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Study on the effect of replacement of fishmeal with soybean meal on growth of striped snakehead: *Channa striata*

Mansi Jain, SK Sharma, BK Sharma and Narpat Kumar

Mansi Jain
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

SK Sharma
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

BK Sharma
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Narpat Kumar
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Corresponding Author:
Mansi Jain
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Abstract
The impact of replacement of fishmeal with soybean meal on the growth of fingerlings of the striped snakehead (*Channa striata*) was examined during a 60-day feeding study. 10 fish were allocated uniformly per tank among six treatment groups, each with four replicates, after being harvested from their natural environment. With the exception of the control diet, six iso-nitrogenous diets (T2–T6) containing 52% crude protein were created. In comparison to other groups, T2 saw a weight increase that was much larger (28.8140.281g). The experimental fish in T2 had considerably greater specific growth rates (6.4980.054) and gross conversion efficiencies (0.5670.006) than the other treatment groups. In contrast, T2 (1.7640.020) and T1 (1.8960.009) had much lower meal conversion ratios. This result shows that 24% of FM could be easily replaced by SBM as protein source in diets of striped snakehead (*Channa striata*) and for further addition 28% FM could be replaced without showing any negative impact. On the basis of outcome of the current investigation replacement of fishmeal with soybean has shows positive results in replacement of fishmeal with soybean meal.

Keywords: Betaine HCL pepsin, striped snakehead, *Channa striata,* fish meal, soybean meal

Introduction
Aquaculture has become the most promising sector playing a crucial role in global food production. It is the fastest growing component of agriculture sector. At present, the world's greatest challenges is to feed more than 9 billion people by 2050. It becomes more challenging in the context of climate change, economic and financial uncertainty, and growing competition for exploiting natural resources. Global production of aquatic animals was estimated at 178 million tonnes in 2020, a slight decrease from the all-time record of 179 million tonnes in 2018 (SOFIA 2022) [5]. *Channa striata*, the striped snakehead, is a species of snakehead fish. There is a good domestic market available for murrels, as return by adopting murrels as a variety in their fish culture practices. The technology of murrel farming has a major constraint for breeding and feeding of murrel in commercial way. Snakehead is acclaimed a carnivorous species with a high protein requirement (Samantaray and Mohanty 1997; Be and Hien 2010) [4, 1]. In aquaculture feed, fish meal (FM) has traditionally been the main protein source due to its high digestibility and excellent profile of essential amino acids (Hien *et. al.*, 2017) [2]. Defatted soybean meal (SBM) has received the greatest research attention among plant protein sources as a replacer of fishmeal because of its high protein content, comparatively well-balanced amino acid profiles, affordable pricing, and consistent supply (Storebakken et al., 2000) [6]. Replacement of fish meal with soybean meal (SBM) can reduce the fish production cost many folds. However, researchers have recommended limited use of soybean meal in the diet of carnivorous fish. Be and Hien (2010) [1] found suitability of FM replacement by SBM up to 30% in diet for snakehead.
As we know that fish meal (FM) has been the main protein source in aquaculture due to its high digestibility (Hein *et. al.,* 2017). Due to its lack of availability and high price, attempts are made to replace it with plant protein. Keeping in mind the present study was undertaken to assess the utility of Betaine HCL Pepsin as feed attractant to replace fishmeal (FM) from plant protein source (SBM) in the diet of snakehead fishes.

Material and methods
a. Site of experiment
The study was carried out in the wet laboratory of the Department of Aquaculture, College of

Fisheries, Udaipur (Rajasthan) for a period of 60 days from 26 July to 26 September, 2022. 24 FRP tanks of 225- litres capacity were used for the experiment. After acclimation fishes were transferred to 6 treatments (including control) with 4 replicates for each at the rate of 10 fishes per tank. These fingerlings were fed @ 3% body weight twice daily given in morning and evening. The diet was divided equally between the two feeding. Observations were taken for their periodic weight at fortnight interval. At the end of the experiments the samples were analysed for growth performance and feed utilization. The results were statistically tested for significant difference following SPSS 16.0.

