.29mg/kg). These findings suggest lycopene as a promising natural growth promoter in aquaculture feed formulations for sustainable fish culture activities as alternate to synthetic chemical growth promoters.

INTRODUCTION

Aquaculture plays a crucial role in ensuring food security and meeting the nutritional needs of the growing global population (Pradeepkiran, 2019). Fish serves as a valuable source for the procurement of animal protein, thus supplements the daily protein needs of humans in a considerable quantity. Approximately half of the world's food fish is sourced from aquaculture. Thus, the focus for enhancing the growth and development of freshwater fish is gaining interest (Boyd *et al.*, 2022).

Channa punctata, commonly known as spotted snakehead, is very common in the Indian subcontinent and adjoining areas and are naturally found in ponds, swamps and brackish water bodies. It is widely consumed in the Indian subcontinent due to its rich

nutritional profile. To meet its higher demand-based supply and to benefits local farmers for their subsistence, efforts to boost its yield are steadily growing (**Harikrishnan et al., 2021**). Providing nutritionally balanced diet is essential for effectively cultivating fish in captivity. In order to provide proper nutrition, fish feed could be supplemented with various growth stimulators to boost their growth parameters (**Xu et al., 2021**).

In addition to its essential nutrients, supplementation with appropriate antioxidants also promotes fish development. Antioxidants not only provide protection against several disease conditions but also help in the overall physiological development in fish (**Shafe et al., 2024**). Fish in cultivation usually receive commercial diet that lacks proper nutritive supplementation necessary for proper fish growth. Antioxidant supplementation may enhance fish growth and development (**Ahmed et al., 2022; Hu et al., 2025**).

Carotenoids are a group of natural antioxidants found in different vegetables and fruits, promotes growth in several fish species (**Crupi et al., 2023**). In addition to growth, it also protects fish from harmful effects of a variety of toxicants (**Nakano & Wiegertjes, 2020**). Lycopene, an important noncyclic, water-insoluble carotenoids found in different vegetables mainly tomatoes are directly associated with fish health by playing a significant role in inhibiting protein, lipid and DNA oxidation (**Imran et al., 2020; Tufail et al., 2024**). Its antioxidant, chemotherapeutic and anti-apoptotic properties has gained serious attention in the recent past (**Caseiro et al., 2020; Long et al., 2024**). Its curative activities are mostly attributed to its effect against singlet oxygen and free radicals (**Bacanli et al., 2017**). Therefore, this study investigates the effects of dietary lycopene supplementation on growth parameters in *Channa punctata*, aiming to determine its potential as a natural growth enhancer in aquaculture.

MATERIALS AND METHODS

Rearing of fish

Fingerlings of *Channa punctata* were collected from local farms and were treated with 0.02% KMnO₄ solution and 0.004% formalin solution to avoid infection and were subsequently transferred to indoor fish tanks for 2 weeks. During this period, fingerlings were fed with commercial basal diet (protein: 42%; fat: 9%; ash: 8%; fibre: 3% and moisture: 11%) procured from Hi-Pro Feeds India Pvt. Ltd. *Channa punctata* fingerlings with an average weight of 4.95 ± 0.05 g were selected for the experiment.

Experimental design

Channa punctata treated with different concentrations of antioxidant lycopene were assessed for growth performance analysis. Seven different forms of experimental setups were prepared. The first group of experiment contained only the commercial basal

diet and were marked as control group. For group 2, fish were given diet containing corn oil. While for groups 3 to group 7, fish were provided with five increasing concentrations of lycopene (lyc) supplemented diet. Different feeding groups were marked from L2 to L6 by varying lycopene concentrations (Table 1).

Table 1. Types of dietary treatments for growth analysis in *Channa punctata*

Serial No.	Feeding groups	Dietary supplementation
1	L0	Control (basal diet)
2	L1	Corn oil
3	L2	10 mg/kg lycopene
4	L3	12 mg/kg lycopene
5	L4	14 mg/kg lycopene
6	L5	16 mg/kg lycopene
7	L6	18 mg/kg lycopene

Diet was provided twice daily at a rate of two percent of fish body weight per day. All these experiments were performed in triplicate set (10 fish per aquarium) for eight weeks. Water in each aquarium (capacity 90 L; 80×35×35 cm³) was changed daily to maintain a hygienic situation. The water quality parameters were checked regularly and proper aeration was maintained for securing proper environment. All experimental procedures were conducted in accordance with institutional guidelines for animal care.

