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EFFECT OF GUAVA LEAF EXTRACT (*Psidium guajava*) AS A FEED ADDITIVE ON GROWTH PERFORMANCE, FEED UTILIZATION AND SURVIVAL OF *Labeo catla*

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ABSTRACT

Aquaculture has emerged as one of the fastest-growing food production sectors, contributing significantly to global food security, nutrition and rural livelihoods. The present study was conducted to evaluate the effects of guava leaf extract (*Psidium guajava*) as a feed additive on the growth performance, feed utilization and survival rate of *Labeo catla.* The experiment was carried out during 2025-2026 at the Department of Aquaculture, College of Fisheries Science, Kamdhenu University, Veraval, Gujarat. Five experimental diets containing 30% crude protein were formulated with different inclusion levels of guava leaf extract: 0% (T0), 0.25% (T1), 0.50% (T2), 0.75% (T3) and 1 % (T4). A total 300 healthy *Labeo catla* (mean initial weight: 0.42 g) were randomly stocked into 20 experimental tanks at a stocking density of 15 fish per tank and fed twice daily at 5% body weight for 60 days experimental period. Growth parameters including Final Mean Weight, Mean Weight Gain, Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and Survival Rate were evaluated. The highest final mean weight (2.459 ± 0.032 g), Mean weight gain (2.021 ± 0.031 g), SGR (2.93 ± 0.030%), PER (1.51 ± 0.016) and Survival rate (93.33 ± 2.721%) along with the lowest FCR (2.20 ± 0.023) were recorded in T3 (0.75% guava leaf extract). Statistical analysis indicated significant differences ($p < 0.05$) among the treatments. The results indicated that dietary supplementation of 0.75% guava leaf extract significantly enhanced growth performance, feed utilization efficiency and survival rate in *Labeo catla*. The study suggests that guava leaf extract may be used as a promising natural feed additive for sustainable freshwater aquaculture practices.

***Keywords*:** Aquaculture, *Labeo catla*, *Psidium guajava*, guava leaf extract, growth performance, feed utilization, freshwater aquaculture, survival.

Introduction

Aquaculture is a rapidly growing sector that contributes significantly to global food security, nutrition and livelihoods through the controlled farming of aquatic organism in freshwater, brackish and marine environments to enhance sustainable food production for human consumption (FAO, 2022). Global fisheries and aquaculture production reached an unprecedented 235 million tonnes in 2024, highlighting the sector's increasing contribution to meeting the food demands of a growing global population (FAO, 2026). Fish is an affordable source of high-quality protein and essential nutrients, playing a crucial role in enhancing food security and combating malnutrition in developing countries (Balai *et al*., 2017). India ranks second globally in fish production, contributing about 8% of the world's total fish output. Aquaculture contributes significantly to India's agricultural economy by providing rural employment and supplying high-quality animal protein to meet the nutritional needs of a growing population (Naylor, 2021; Department of Animal Husbandry and Dairying, 2022). India's fisheries sector is predominantly driven by inland fisheries and aquaculture. Between 2019–20 and 2024–25, total fish production increased at an average annual growth rate of 6.47%, with inland fisheries growing at 7.69% compared to 3.05% in the marine sector. Inland fish production accounted for 151.60 lakh tonnes (77%) of the projected total fish production of 197.75 lakh tonnes in 2024–25. Among cultured freshwater species, Indian major carps namely *Labeo catla* (catla), *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal) remain the backbone of inland aquaculture contributing approximately 54% of total inland fish production (Department of Fisheries, 2025).