b. Experimental diet

Six iso-nitrogenous (52% crude protein) experimental diets were formulated to replace fish meal (FM) with soybean meal (SBM) by 100% FM and 0% SBM (T1 (control)), 24% SMB (T2), 28% SBM (T3), 32%SBM (T4), 34% SBM (T5) and 42.7% SBM (T6) with addition of 0.5% betaine HCL pepsin except in control to study its effect (mentioned in Table 1).

c. Growth Parameters

The growth parameters of *Channa striata* fingerlings were analysed at 15 days interval. The Body weight and total length of fish were measured to assess the growth of fish. Based on the fortnight interval the weight of each fish, net weight gain (WG), specific growth rate (SGR) and feed conversion ratio (FCR) were calculated by following formulae:-

Net Weight Gain (WG)

The average body weight gain was calculated by the following formula

Body weight gain (g) = Final weight of fish (g) – Initial weight of fish (g)

$$\text{Weight gain in percent} = \frac{(\text{Final Wt} - \text{Initial Wt}}{\text{Initial Wt}} \times 100$$

Specific Growth Rate (SGR)

$$SGR\ \% = \frac{(Log\ n\ Wt - Log\ n\ Wo)}{D}\ x\ 100$$

Where,
Wo = Initial weight of live fish (g)
Wt = Final weight of live fish (g)
D = Duration of feeding (days)

Gross Conversion Efficiency (GCE)

$$GCE = \frac{\text{Weight gained (g)}}{\text{Food given(g)}}$$

Food Conversion Ratio (FCR)

$$FCR = \frac{Feed\ given\ (g)}{Weight\ gain\ (g)}$$

Results

At the end of the experiment at the period of 60 days, the growth performance of experimental snakehead (*Channa striata)* fingerlings was estimated for different formulated experimental diets. The growth performance was determined in terms of weight gain (WG), percent weight gain (% WG) specific growth rate (SGR), feed conversion ratio (FCR) and gross efficiency ratio (GEC).

The highest weight gain was observed in T2 (33.260±0.447) followed by T1 (28.814±0.281), T3 (28.347±0.321), T4 (27.517±0.185) and T5 (26.680±0.201) and lowest weight gain was observed in T6 (23.435±0.271). However, the weight gain in T1 and T3 were comparatively same. The statistical analysis of variance indicated a significant difference in weight gain between all treatments except T1 and T3. The result of weight gain are presented in Table 2 and Fig. 1. The total percent weight was observed highest in T2 (165.101±2.181) followed by T1 (143.112±1.327), T3 (140.735±1.610), T4 (136.496±0.956) and T5 (132.488±0.980) and lowest percent weight gain was observed in T6 (116.404±1.369). The statistical analysis of variance indicated a significant difference in percent weight gain between all the treatments except T1 and T3. The result of percent weight gain pertaining to experimental fish *Channa striata* are present in Table 3 and Fig. 2. The value of SGR was observed highest in T2 (6.498±0.054) and lowest in T6 (5.146±.042). The value of SGR in remaining treatments were T1 (5.922±0.036), T3 (5.856±0.044), T4 (5.738±0.026) and T5 (5.624±0.028). The result of specific growth rate are present in Table 4 and Fig. 3. The value of FCR was observed highest in T6 (2.132±0.018) and lowest in T2 (1.765±0.020). The value of FCR in remaining treatments were T1 (1.896±0.009), T3 (1.925±0.021), T4 (1.938±0.017) and T5 (1.964±0.011). The results of food conversion ratio are present in Table 5 and Fig. 4. The value of GCE was observed highest in T2 (0.567±0.006) and lowest in T6 (0.469±0.004). The value of GCE in remaining treatments were T1 (0.527±0.002), T3 (0.519±0.005), T4 (0.516±0.004) and T5 (0.509±0.003). The result of gross conversion efficiency are present in Table 6 and Fig. 5.

