Comparative study on the growth and feed utilization of Labeo rohita fed with different concentrations of Solanum betaceum cav. and Garcinia gummi-gutta (.L) roxb

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Abstract

Indian fisheries and aquaculture are significant areas of food production, providing nutritious security to the food bin, increasing farming fares, and attracting approximately fourteen million people in various fields. This study aimed to determine the impact of dietary tamarillo (S. betaceum) and malabar tamarind (G. gummi-gutta) on the growth performance of L. rohita. The fish were fed with a control diet and test diets enhanced with S. betaceum and G. gummi-gutta at 5, 10, and 20 g/100g feed for 40 days. Fish growth were evaluated in terms of weight gain, specific growth rate and food utilization ratio. All of the growth indices were significantly higher in treatments where the fish were fed with 20 g tamarillo and 10 g malabar tamarind integrated diet. When compared to the control group, enhancement of fish appetite was notably seen in groups treated with dietary inclusion of S. betaceum and G. gummi-gutta, and could be recommended as a safe growth promoter for improving fish growth and production.

Keywords: Medicinal plants, Labeo rohita, Solanum betaceum, Garcinia gummi-gutta, Growth, Feed utilization

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Introduction

Fisheries and aquaculture play critical roles in food production, nutritional security, and job opportunities for millions of people (Lal and Jena, 2019). Fisheries and aquaculture provide not just diet but both dietary needs for human consumption andent and revenue production prospects, particularly in economically deprived rural areas. (Jayasankar, 2018). Diseases that cause substantial losses in productivity are major problems that can contribute to enormous economic losses in the worldwide fish and shellfish aquaculture industry (Srivastava and Pandey, 2015). Plants have lately been identified as a source of safer and less expensive alternatives with desirable traits such as no adverse effects on the environment. So far, no herbal resistance or adverse effects have been observed in regard to herbal dietary supplements. (Ramudu and Dash, 2013).

Enhancing growth performance and incorporating medicinal herbs into feed are two important approaches in fish farming. The active ingredients in the herbs are thought to improve nutritional digestion, absorption, and assimilation. Furthermore, these bioactive chemicals can promote the secretion of digestive enzymes and the maintenance of healthy intestinal microbiota (Mohammad, 2017). The use of plants as a substitute for antibiotics in aquaculture has risen significantly. Additionally, several studies have indicated the potential of plants in

enhancing fish health, growth, and feed digestibility.

Labeo rohita is the most popular among the three Indian major carp varieties used in freshwater aquaculture polyculture practices. Exceptional growth potential and adaptability, along with high customer demand, have made rohu one of the most prominent and tastiest freshwater fish cultivated in India, Bangladesh, and other neighbouring countries. It is a major source of protein and omega-3 PUFA fatty acids. Among all IMCs, rohu has the highest protein content. It is also a good source of calcium and vitamin A (Majumder et al., 2018).

The presence of phytochemical compounds such as alkaloids, phenolic compounds, steroids, tannins, flavonoids, glycosides, diterpenes, and triterpenes was observed in the preliminary phytochemical screening of the plant's rind extract. The detection of secondary bioactive components in the extract of G. gummi-gutta fruit rind suggests a scientific need for further study focused on the pharmacological activity of plant extracts (Rehna et al., 2021). The phytochemical and antioxidant properties of Tamarillo were evaluated by Nallakurumban et al., (2015) who concluded that (S. betaceum) has an appropriate amount of phytoconstituents in the fruits, denoting that tamarillo (S. betaceum) is among the richest sources of natural antioxidants as well as vitamins and minerals that can boost the immune system. Tree tomato fruit (S. betaceum) is rich in antioxidants and an excellent source of bio-compounds, making it a potential nutraceutical fruit crop (Viera et al., 2022). Considering the economic as well as the biological importance, of the selected plants the purpose of this study is to determine the effect of G. gummi-gutta and S. betaceum in improving growth in L. rohita.

Materials and method

Sample Collection

Two medicinal plants G. gummi-gutta and S. betaceum was selected. The fruits of G. gummi-gutta were collected from Thrissur district, Kerala and the fruits of S. betaceum were collected from Nilgiris district, Tamil Nadu. The collected fruits were identified in Botanical Survey of India, southern region centre, Tamil Nadu Agricultural University campus (TNAU), Lawley Road, Coimbatore-03. Fresh and tender fruits of selected plants that are considered having the medicinal properties were dried, powdered and stored for use.