Catla catla (Hamilton, 1822) is a fast-growing Indian major carp belonging to the family Cyprinidae. It is widely distributed in freshwater ecosystems and is extensively cultured because of its rapid growth, high production potential and commercial importance (FAO, 2020; Manam & Quraishi, 2024). Among the Indian major carps, catla ranks second in economic importance after rohu (*Labeo rohita*), while mrigal (*Cirrhinus mrigala*) occupies the third position. Owing to its surface-feeding habit, catla serves as the surface-feeding component in composite carp culture systems, facilitating efficient utilization of the upper water column (Jhingran, 1991). The growth performance of *Labeo catla* is determined by appropriate stocking density, balanced nutrition and optimum water quality. Under favourable culture conditions, including suitable temperature, dissolved oxygen, pH and low ammonia levels catla can attain 1–2 kg within one year (Boyd, 2015).

The extensive use of antibiotics and chemotherapeutic agents in aquaculture has raised concerns regarding antimicrobial resistance, drug residues and environmental contamination (Seyfried *et al*., 2010; Rico *et al*., 2013). Consequently, herbal (phytogenic) feed additives have gained considerable attention as sustainable alternatives due to their natural, biodegradable and eco-friendly characteristics (Reverter *et al*., 2014). These plant-derived additives enhance fish health, growth performance, immune responses and disease resistance while minimizing environmental impacts and supporting sustainable aquaculture practices (Syahidah *et al*., 2015). Plant extracts are widely used as functional feed additives in aquaculture because of their growth-promoting, appetite-stimulating, immunostimulatory, antistress and antimicrobial properties. These beneficial effects are largely attributed to bioactive phytochemicals, including flavonoids, phenolics, alkaloids, tannins, saponins, terpenoids and essential oils (Citarasu, 2010; Chakraborty & Hancz, 2011).

Among medicinal plants, guava (*Psidium guajava*), a member of the Myrtaceae family, has gained considerable attention as a phytogenic feed additive due to its rich phytochemical composition and therapeutic properties (Joseph & Priya, 2011). Guava (*Psidium guajava*) leaves are rich in bioactive compounds, including flavonoids, tannins, essential oils, carotenoids, triterpenoids, polyphenols and vitamin C, which possess antimicrobial, antiviral, antioxidant and anti-inflammatory properties (Gutierrez *et al*., 2008; Joseph & Priya, 2011). Owing to their rich bioactive composition, guava (*Psidium guajava*) leaves have gained attention as a natural feed additive in aquaculture. Dietary supplementation has been reported to improve growth performance, feed utilization and overall fish health (Abdelhamid & Soliman, 2012; Omitoyin *et al*., 2019).

Despite the economic importance of *Labeo catla*, limited studies on the effects of dietary guava (*Psidium guajava*) leaf extract as a phytogenic feed additive. Therefore, the present study investigated its effects on growth performance, feed utilization and survival in *Labeo catla.*

Materials and Methods

Experimental Location

The research was conducted from October 5th to December 5th, 2025 for 60 days at the Department of Aquaculture, College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India.

Experimental Fish

Healthy fry of *Labeo catla* with an average initial body of (0.42 ± 0.02) were procured from the Aqua hatchery, Surendranagar, Gujarat, India in oxygen filled polyethylene bags to minimize transportation stress. Upon arrival, the fish were acclimatized in 500 litres FRP tank and maintained under continuous aeration for a period of seven days and fed a basal diet twice daily.

Experimental Design and Setup

A 60-day feeding experiment was conducted using 20 plastic experimental tanks (2 × 1 × 1), each having the capacity of 40 litres. A total of 300 healthy *Labeo catla* fry were randomly distributed among 20 plastic tanks at a stocking density of 15 fish per tank. The experiment was arranged in a Completely Randomized design consisting of 5 dietary treatments, each with 4 replicates per treatment. Water quality parameters were maintained within the optimum range throughout the experimental period.

Experimental Diet Preparation

Ingredients like fish meal and fish oil was procured from fish meal processing plant, Veraval, while groundnut oil cake, wheat flour, tapioca powder and plant oil were obtained from the local market in

Veraval. Crude guava leaf extract was prepared according to the Fawole *et al*. (2016) with minor modification. Fresh leaves of guava were washed, shade-dried and powdered. About 25 g leaf powder was mixed with 250 ml of 95% ethanol and extracted on an orbital shaker at 200 rpm for 24 hours. The extract was filtered, centrifuged at 10,000 rpm for 5 min, concentrated using a rotary evaporator and stored at 4^{o}C until use.