Table 1: Experimental diets under current study

Ingredients	Treatments					
	T1	T2	T3	T4	T5	T6
Fish meal	75	57	54	51	49.5	43
Soybean meal	0	28	32	35.5	39	45.5
Rice bran	16	5.5	4.5	4	2	2
Wheat flour	5	5	5	5	5	5
Vegetable oil	2	2	2	2	2	2
Betaine HCL Pepsin	0	0.5	0.5	0.5	0.5	0.5
Vitamin mineral mixture	2	2	2	2	2	2
Total	100	100	100	100	100	100
% Fish meal replacement	0%	24%	28%	32%	34%	42.7%

Table 2: Weight gain of *Channa striata* in different treatments

S. No.	Treatment	Initial Wight	Net Wight Gain (gm)				
		0 days (Initial)	15 day	30 day	45 day	60 day	Total (0 – 60 days)
1	T1	$20.133^{a}\pm0.015$	$6.829^{cd}\pm0.049$	$6.642^{b}\pm0.311$	$7.172^{ab}\pm0.315$	$8.170^{a}\pm0.261$	$28.814^{d}\pm0.281$
2	T2	$20.145^{a}\pm0.006$	$7.922^{e}\pm0.036$	$9.042^{c}\pm0.350$	$7.895^{bc}\pm0.388$	$8.400^{a}\pm0.484$	$33.260^{e}\pm0.447$
3	T3	$20.142^{a}\pm0.011$	$6.947^{d}\pm0.179$	$5.617^{a}\pm0.188$	$8.627^{c}\pm0.363$	$7.155^{a}\pm0.556$	$28.347^{cd}\pm0.321$
4	T4	$20.160^{a}\pm0.008$	$6.200^{c}\pm0.200$	$5.367^{a}\pm0.106$	$8.540^{c}\pm0.389$	$7.410^{a}\pm0.295$	$27.517^{bc}\pm0.185$
5	T5	$20.137^{a}\pm0.004$	$5.147^{b}\pm0.384$	$6.787^{b}\pm0.171$	$6.867^{ab}\pm0.615$	$7.877^{a}\pm0.372$	$26.680^{b}\pm0.201$
6	T6	$20.132^{a}\pm0.006$	$4.307^{a}\pm0.243$	$5.532^{a}\pm0.568$	$6.527^{a}\pm0.310$	$7.067^{a}\pm0.379$	$23.435^{a}\pm0.271$

Table 3: Percent weight gain of *Channa striata* fingerling in different treatments

S. No.	Treatment	15 days	30 days	45days	60 days	Total(0-60days)
1	T1	$33.919^{cd}\pm0.273$	$24.637^{ab}\pm1.163$	$21.340^{a}\pm0.888$	$20.065^{a}\pm0.863$	$143.112^{d}\pm1.327$
2	T2	$39.327^{e}\pm0.183$	$32.216^{c}\pm1.247$	$21.309^{a}\pm1.244$	$18.667^{a}\pm1.090$	$165.101^{e}\pm2.181$
3	T3	$34.491^{d}\pm0.890$	$20.741^{a}\pm0.733$	$26.375^{b}\pm1.069$	$17.356^{a}\pm1.509$	$140.735^{cd}\pm1.610$
4	T4	$30.753^{c}\pm0.985$	$20.368^{a}\pm0.472$	$26.931^{b}\pm1.317$	$18.421^{a}\pm0.869$	$136.496^{bc}\pm0.956$
5	T5	$25.651^{b}\pm1.906$	$26.866^{b}\pm0.822$	$21.475^{a}\pm2.080$	$20.263^{a}\pm1.146$	$132.488^{b}\pm0.980$
6	T6	$21.396^{a}\pm1.216$	$22.696^{a}\pm2.506$	$21.820^{a}\pm1.265$	$19.384^{a}\pm1.159$	$116.404^{a}\pm1.369$

Table 4: Specific growth rate of *Channa striata* fingerling in different treatments