Acclimatization

Healthy fingerlings of the L. rohita fish (average length 9.4 ±0.17 cm and average body weight 16.5 ±0.21 g) were purchased from the National fish seed farm, Bhavanisagar fish farm in Tamil Nadu and were transported to the lab in oxygenated polythene bags. Fish were acclimatized in the lab for 10 days. The diet of Sahoo and Mukherjee (2002), was followed which consists of (Groundnut oil cake 400 + Rice bran 330 + Soya bean meal 200 + Fish meal 50 + Minerals and vitamins mixture1 20) g kg-1. The tanks are maintained and kept clean to avoid contamination.

Experimental design

The study was conducted for 40 days using 21 tubs including triplicate. The setup includes one control and six experimental groups. The triplicate groups of the treatments were marked as Control, G1, G2, G3, S1, S2, and S3. A total of seven feeds such as Control, G1 (Control + 5g G. gummi-gutta), G2 (Control + 10g G. gummi-gutta) G3 (Control + 15 g G. gummi-gutta), S1 (Control + 5g S.betaceum), S2 (Control + 10g S.betaceum) and S3 (Control + 20g S.betaceum) were used for this research. Fishes in the control are fed with the basal diet. The experimental setup was maintained for 40 days. A total of 315 healthy fingerlings of Labeo rohita were stocked in the 21 tubs (15 in each tub). After stocking, the fingerlings were acclimated for one week (7 days) prior to the start of the experiment. Feeding was done twice daily by 8.00 am and 5.00 pm at 3% body weight. Biometric parameters of experimental fishes including total length (TL) and total weight (TW) were measured and noted once a week.

Mode of feeding the fish

The experimental fish were fed on formulated feed twice a day for an hour between 9 AM to 10 AM and 5 PM to 6 PM. The remaining food in the experimental tubs was removed using a siphon with the least disturbance to the fish. The unfed feed was collected and dried in, dried in a hot air oven, from these values the feed consumed was calculated.

Feed consumed = Feed given – Unfed collected

Faeces Collection

Faecal matter in the experimental tubs were removed daily. The faeces were collected carefully using a siphon without disturbing the experimental fish. The faeces were also dried in hot air oven and weighed.

Termination of Experiments

Live weights of the experimental fish were recorded in 10th, 20th, 30th and 40th days. Based on the obtained data the growth and food utilization parameters were calculated according to the standard formulas.

Growth parameters

The growth parameters were calculated by using the following formulas of Nyadjeu et al., (2021) and Neepa et al., (2022).

Length = Average final length - Average initial length

Length gain (%) = (Average final length - Average initial length/Average initial length) 100

Growth = Final weight – Initial weight

Growth rate = (Weight gain/ Number of days x Initial weight) (mg. day -1)

Specific growth rate = (In Final Weight – In Initial Weight/ Number of Days)

Weight gain % = (Final Weight – Initial Weight/ Initial Weight) x 100

Food utilization parameters

The scheme of food utilization is expressed with the modified formula of Petursewiez and Macfutyen (1970), Pandian (1967), Da et al., (2016), Osborne et al., (1919), Hassan and Jafri, (1996) and Neepa et al., (2022).

The formula adopted for the present investigation was: C = P + M + F

Where, C = Food consumed, P = Production or Growth, M = Metabolism (Respiration or excretion) and F = Faeces output

From this relationship the food utilization parameters were calculated as follows:

Feeding rate=Total dry food consumed/ Number of days x Initial live weight

Food absorbed = Food consumed – Faeces produced (mg. g body wt.-1 day-1)

Average daily growth % = (Final Weight – Initial Weight/ Experiment duration in days) x 100

Absorption rate = (Total food absorbed (dry)/ Number of days x initial live wt. of fish)

Absorption efficiency = (Food absorbed/ Food consumed) x 100

Gross Conversion efficiency (K1) = (Growth rate/ Feeding rate) x 100

Net Conversion efficiency (K2) = (Growth rate/ Absorption rate) x100

Feed conversion ratio (FCR) = (Total feed intake (g)/Total wet weight gain (g)).

Feed conversion efficiency % = (Weight gain (mg)/ Dry feed consumed) x100

Protein efficiency ratio (PER) = wet weight gain (g)/total protein intake (g).

Protein intake (PI) = feed intake (g) x percent protein in diet.

Total feed intake per fish (FI) = [total feed intake (g)/number of fish].

Survival rate (SR%) = (Final number of fish / Initial number of fish) x100

Results

Growth performances

The growth results observed in L. rohita are tabulated in Tables 1, 2, 3 and 4 and illustrated in Figures 1, 2, 3 and 4.