Growth parameters

Channa punctata treated with different concentrations of antioxidant lycopene was assessed for growth performance analysis. Parameters considered for analyzing growth performance in fish includes food conversion ratio (FCR), specific growth rate (SGR), average weight gain (AWG), total length increase (TLI) and condition factor (CF). Standard protocols have been adopted for conducting the above tests (Goda *et al.*, 2007; Thongprajukaew *et al.*, 2017). These growth parameters were calculated using the following equation:

$$\text{FCR} = \text{Dry feed fed (g)} / \text{wet weight gain (g)}$$

$$\text{SGR} = 100 [\ln W_t - \ln W_0] / [t - t_0]$$

$$\text{AWG} = 100 \times [(\text{FBW} - \text{IBW}) / \text{IBW}]$$

DFI= $100 \times [\text{Dry Feed Intake} / \{(\text{IBW} + \text{FBW})/2\} / \text{feeding days}]$.

CF= $[\text{Weight of the fish (g)} / \text{Length of the fish (cm)}] \times 100$

Where, W_t = Mean weight (g) at day t ; W_0 = Mean weight (g) at day t_0 ; $\ln$ = Natural logarithm; IBW= Initial body weight (g); FBW= Final body weight (g).

During the experimental period, water parameters were regulated at a temperature of 27–31°C (using a thermostat; TC-306T, Inkbird, China), dissolved oxygen levels above 7 mg/L (by an electronic DO meter; Lutron DO-5509), pH and salinity between 7.6–7.8 and 26–28, respectively (using a digital pH cum salinity meter; Bionexis) to ensure stable water quality within limits.

Statistical analysis

Data were analyzed statistically using SPSS software package (version 14). The experimental data were expressed in form of mean±standard error. For analysing different growth parameters in fish, one-way analysis of variance (ANOVA) was applied after testing the homogeneity of variance among experiments through Levene's test. Duncan's multiple range and post-hoc test were performed upon observing substantial variation in the ANOVA test (Zhou *et al.*, 2024). Variations in values were statistically significant at $P < 0.05$. Quadratic regression analysis was performed to satisfy the pertinent of the results at different lycopene concentrations. Second order polynomial regression was used to determine specific lycopene supplementation level that provided maximum values of AWG and SGR in *Channa punctata*.

RESULTS

From the growth experiment it is evident that food supplemented with lycopene possesses a significant impact on the growth parameters of *Channa punctata*. The general growth trend shows a steady gain in weight, length and SGR values to a certain range and subsequently declines. The optimum level is ascertained through second order polynomial fit analysis. There has been a notable change in weight (6.64 ± 0.08 g to 10.11 ± 0.12 g) and length (0.8 ± 0.05 cm to 3.03 ± 0.33 cm) gain in fish treated with increasing concentrations of lycopene compared to control. FCR decreases from 1.39 ± 0.03 (control) to 1.10 ± 0.06 (14 mg/kg lyc) and subsequently increases to 1.16 ± 0.02 and 1.23 ± 0.04 at lycopene concentration of 16 and 18mg/ kg, respectively. Lycopene supplemented food increases the SGR compared to control (1.51 ± 0.04 % day⁻¹) with a maximum value of 1.98 ± 0.08 % day⁻¹ (14 mg/kg lyc). Further higher lycopene concentration shows a decreasing SGR trend of 1.86 ± 0.04 (16mg/ kg lyc) and 1.74 ± 0.08 (18mg/ kg lyc). The changes in different growth parameters of *Channa punctata* with differential concentrations of lycopene supplemented diets are shown in Table (2).