S. No.	Treatment	15 Days	30 Days	45 Days	60 Days	Total
1	T1	$1.947^{cd}\pm0.013$	$1.467^{bc}\pm0.062$	$1.289^{a}\pm0.048$	$1.218^{a}\pm0.048$	$5.922^{d}\pm0.036$
2	T2	$2.211^{e}\pm0.008$	$1.860^{d}\pm0.062$	$1.286^{a}\pm0.068$	$1.140^{a}\pm0.061$	$6.498^{e}\pm0.054$
3	T3	$1.975^{d}\pm0.044$	$1.256^{ab}\pm0.040$	$1.559^{b}\pm0.056$	$1.065^{a}\pm0.086$	$5.856^{cd}\pm0.044$
4	T4	$1.758^{c}\pm0.050$	$1.235^{a}\pm0.026$	$1.588^{b}\pm0.068$	$1.126^{a}\pm0.048$	$5.738^{bc}\pm0.026$
5	T5	$1.515^{b}\pm0.101$	$1.586^{c}\pm0.043$	$1.293^{a}\pm0.116$	$1.229^{a}\pm0.063$	$5.624^{b}\pm0.028$
6	T6	$1.291^{a}\pm0.066$	$1.359^{ab}\pm0.135$	$1.314^{a}\pm0.069$	$1.180^{a}\pm0.064$	$5.146^{a}\pm0.042$

Table 5: Feed conversion ratio of *Channa striata* fingerling in different treatments

S. No.	Treatment	15	30	45	60	Total
1	T1	$1.323^{ab}\pm0.007$	$1.838^{bc}\pm0.174$	$2.119^{ab}\pm0.083$	$2.255^{a}\pm0.099$	$1.896^{b}\pm0.009$
2	T2	$1.144^{a}\pm0.005$	$1.403^{a}\pm0.107$	$2.133^{ab}\pm0.125$	$2.437^{a}\pm0.151$	$1.764^{a}\pm0.020$
3	T3	$1.307^{ab}\pm0.033$	$2.177^{cd}\pm0.154$	$1.714^{a}\pm0.071$	$2.658^{a}\pm0.252$	$1.925^{bc}\pm0.021$
4	T4	$1.147^{b}\pm0.047$	$2.212^{d}\pm0.105$	$1.682^{a}\pm0.077$	$2.458^{a}\pm0.114$	$1.938^{bc}\pm0.017$
5	T5	$1.792^{c}\pm0.141$	$1.679^{ab}\pm0.108$	$2.170^{b}\pm0.257$	$2.242^{a}\pm0.129$	$1.964^{c}\pm0.011$
6	T6	$2.123^{d}\pm0.118$	$2.056^{cd}\pm0.449$	$2.083^{ab}\pm0.120$	$2.345^{a}\pm0.136$	$2.132^{d}\pm0.018$

Table 6: Gross conversion efficiency of *Channa striata* fingerling in different treatments

S. No.	Treatment	15 days	30 days	45 days	60 days	Total
1	T1	$0.755^{d}\pm0.004$	$0.547^{ab}\pm0.025$	$0.474^{a}\pm0.019$	$0.445^{a}\pm0.038$	$0.527^{c}\pm0.002$
2	T2	$0.873^{e}\pm0.004$	$0.715^{c}\pm0.027$	$0.473^{a}\pm0.027$	$0.414^{a}\pm0.048$	$0.567^{d}\pm0.006$
3	T3	$0.766^{d}\pm0.019$	$0.460^{a}\pm0.016$	$0.586^{b}\pm0.023$	$0.385^{a}\pm0.067$	$0.519^{bc}\pm0.005$
4	T4	$0.683^{c}\pm0.021$	$0.452^{a}\pm0.010$	$0.598^{b}\pm0.029$	$0.409^{a}\pm0.038$	$0.516^{bc}\pm0.004$
5	T5	$0.568^{b}\pm0.042$	$0.597^{b}\pm0.018$	$0.477^{a}\pm0.046$	$0.450^{a}\pm0.050$	$0.509^{b}\pm0.003$
6	T6	$0.475^{a}\pm0.027$	$0.504^{a}\pm0.055$	$0.484^{a}\pm0.028$	$0.430^{a}\pm0.051$	$0.469^{a}\pm0.004$