Experimental diets containing 30% crude protein were formulated using the Pearson's square method. Five diets were prepared, comprising a control diet without guava leaf extract (T0) and four diets supplemented with guava leaf extract at 0.25 % (T1), 0.50% (T2), 0.75% (T3) and 1 % (T4). The weighed feed ingredients were ground, sieved and thoroughly blended with water to form a homogeneous dough. The dough was thermally processed at 121^{o}C and 15 psi pressure for 15 minutes. After cooling, vitamin - mineral premix and guava leaf extract was added according to the respective treatments. The feed mixture was pelletized using a mechanical pelletizer, sun dried to less than 10 % moisture content and stored in airtight containers.

Table 1: Composition of Experimental Diets

Ingredients (g)	Diet (30% protein)				
	T0 (Control)	**T1 (0.25%)**	**T2 (0.50%)**	**T3 (0.75%)**	**T4 (1%)**
Fish meal	38.00	38.00	38.00	38.00	38.00
GNOC	28.00	28.00	28.00	28.00	28.00
Tapioca Powder	11.00	10.75	10.50	10.25	10.00
Wheat Flour	17.00	17.00	17.00	17.00	17.00
Fish Oil	2.00	2.00	2.00	2.00	2.00
Plant Oil	2.00	2.00	2.00	2.00	2.00
Vitamin-Mineral premix	2.00	2.00	2.00	2.00	2.00
Guava leaf extract	0.00	0.25	0.50	0.75	1.00
Total	100.00	100.00	100.00	100.00	100.00

Experimental and Feeding Procedure

The feeding trial was conducted for 60 days. Experimental fish were fed their respective diets containing 30% crude protein twice daily at 8:00 am and 5:00 pm. Feed was provided at 5 % of the total body weight per day and adjusted fortnightly based on fish growth. Fish were sampled at 15-days interval to record body weight using electronic balance. Survival, feeding behaviour and health status were monitored throughout the experimental period. At the end of 60-day experimental period growth performance, feed conversion ratio (FCR), protein efficiency ratio and survival rate were calculated.

Growth Parameters

Growth Performance - Fish were sampled at 15-day intervals to record body weight for the evaluation of growth performance. Mean weight gain (MWG), survival rate (%) and specific growth rate (SGR) calculated using method described by Manivannan and Saravanan (2012) using the formula given below-

Mean Weight Gain (g) = Mean final weight – Mean initial weight

Specific Growth Rate =

$$\text{SGR (\%/day)} = \frac{\text{LnW2} - \text{LnW1}}{\text{T}} \times 100$$

where, T = Experimental period, W2 = Final weight and W1 = Initial weight

Survival rate (%) $= \frac{\text{No. of fish survived after rearing}}{\text{No. of fish stocked}} \times 100$

Feed Utilization - Feed utilization was evaluated at the end of the 60-day feeding trial using feed conversion ratio (FCR) and protein efficiency ratio (PER) was calculated according to El-Sayed (1998) using the formula given below:

FCR $= \frac{\text{Feed Intake (g)}}{\text{Weight Gain (g)}}$

PER $= \frac{\text{Weight Gain (g)}}{\text{Protein Intake(g)}}$

Physico-Chemical Water Quality Parameters

Water quality parameters including temperature, pH, dissolved oxygen (DO) and hardness were monitored weekly following APHA (2017) standard procedure. Temperature and pH were measured using the thermometer and pH meter respectively, while dissolved oxygen was measured by the Winkler's method and hardness were estimated by titration method

Statistical Analysis

The experiment was conducted in a completely randomized design (CRD with Five treatments and four replicates. Data were analysed by one-way ANOVA following Snedecor and Cochran (2014) and treatment means were compared using Duncan's Multiple Range Test (DMRT) at $p < 0.05$ significance level using IBM SPSS Statistics version 27.