Table 2. Effects of varying dietary lycopene concentrations on growth parameters in *Channa punctata* (Mean±SEM, n=3)

Growth Parameter	Varying Levels of Lycopene (mg/kg dry diet) Supplemented Diet							P- Value
	L0	L1	L2	L3	L4	L5	L6	
Average Initial Weight (g)	4.96±0 .07	5.10±0 .16	4.98±0 .12	4.98±0 .08	4.85±0 .07	4.91±0 .10	4.87±0 .13	0.76
Average Final Weight (g)	11.63± 0.14 ^a	11.60± 0.15 ^a	12.71± 0.01 ^b	13.77± 0.13 ^c	14.77± 0.13 ^d	13.93± 0.21 ^c	12.96± 0.24 ^b	< 0.05
Initial Length (cm)	6.83±0 .06	7.03±0 .14	6.8±0. 17	6.96±0 .06	7.03±0 .16	7.1±0. 11	7.06±0 .08	0.4
Final Length (cm)	7.63±0 .08 ^a	7.76±0 .14 ^a	7.90±0 .05 ^a	8.10±0 .05 ^a	8.86±0 .23 ^b	10.13± 0.37 ^c	9.43±0 .28 ^b	< 0.05
Feed Conversion Ratio (FCR)	1.39±0 .03 ^{ab}	1.44±0 .06 ^a	1.28±0 .03 ^{bc}	1.19±0 .02 ^{cd}	1.10±0 .06 ^d	1.16±0 .02 ^{cd}	1.23±0 .04 ^c	< 0.05
Specific Growth Rate (SGR) (%/day)	1.51±0 .04 ^{ab}	1.46±0 .07 ^a	1.66±0 .04 ^{bc}	1.81±0 .03 ^{cd}	1.98±0 .08 ^e	1.86±0 .04 ^{de}	1.74±0 .08 ^{c^d}	< 0.05

Notes: Table data are expressed as Mean±SEM; Means in the same row with different superscripts are significantly different ($P < 0.05$).

The result shows that values of AWG and TLI of fish were initially increased followed by a gradual decline, showing an intermediate lycopene group as the maximum in comparison to the control (Fig. 1). Maximum CF value was found in L3 supplementation (Fig. 2).

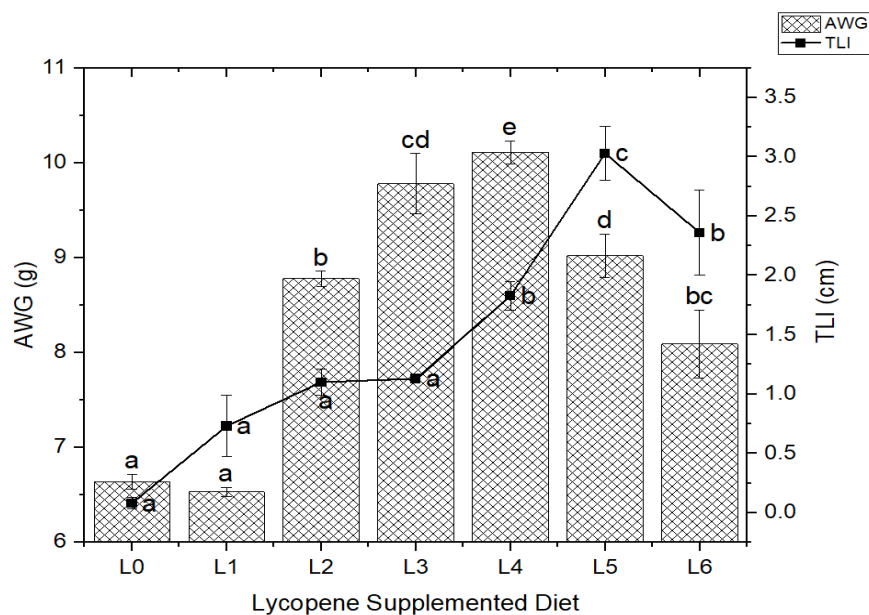


Fig. 1. Average weight gain (AWG) and total length increase (TLI) of *Channa punctata* fed with varying concentrations of lycopene-supplemented diets over an 8-week period