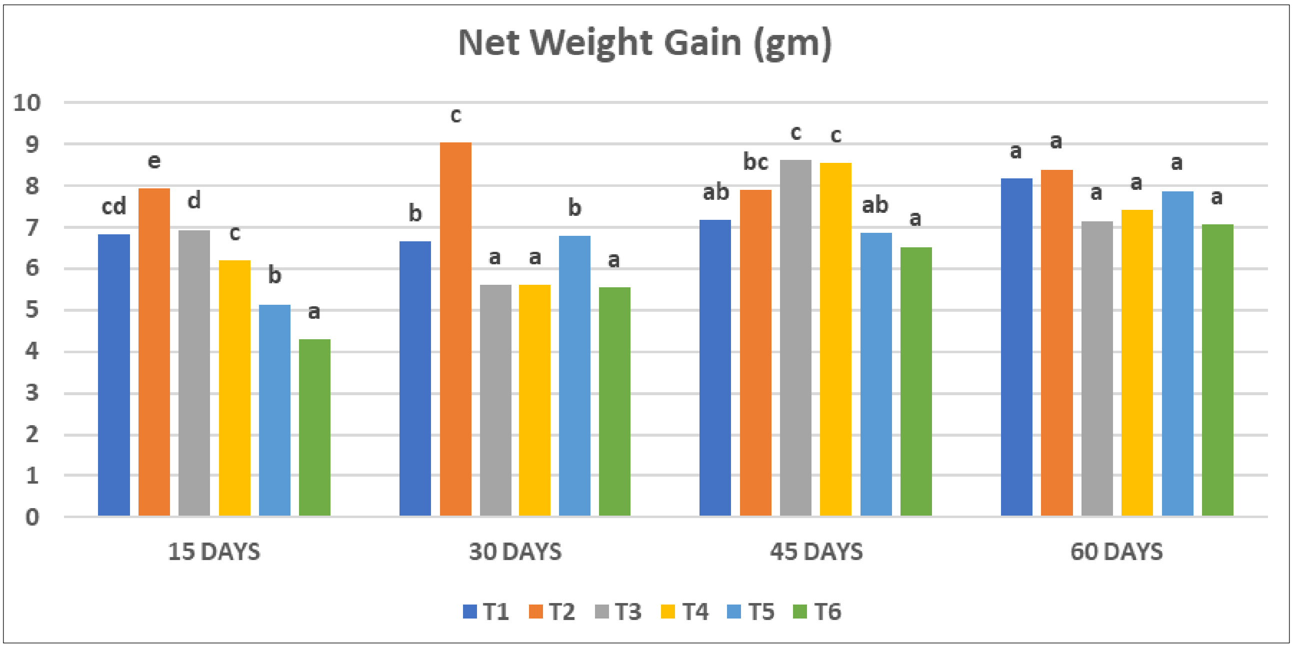

Fig 1: Net weight gain in different treatments during experimental period.