Results and Discussion

Effect of Guava Leaf Extract (*Psidium guajava*) on the Growth Performance and Survival of *Labeo catla*

The growth performance and survival of *Labeo catla* fed diets supplemented with guava leaf extract are presented in Tables 2 and 3 and graphically illustrated in Figures 1- 4. Fish were sampled at 15-day intervals throughout the 60-day feeding trial to monitor growth performance and survival. The initial mean weight in treatments T0, T1, T2, T3 and T4 were (0.441 ± 0.006), (0.420 ± 0.014), (0.425 ± 0.011), (0.424 ± 0.012) and (0.430 ± 0.014) g respectively. The final mean weight of *Labeo catla* in treatments T0, T1, T2, T3 and T4 were (1.980 ± 0.046), (2.212 ± 0.042), (2.349 ± 0.028), (2.459 ± 0.032) and (2.326 ± 0.024) g respectively. Among the treatments, the highest mean weight was observed in T3 (0.75 % guava leaf extract) followed by T2 (0.50%), T4 (1%), T1 (0.25%) and lowest was recorded in the T0 (control).

Mean Weight Gain

The highest mean weight gain at the end of 60 days feeding trial was recorded in treatment T3 (2.021 ± 0.031) g and the lowest in treatment control T0 (1.542 ± 0.033) g. Statistical analysis showed significant differences ($p < 0.05$) among the treatments during the experimental period. At the end of 60 days experimental period, the highest mean weight gain was recorded in T3 (0.75% guava leaf extract) than all others treatments. The observed increase in growth performance of *Labeo catla* due the beneficial effects of guava leaf extract which enhances digestion, nutrient absorption and overall metabolic efficiency. The results indicated that dietary supplementation with guava leaf extract significantly enhanced growth performance, with 0.75% inclusion level being the most effective**.** Similar findings were obtained by Omitoyin *et al*. (2019) where maximum growth was observed at 0.75% aqueous guava extract in Nile tilapia (*Oreochromis niloticus*). Hossain *et al*. (2024) and Kamble *et al*. (2024) observed peak growth at 0.7-1.0 % inclusion of guava leaf extract in Nile tilapia (*Oreochromis niloticus*). In a related Indian major carp, Giri *et al*. (2015) observed maximum weight gain at 0.5% guava leaves incorporation in *Labeo rohita.* Similarly, Gobi *et al*. (2016) documented enhanced growth in *Oreochromis mossambicus.*

Survival Rate

The highest survival (93.33%) was recorded in T2 and T3, followed by T4 and T1, while the lowest survival (83.33%) was observed in the control group T0 after 60 days of feeding trial. Survival rate showed significant difference among treatments ($p > 0.05$) at 60 days. The higher survival rate in guava leaf extract-fed fish may be due to the antimicrobial, antioxidant and immunostimulatory properties of guava leaf phytochemicals which enhance immunity, reduce oxidative stress and improve resistance to pathogens. Similar findings were reported by Omitoyin *et al*. (2019) and Hossain *et al*. (2024), who observed high survival rates in *Oreochromis niloticus* fed diets supplemented with guava leaf extract. Similarly, Dewi *et al*. (2021) observed that dietary guava leaf extract significantly increased the survival of *Penaeus vannamei* by enhancing non-specific immune responses and resistance against bacterial infection.