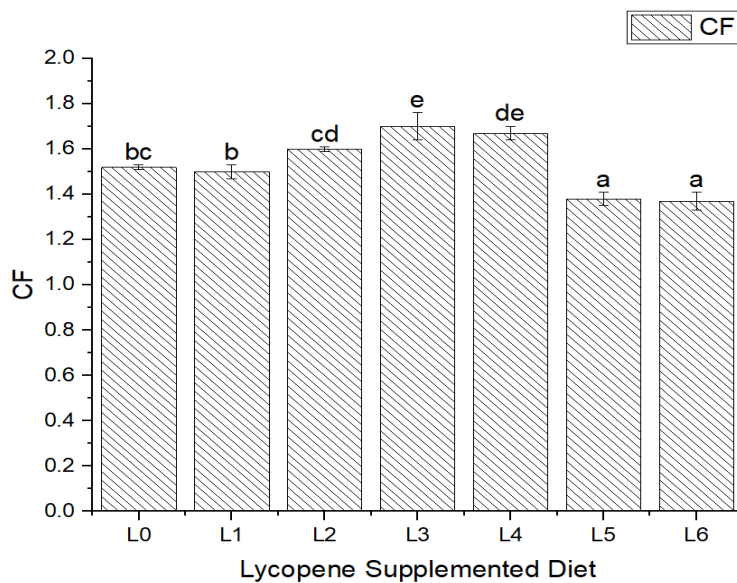


Fig. 2. Condition factor (CF) of *Channa punctata* fed with varying concentration of lycopene-supplemented diets over an 8-week period

Second order polynomial fit analysis between dietary lycopene level with AWG and SGR, shows the optimal dietary concentration of lycopene to be 13.47 mg/kg (Fig. 3) and 14.29 mg/kg (Fig. 4) for getting maximum weight and growth, respectively.

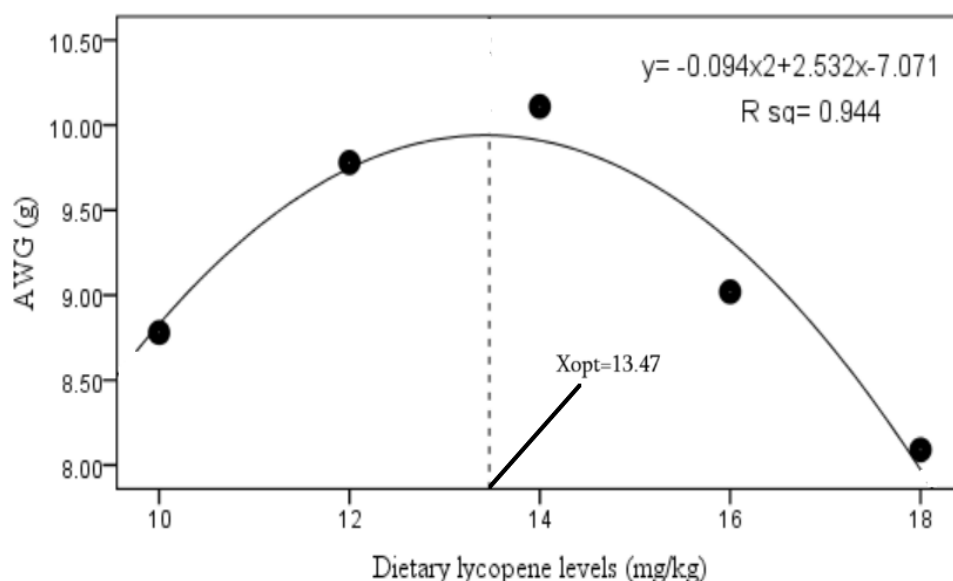


Fig. 3. Second order polynomial fit analysis between the average weight gain (AWG, g) with the dietary lycopene (mg/kg) levels. X_{opt} represents the optimal dietary lycopene level that results in maximum AWG