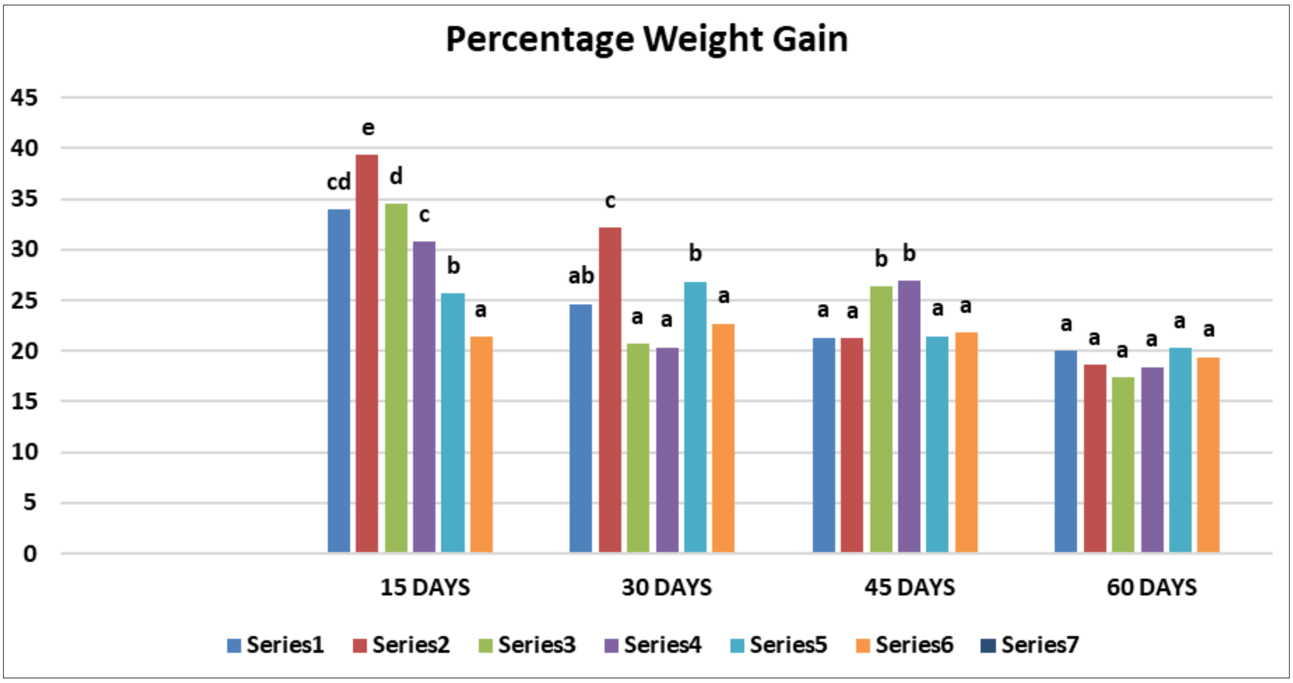

Fig 2: Percentage weight gain in different treatments during experimental period.

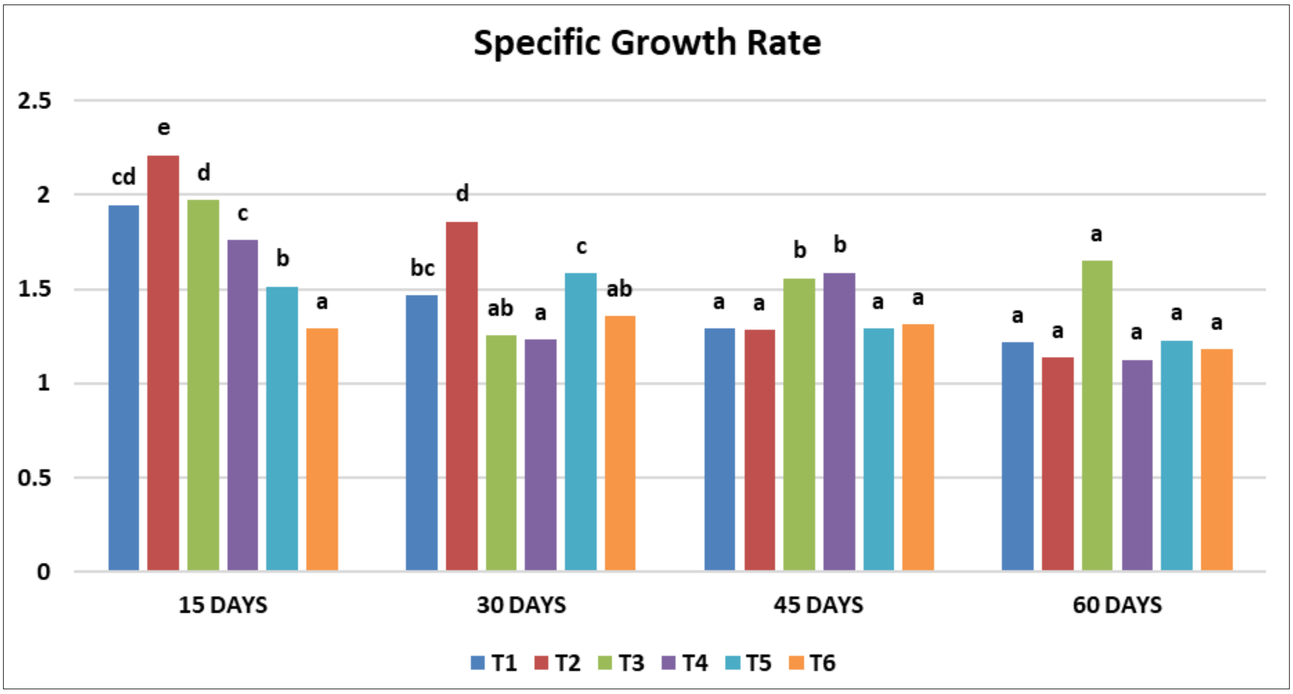

Fig 3: Specific Growth Rate in different treatments during experimental period.