Specific Growth Rate

The effect of dietary guava leaf extract on the specific growth rate (SGR) of *Labeo catla* was assessed after 60 days of feeding trial. The highest SGR was recorded in T3 (2.93 ± 0.030), while the lowest was observed in the control group T0 (2.50 ± 0.020). T3 showed a significantly ($p < 0.05$) higher specific growth rate (SGR) than the other treatments, confirming the beneficial effect of 0.75% guava leaf extract incorporation on growth performance. The improved SGR in guava leaf extract fed fish may be attributed to bioactive compounds such as flavonoids, phenolics, tannins and saponins which enhance nutrient digestion, antioxidant activity and metabolic efficiency resulting in improved growth. These findings are in close agreement with Omitoyin *et al*. (2019) who reported maximum SGR at (0.75%) inclusion level of guava leaf extract in *Oreochromis niloticus.* Similarly, Hossain *et al*. (2024) observed optimum SGR at (0.7%) inclusion level of guava leaf extract in *Oreochromis niloticus* due to enhanced digestion and metabolic activity. Giri *et al*. (2015) also reported improved growth SGR at 0.5% inclusion confirming the dose-dependent response of guava-based additives. Kamble *et al*. (2024) also demonstrated that dietary guava leaf extract enhanced growth, nutrient utilization and gut health in Nile tilapia which contributed to improved growth performance.

Effect of Guava Leaf Extract on Feed Utilization of *Labeo catla*

The effects of dietary guava leaf extract on feed utilization were evaluated following the 60-day feeding trial. Statistical analysis revealed significant difference ($p < 0.05$) among the treatments. The feed utilization parameters (FCR and PER) are presented in Table 3 and graphically illustrated in Figures 5 and 6.

Feed Conversion Ratio (FCR)

Fish fed the 0.75% guava leaf extract diet (T3) exhibited the lowest FCR (2.20 ± 0.023), whereas the control group (T0) recorded the highest value (2.46 ± 0.027). T3 exhibited a significantly ($p < 0.05$) lower feed conversion ratio (FCR) than the other treatments, indicating superior feed utilization with 0.75% guava leaf extract supplementation. The improved FCR may be attributed to the bioactive compounds in guava leaves, particularly flavonoids, quercetin and polyphenols which enhance digestive efficiency, nutrient absorption and metabolic activity. Similar findings were reported by Giri *et al*. (2015**)**, who observed significantly lower FCR in *Labeo catla* fed guava leaf-supplemented diets. Omitoyin *et al*. (2019) reported the lowest FCR in *Oreochromis niloticus* fed diets containing 0.75% guava leaf extract, while Gobi *et al*. (2016**)** observed improved feed efficiency in *Oreochromis mossambicus* following dietary guava leaf supplementation.

Protein Efficiency Ratio (PER)

The highest PER was observed in T3 with 0.75% guava leaf extract (1.51 ± 0.016), which was significantly higher than all other treatments ($P < 0.05$), while the lowest PER was recorded in the control group T0 (1.35 ± 0.014). The higher PER suggests improved dietary protein utilization and nutrient assimilation. This improvement may be attributed to the phytochemicals present in guava leaves. The present findings are consistent with those of Omitoyin *et al*. (2019), who reported that dietary supplementation of aqueous guava leaf extract significantly improved feed utilization in *Oreochromis niloticus*, with the best performance obtained at 0.75% incorporation level. The enhanced nutrient utilization observed in their study was attributed to improved digestive efficiency and physiological condition of the fish. Similarly, Giri *et al*. (2015) reported that dietary guava leaf supplementation enhanced feed utilization in *Labeo rohita* indicating better utilization of dietary nutrients for growth. Kamble *et al*. (2024) demonstrated that guava leaf extract improved intestinal microbiota, nutrient utilization and growth in Nile tilapia further supporting the role of guava phytochemicals in enhancing feed and protein utilization.

Table 2 : Mean Initial Weight (g), Mean Final Weight (g), Mean Weight Gain (g) and Survival rate (%) of *Labeo catla* recorded in different treatments during the 60-day experimental period (Mean ± SE).