According to the findings of this study, the treatment groups consumed maximum feed per fish than the control diet. This indicates that at these inclusion levels, feed intake may not be adversely affected. There was significant enhancement of growth in all the treatments such as Initial length, final length, length gain %, initial weight, final weight, growth (g/fish), growth rate (g/fish/day), specific growth rate (%), and weight gain %.

An overall increase in growth parameters has potentially increased in L. rohita exposed to three different concentrations of the fruits when compared to control group of fish, at regular intervals of 10, 20, 30 and 40 days. Better growth performance was obtained in fish treated with 10 g of G. gummi-gutta and 20 g of S. betaceum (Table 1-3). However, there were no significant differences in growth performance across the different concentrations (P< 0.01).

Food utilization parameters

Data on feed utilization parameters of the fish during the experiment are shown in Table 5. All fish fed appeared active and healthy. Survival of the fish during the experiment ranged from 93.3 % to 100 % as shown in Fig. 5.

There is substantial stimulation of growth in all the treatments such as food consumed, faecal matter, feeding rate, food absorbed, absorption rate (mg/day), absorption efficiency average daily growth, gross conversion efficiency, net conversion efficiency %, feed conversion efficiency and protein efficiency ratio. The feed conversion ratio was minimum in the treatment groups when compared to control group. An overall increase in food utilization parameter has significantly increased in L. rohita exposed to three different concentrations of the fruits of G. gummi-gutta and S. betaceum when compared to control group of fish, at regular intervals and the result is calculated after 40 days of the treatment. Maximum feed utilization was noted in fish treated with 10 g of G. gummi-gutta and 20 g of S. betaceum (Table-5). Similarly, when the results of G. gummi-gutta and S. betaceum were compared fish treated with S. betaceum showed higher growth and feed utilization. However, there were no significant differences in feed utilization parameters across the different concentrations (P< 0.01).

Table 1: Comparison of total length and weight of L. rohita fish in different treatments during the study period.

Variable	Treatment	Day				
		1	10	20	30	40
Length (mm)	**Control**	9.6±0.15**	10.1±0.37**	10.7±0.21**	11.3±0.21**	11.9±0.12**
	Control + 5g G. gummi-gutta	9±0.17**	9.7±0.26**	10.5±0.28**	11.2±0.12**	11.7±0.15**
	Control + 5g S. betaceum	9.3±0.11**	9.8±0.65**	10.7±0.1**	11.3±0.15**	12.1±0.15**
	Control + 10g G. gummi-gutta	9.4±0.12**	10.5±0.36**	11.2±0.12**	12.1±0.06**	12.6±0.1**
	Control + 10g S. betaceum	9.1±0.15**	9.9±0.37**	10.7±0.06**	11.5±0.17**	12.2±0.1**
	Control + 20g G. gummi-gutta	9.5±0.37**	10.7±0.25**	11.6±0.21**	12.8±0.15**	13±0.21**
	Control + 20g S. betaceum	9.8±0.20**	10.8±0.36**	12±0.15**	13.2±0.16**	13.6±0.21**
	p-value	0.154	0.331	0	0	0
Weight (g)	**Control**	16.4±0.55**	17±0.12**	17.7±0.25**	18.5±0.15**	20±0.15**
	Control + 5g G. gummi-gutta	16.8±0.26**	17.6±0.15**	18.4±0.15**	19.7±0.1**	21.1±0.1**
	Control + 5g S. betaceum	16.2±0.15**	17.4±0.1**	18.6±0.06**	19.8±0.1**	21.1±0.21**
	Control + 10g G. gummi-gutta	16.5±0.25**	18±0.15**	19.3±0.31**	20.7±0.12**	22.2±0.11**

	Control + 10g S. betaceum	16.9±0.1**	18.7±0.15**	20.1±0.11**	21.4±0.26**	22.3±0.26**
	Control + 20g G. gummi-gutta	17±0.25**	18.3±0.15**	19.5±0.15**	20.4±0.15**	21.8±0.25**
	Control + 20g S. betaceum	17±0.26**	19±0.17**	20.5±0.2**	22.3±0.40**	23.2±0.2**
	p-value	0.378	0	0	0	0

Values are Mean ± standard error of the samples; **-significant at $p<0.01$.