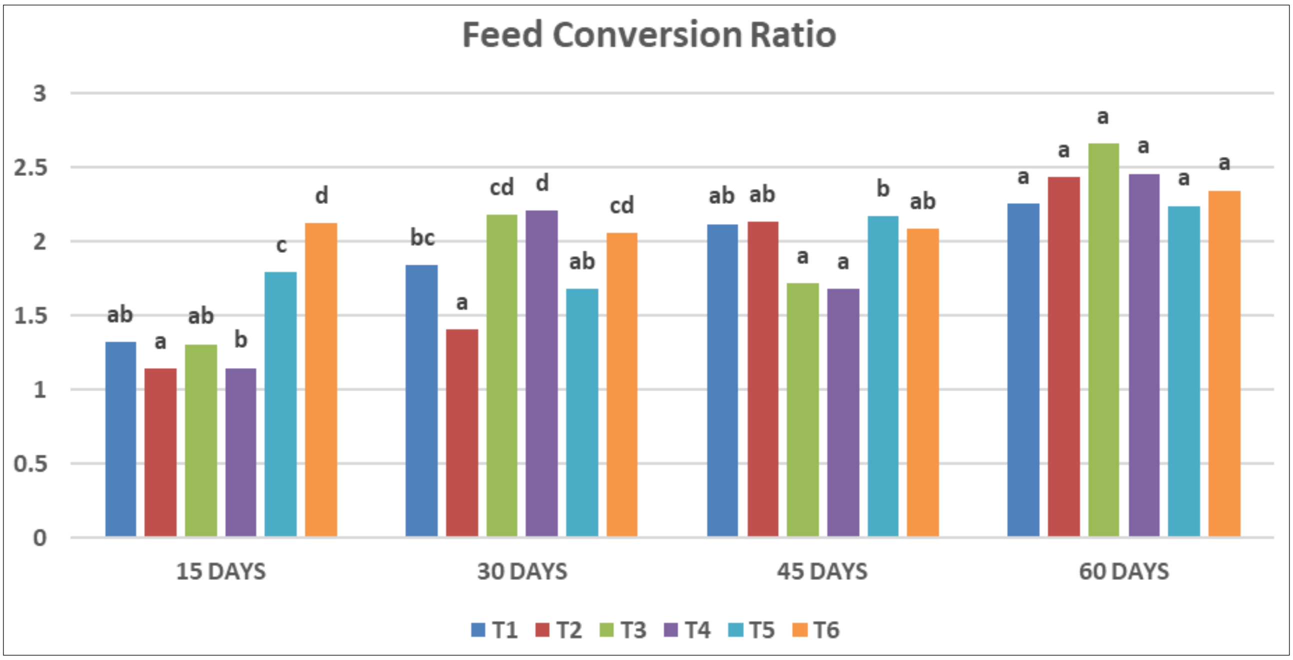

Fig 4: Feed conversion ratio in different treatments during experimental period.