Diets	Initial Mean Weight (g)	Final Mean Weight (g))	Mean Weight Gain (g)	Survival Rate (%)
Control diet	0.441 ± 0.006^{a}	1.980 ± 0.046^{d}	1.542 ± 0.033^{d}	83.33 ± 1.924^{b}
Treatment 1	0.420 ± 0.014^{a}	2.212 ± 0.042^{c}	1.774 ± 0.048^{c}	85.00 ± 1.666^{b}
Treatment 2	0.425 ± 0.011^{a}	2.349 ± 0.028^{b}	1.904 ± 0.034^{b}	93.33 ± 2.721^{a}
Treatment 3	0.424 ± 0.012^{a}	2.459 ± 0.032^{a}	2.021 ± 0.031^{a}	93.33 ± 2.721^{a}
Treatment 4	0.430 ± 0.014^{a}	2.326 ± 0.024^{b}	1.888 ± 0.024^{b}	86.66 ± 0.000^{b}

Table 3 : Specific Growth Rate, Feed Conversion Ratio and Protein Efficiency Ratio of *Labeo catla* recorded in different treatments during the 60-day experimental period.

Diets	Specific Growth Rate (%)	Feed Conversion Ratio	Protein Efficiency Ratio
Control diet	2.50 ± 0.020^{d}	2.46 ± 0.027^{a}	1.35 ± 0.014^{d}
Treatment 1	2.75 ± 0.021^{c}	2.32 ± 0.019^{b}	1.43 ± 0.012^{c}
Treatment 2	2.84 ± 0.023^{b}	2.22 ± 0.027^{cd}	1.49 ± 0.019^{ab}
Treatment 3	2.93 ± 0.030^{a}	2.20 ± 0.023^{d}	1.51 ± 0.016^{a}
Treatment 4	2.81 ± 0.039^{bc}	2.30 ± 0.031^{bc}	1.44 ± 0.020^{bc}

Physico-Chemical Water Quality Parameter

During the 60-day experimental period, the water quality parameters such as dissolved oxygen (DO), temperature, pH and hardness were monitored weekly throughout the experimental period. Physico-chemical water quality parameter recorded is presented in Table - 4.

Table 4 : Temperature (°C), Dissolved oxygen (ppm), pH, and hardness (mg/l) recorded in the experimental treatment during the 60-day experimental period.

Treatments	**Temperature (°C)**		**Dissolved oxygen (ppm)**		**pH**		**Hardness (mg/l)**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
T0	25.54	28.33	5.53	6.55	7.14	7.81	164	223
T1	25.65	28.52	5.46	6.51	7.18	7.87	168	232
T2	25.87	28.76	5.59	6.45	7.03	7.85	165	226
T3	25.24	28.27	5.51	6.58	7.09	7.89	162	238
T4	25.12	28.86	5.58	6.53	7.04	7.83	166	234

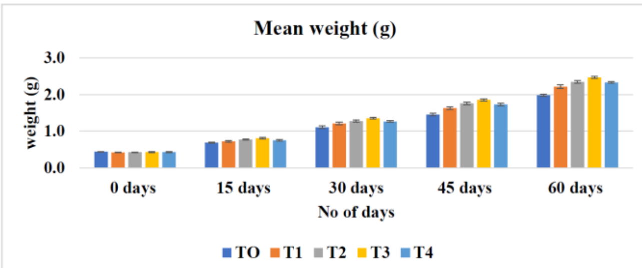

Fig. 1: Mean weight of *Labeo catla* recorded in different treatments during the 60 days experimental period.

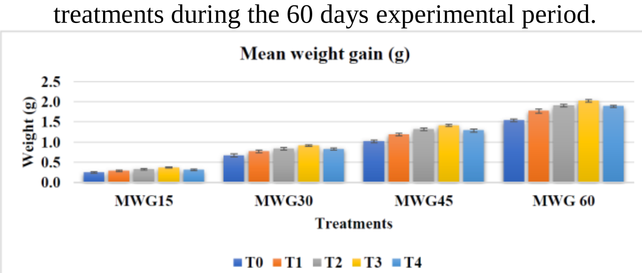

Fig. 2: Mean weight gain of *Labeo catla* recorded in different treatments during the 60 days experimental period.