Table 2: Comparison of L. rohita growth indices and survival rate in different feeding treatments during the study period

Treatment	Weight gain %	Length gain %	Growth (g/fish)	Growth rate (g/fish/day)	Specific growth rate %	Survival rate
Control	21.9±0.01**	23.9±0.13**	3.6±0.15**	0.36±0.01**	1.98±0.01**	93.3±0.51**
Control + 5g *G. gummi-gutta*	25.6±0.02**	30±0.23**	4.3±0.11**	0.43±0.03**	2.28±0.05**	97.6±0.31**
Control + 5g *S. betaceum*	30.2±0.01**	30.1±0.32**	4.9±0.25**	0.49±0.02**	2.64±0.02**	100±0.00**
Control + 10g *G. gummi-gutta*	34.5±0.01**	34±0.12**	5.7±0.1**	0.57±0.01**	2.97±0.01**	98.3±0.35**
Control + 10g *S. betaceum*	31.9±0.01**	34±0.18**	5.5±0.08**	0.54±0.01**	2.77±0.02**	97±0.25**
Control + 20g *G. gummi-gutta*	28.2±0.02**	36.8±0.07**	4.8±0.21**	0.48±0.01**	2.48±0.04**	99±0.43**
Control + 20g *S. betaceum*	36.4±0.01**	38.7±0.13**	6.2±0.06**	0.62±0.02**	3.11±0.01**	100±0.00**
p-value	0	0	0	0	0	0

Values are Mean ± standard error of the samples; **-significant at $p<0.01$.

Table 3: Comparison of L. rohita feed utilization parameters in different feeding treatments during the study period

Variable	Control	Control + 5g *G. gummi-gutta*	Control + 5g *S. betaceum*	Control + 10g *G. gummi-gutta*	Control + 10g *S. betaceum*	Control + 20g *G. gummi-gutta*	Control + 20g *S. betaceum*
Food Consume (mg/day)	560±1.0**	574±1.53**	565±1.00**	583±1.52**	577±1.15**	591±0.57**	587±0.76**
Faecal Matter (mg/day)	103±1.53**	115±1.32**	109±1.15**	110±0.57**	117±1.20**	121±0.76**	123±1.00**
Feeding Rate (mg/day)	1.14±0.07**	1.18±0.09**	1.12±0.06**	1.15±0.01**	1.13±0.04**	1.16±0.04**	1.19±0.01**
Food Absorbec (mg/day)	457±1.15**	459±1.52**	456±0.57**	473±1.00**	460±1.00**	470±0.76**	464±0.86**

Average daily growth %	9±0.31**	10.7±0.13**	12.2±0.05**	14.2±0.07**	13.7±0.08**	12±0.11**	15.5±0.05**
Absorption Rate (mg/day)	0.928±0.08***	0.944±0.02***	0.904±0.04**	0.932±0.03**	0.901±0.03**	0.921±0.03**	0.937±0.06**
Absorption Efficiency (mg/day)	81.6±0.31**	79.9±0.26**	80.7±0.21**	81.1±0.23**	79.7±0.26**	79.5±0.48**	79.±0.53**
Gross Conversi Efficiency (%)	31.5±0.82**	36.4±0.73**	43.7±0.45**	41.7±0.22**	47.7±0.29**	49.1±0.26**	52.1±0.26**
Net Conversior Efficiency (%)	38.7±1.32**	45.5±0.29**	54.2±0.25**	51.5±0.26**	59.9±0.65**	61.8±0.29**	66.1±0.13**
Feed Conversic Ratio	0.156±0.02***	0.133±0.05***	0.115±0.03**	0.121±0.06**	0.107±0.03**	0.104±0.05**	0.095±0.03**
Feed Conversic Efficiency %	6.43±0.48**	7.49±0.21**	8.67±0.29**	8.23±0.12**	9.36±0.30**	9.64±0.22**	10.5±0.23**
Protein Efficier Ratio	1.78±0.08**	3.08±0.03**	3.44±0.03v	3.34±0.05**	3.62±0.02**	3.91±0.05**	4.04±0.05**

Values are Mean ± standard error of the samples; **-significant at p<0.01.

Discussion

The results suggest that the dietary feed at all concentrations enhanced the growth of Labeo rohita fingerlings. There are not many reports regarding the potential of Garcinia gummi-gutta and Solanum betaceum as growth-promoting agents in fishes. The results showed that the addition of Garcinia gummi-gutta and Solanum betaceum in the diet of Labeo rohita enhances growth and nutrient utilization, which is reflected in improved weight gain, FCR and SGR. Better feed utilization values were obtained in all treatments, and the poorest occurred in control. The growth and feed utilization were highly enhanced in the fishes treated with 20g of S. betaceum and 10g of G. gummi-gutta.