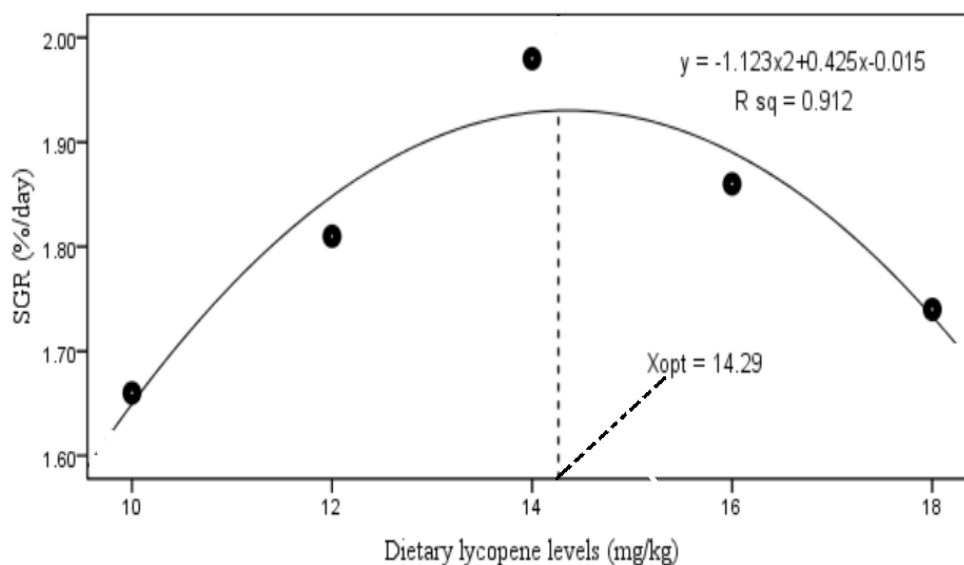


Fig. 4. Second order polynomial fit analysis between the specific growth rate (SGR, % day⁻¹) with the dietary lycopene (mg/kg) levels. X_{opt} represents the optimal dietary lycopene level that results in maximum SGR

In the present study, FCR declines at lower lycopene concentrations were followed by an upward trend, with the L2 group exhibiting the least FCR value.

DISCUSSION

The underlying aim of this study was to ascertain the optimal and effective concentration of lycopene supplemented diet, for getting better growth performance in *Channa punctata*. The results of the current study indicate a positive influence of dietary lycopene on various growth parameters of the experimental fish. **Sahin et al. (2014)** reported a 10.5% increase in body weight of the rainbow trout (*Oncorhynchus mykiss*) fed on diet supplemented with lycopene. Our findings are consistent with the results of juvenile hybrid grouper fish experiment, in which the polynomial fit analysis showed an optimum value of 282.22mg/ kg of lycopene providing maximum weight gain (**Zhou et al., 2024**). In an experiment, it was reported that, 50mg/ kg of dietary lycopene supplementation improved gestational performance and thus enhanced reproductive fitness in female pigs (**Sun et al., 2021**). Egg fertilization and hatchability rate in hens were optimized at 40mg/ kg lycopene supplemented diet for 35 days (**Sun et al., 2014**). Another study also focused on the effectivity of lycopene (20mg/ kg for 28 days) in elevating egg weight and productivity in Hy-line brown laying hens (**An et al., 2019**). In a 42-day feeding trial with lycopene supplemented feed (10, 20, 30mg/ kg), there was an elevation in FCR and FBW rates in broiler chickens. Additionally, upon receiving 100mg/ kg of lycopene supplementation, the body weight increment was much higher (**Wan et al., 2020; Wang et al., 2022**). In addition, an enhanced growth was recorded in Japanese quail fed with lycopene supplemented diet (**Amer et al., 2020**). However, several studies indicated same pattern of results upon addressing fish and other species, where lycopene promotes growth parameters, either reversing the impact of toxicants or by promoting normal physiological orchestra (**Zhang et al., 2018; Zhou et al., 2024**).

The findings of this study highlighted clearly the influence of dietary lycopene supplementation on the growth performance in *Channa punctata*. Among the various lycopene concentrations used in the experiment, results showed that moderate lycopene concentration (14.29mg/ kg) provided an effective growth efficiency. Although it is worth noting that, higher levels of lycopene supplementation showed lesser growth indicating a critical point beyond which its effect reverses. This could be due to potential oxidative stress, nutrient imbalance, metabolic burden or bioavailability issues. Thus, it was remarkably essential to ascertain the optimum lycopene concentration needed for maximizing growth performance in *Channa punctata*.

CONCLUSION

This study, however, highlights the increasing attention of the utilization of natural carotenoid antioxidants in sustainable fish culture activities as alternate to synthetic chemical growth promoters. Thus, the effective use of lycopene in fish feed may serve as a productive approach in aquaculture practices and would facilitate effective feed formulation for commercial utilization. The protective role of lycopene improves

efficiency of nutrient utilization and assimilation by promoting immune competence which leads to better resistance and endurance against various diseases. By optimizing growth performances through dietary modulation, lycopene enhances physiological adaptability and endurance. Nevertheless, further studies are needed to properly understand its role in fish immunity, enzymatic activity, stress management and overall health parameters. Its influence in protecting immune cells, resisting diseased condition and stabilizing antioxidant enzymes could provide a valuable avenue in future.

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