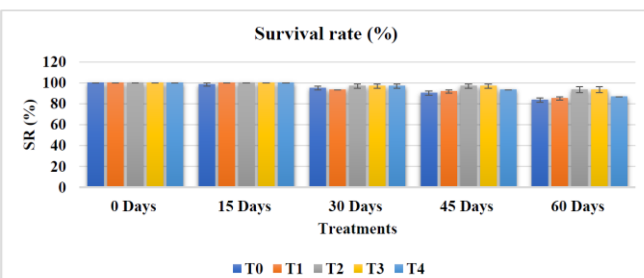

Fig. 3: Survival rate (%) of *Labeo catla* recorded in different treatments during 60 days trial.

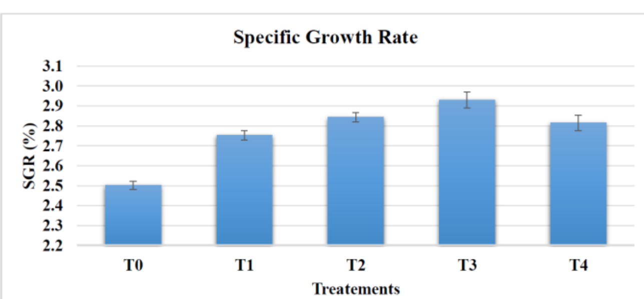

Fig. 4: Specific growth rate of *Labeo catla* recorded in different treatments during 60 days experimental period.

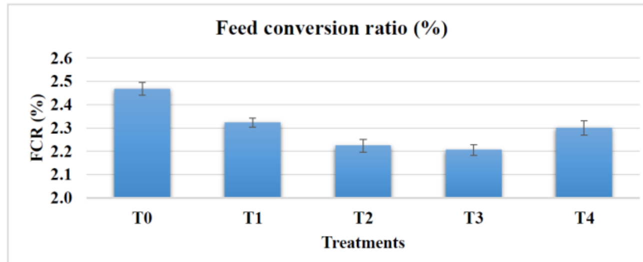

Fig. 5: Feed conversion ratio (FCR) of *Labeo catla* recorded in different treatments during 60 days experimental period

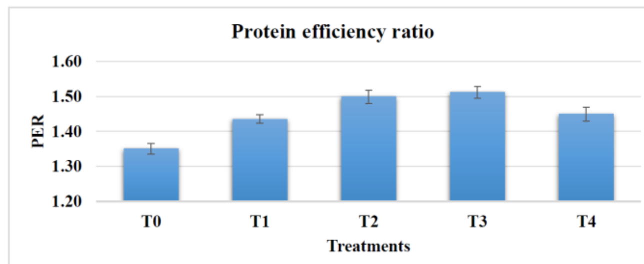

Fig. 6 : Protein efficiency ratio (PER) of *Labeo catla* recorded in different treatments during the 60 days experimental period.

Conclusion

The present study showed that the guava leaf extract (*Psidium guajava*) dietary supplementation significantly enhanced the growth performance, feed utilization and survival rate of *Labeo catla.* Among the treatments, 0.75 % guava leaf addition (T3) showed the best performance in terms of Final mean weight, Mean weight gain, Specific growth rate (SGR), Protein efficiency ratio (PER), Feed conversion ratio and Survival rate (%). The enhanced performance due to the bioactive compounds present in guava leaves such as flavonoids and phenolics, which enhances nutrient utilization and physiological efficiency. The results indicate that guava leaf extract is a potential natural feed additive for sustainable carp culture. However, the study was conducted under controlled laboratory conditions for a limited duration. Further studies under field conditions and long-term evaluations are required to confirm its practical application in commercial aquaculture systems

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Ethical Approval

All experimental procedures involving live fish were conducted following standard guidelines for the care and use of laboratory animals in aquaculture research. Appropriate measures were taken to minimize stress and discomfort throughout the experimental period under the supervision of the Department of Aquaculture, College of Fisheries Science, Kamdhenu University, Veraval.

Conflict of Interest

The author declares no conflict of interest.

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