G. gummi-gutta could possibly stimulate the release of digestive enzymes and increase the intake of nutrients by enhancing the gut microbiota, thereby increasing the growth performance. This might be due to the availability of bioactive compounds in the fruit. It may be noted from the results that the incorporation of the G. gummi-gutta at a lower dose enhanced the growth of L. rohita fingerlings (Immanuel et al., 2009; Citarasu, 2010; Hashemi and Davoodi, 2011; Salem and Elsayed, 2018).

This assumption is consistent with the findings of Keer et al., 2020, who observed that a low dose of Shatavari root extract increased the growth of L. rajasthanicus and that the elevation in growth may be attributed to the availability of bioactive constituents present in them. The decline in fingerling growth with increasing Garcinia gummi-gutta concentration might be accompanied by a rise in anti-nutritional factors (ANFs). The inclusion of anti-nutritional factors (ANFs) in fish diets that exceed the tolerance limit may reduce rates of growth in fish (Francis et al., 2001; Garg et al., 2019).

When the fishes were fed with S. betaceum the rate of growth in fishes increased with increasing concentrations. The presence of specific compounds, such as flavonoids, might be accountable for enhanced growth in the treatment groups, in which flavonoids with oestrogenic function promoted growth in Cyprinus carpio (Kocour et al., 2005). When fish were fed diets enriched with S. betaceum, antimicrobial components such as phenols, saponins, and tannins found in the fruit might have encouraged the synthesis of digestive enzymes, which positively influenced biomass and specific growth in L. rohita.

The current study coincided with the study of Adeniyi et al., (2021) who reported the faster growth efficiency (FW, WG, SGR, RGR) and feed utilization (FCR, PER, AEU, APU, nutrient uptake) of O. niloticus with 0.5 - 1.5 % tamarind leaf extract (TLE) could be attributed to TLE's bioactive phytonutrients and antimicrobial properties, which improved digestibility of nutrients and consumption and thus favoured growth in O. niloticus. Flavonoids are the most frequent type of phenolic element produced by plants, and they exhibit antimicrobial, anti-inflammatory, anti-oxidative, and hepatoprotective activity (Tapas et al., 2008; Kumar and Pandey 2013), which might have contributed to the improved growth performance shown in this investigation (Abo-State et al., 2017; Abou-Zeid, 2002; Omitoyin et al., 2018; Solomon et al., 2014).

Kim et al., (1998) suggested that unknown factors in various therapeutic herbs resulted in desirable fish growth trials. FCR values of fishes in the treatment group had better growth and feed utilization compared to the control group. This finding concurs with the study of Adikwu (2003), that a relatively low FCR value indicates improved feed utilisation by fish. Immanuel et al., (2009) also observed that tilapia fingerlings fed diets accompanied with medicinal plant extracts grew more rapidly than those fed the standard diet. Medicinal plants when given as dietary enhancement promoted the growth and feed conversion rate in shrimp (Zakes et al., 2008).

Cek et al., 2007 revealed that medicinal plants showing promising enhancement of growth were reported in different fishes such as common carp. The increase in the growth of fishes might be attributed to the presence of bio-active substances in the fruits of G. gummi-gutta and S. betaceum, which enhanced nutritional intake. Haniffa and Margaret (2014) also observed that striped snakehead fingerlings fed on diets enhanced by medicinal plants showed a faster growth rate than those fed with the control diet. The protein efficiency ratio in the treatment groups was maximum in contrast to the control. According to Da et al., 2016 the higher protein efficiency ratio indicates that the amino acid supply and amino acid profile in the test diets were adequate for Tra catfish requirements. Yakuputiyage, (2013) confirmed that the rate of growth is proportional to the amount of body weight gained as a result of protein utilization in the feed. The bigger the amount of protein digested, the more energy the fish get to grow.

According to the findings, there was no harmful influence on the survival rate when the fish were fed with different concentrations of G. gummi-gutta and S. betaceum fruits. The findings indicate that these fruits have a good potential in promoting the growth of fish, making it a significant method for achieving sustainable, cheap, and reliable fish production. However, when compared fish treated with S. betaceum showed better results than the fish treated with G. gummi-gutta. This study might be crucial to fish farmers because organic growth enhancers have very few drawbacks in contrast to artificial growth regulators since synthetic growth boosters can be bio-accumulated in the flesh of the fish which could be harmful to the consumers. Further studies should be conducted to understand the digestive mechanism of these fruits and focus on the development of rearing methods for different species of fish reared using G. gummi-gutta and S. betaceum fruit powder as a feed supplement.

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