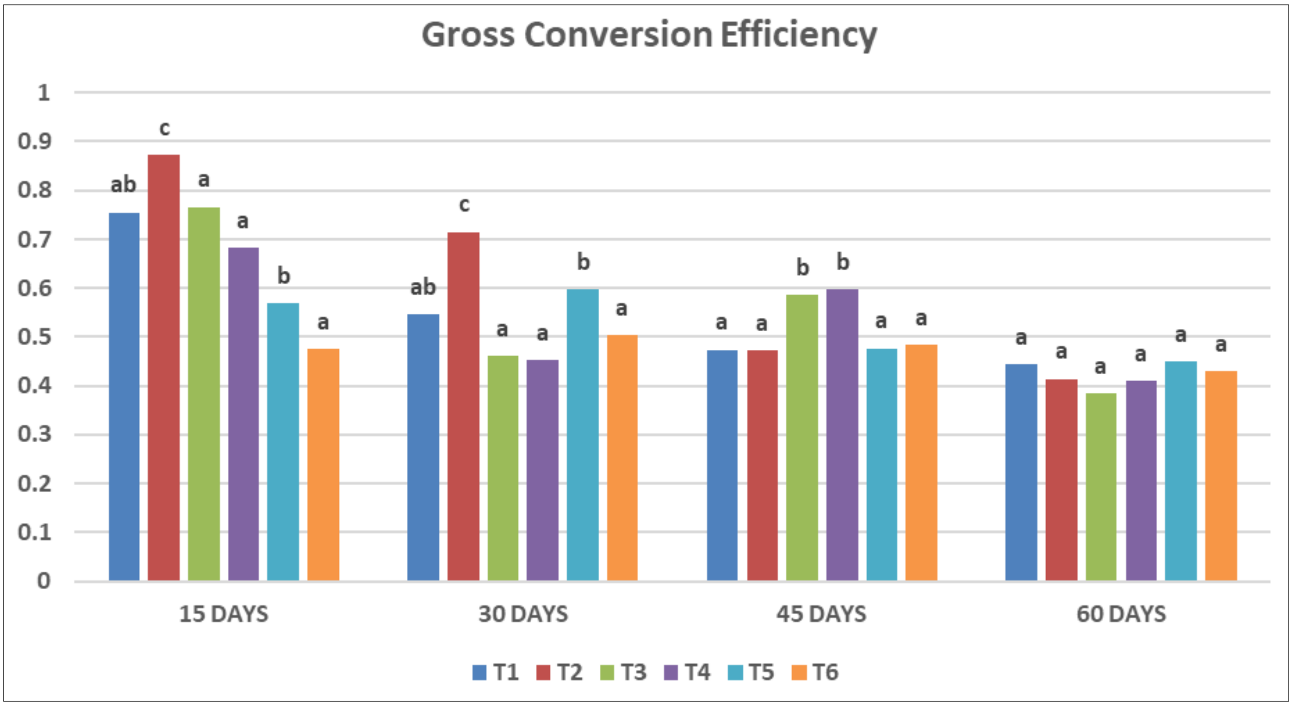

Fig 5: Goss conversion efficiency in different treatments during experimental period.

Discussion

Snakehead is a carnivorous fish species with a high protein requirement (Samantaray and Mohanty, 1997; Be and Hien, 2010) [4, 1]. It was ascertained that striped snakehead require 52% protein diet (Wee and Tacon, 1982) [7]. FM can be replaced by SBM up to 30% in diet for snakehead (Be and Hien, 2010) [1]. In the current study, the weight gain, percentage weight gain, specific growth rate, gross conversion efficiency, food conversion ratio and digestibility were significantly different ($p<0.05$) in different levels of replacement of fish meal with soybean meal supplementation in fish diet. The best growth was observed in T2 in which the ratio of fish meal and soybean meal was 57:28 (in %) with addition of Betaine HCL Pepsin at 0.5%. The weight gain was 33.260±0.447 (165.101±2.181%), specific growth ratio was 6.498±0.054 and average digestibility 73.672±1.130 were the highest compared to other treatments. The FCR was lowest in T2 1.764±0.020 in comparison to other treatments. The gross conversion efficiency for this diet was 0.567±0.006. The second highest growth was observed in T1 (control) where 100% of fishmeal was added in the diet, as fish meal is an animal protein which is highly digestible as compared to other protein sources (NRC, 1983; Hien *et al.*, 2017) [3, 2].

Conclusion

The current investigation has revealed some positive results in replacement of fishmeal with soybean meal. The diet of T2 was found favourable for growth and digestibility of *C. striata*. The outcome of current research has shown how addition of feed attractant in fish diet increases the feed intake and pepsin increases digestibility of feed. Its incorporation did not reflect negative influence on the *C. striata* health. On the basis of the outcome of the current investigation, it can concluded that digestibility can be increased by incorporation of Betaine HCL Pepsin and fishmeal can be replaced by soybean meal in a suggestive way.

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