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Incorporation of shrimp head meal as attractant in the diet of gift tilapia (*Oreochromis niloticus*, Linnaeus, 1758)

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Abstract
Four experimental diets with different incorporation levels of shrimp head meal (0%, 1%, 3% and 5% as T_0, T_1, T_2 and T_3 respectively) were tested as feed attractant in GIFT tilapia in order to determine the suitable incorporation level. The feeds with 35% protein level were prepared manually by using locally available ingredients. The experiment was conducted in triplicate following the statistical tools "completely randomized design". The fishes measuring mean length of 3.56±0.04 cm and the weight of 1.049±0.022 g were randomly distributed in 12 FRP tanks of 200L water capacity at stocking rate of 10 individuals per tank. It was recorded that the values of water quality parameters such as pH, temperature, dissolved oxygen, total alkalinity, hardness and ammonia nitrogen were within the optimal range of GIFT tilapia culture. In the control diet the fishes were measured with lower growth response with mean body weight of 17.28 g after 90 days of culture and the higher mean body weight (21.65 g) was recorded in T_3 (5% SHM). The weight gain of fishes between the control and treatments varied significantly ($p<0.05$). Feed conversion ratios of different experimental groups followed inverse trend with growth response of fishes with the highest and lowest values were observed in T_0 (2.33) and T_3 (2.07), respectively. Highest survival rate (96.67%) was observed in group fed with 5% followed by 93.33% in 3% fed group, 90% in 1% fed group and 83.33% in control group. Therefore, the incorporation of shrimp head meal (SHM) as a feed attractant in the diet at the rate of 5% is observed to be best among all treatment groups with respect to growth, feed utilization and survival of GIFT tilapia (*Oreochromis niloticus*).

Keywords: Shrimp head meal, GIFT tilapia, feed attractant

Introduction
In aquaculture, the feed is the most important factor that impacts the fish growth however additionally influences the value of production, as it contributes to over 50% of the total operational cost (Tanuja *et al*., 2017) [29]. Further, inclusion of protein source in fish feed costs around 50% of the overall cost of all of the feed components taken together (Arruda *et al*., 2009) [1]. Hence, selection of a suitable protein source containing satisfactory protein and also its availability at cheap price is a promising vicinity of studies in aquaculture nutrition. The aquaculture industry relied primarily on the fish meal (FM) based compounded feeds for farming fish species as it is the major protein ingredients in the feed because of more protein, balanced essential amino acid (EAA) profile and great nutrient digestibility and less in anti-nutritional factors (Hardy, 2010) [10]. Now days, FM inclusion had been decreasing notably on account of fish meal (FM) less supply with its big demand and high cost in the market (Hung *et al*., 2007) [13]. Many authors have advocated various plant-based protein sources and animal-based protein sources to replace fish meal, that having less price than fish meal. Further, the use of fish for feeding fish as fish meal is not a wise proposition at a time while the same fish can be higher utilized for feeding humans stricken by malnutrition after suitable cost addition. However, usage of plant protein sources with substitute of fish meal in the fish feed are not being accepted well because of anti-nutritional factors (ANF), poor in certain essential amino acid (EAA), less nutrient digestibility, decrease nutrient availability and very less palatability because of more fiber content material (Yuan *et al*., 2011) [34].
Feed attractants are substances which are added in trace amounts to a basic feed for the purpose of attracting the primary feed, aside from as a source of nutrient (Paul and Giri, 2013) [22]. The feed attractant allows the growing animals in culture systems to approach the feed source. Hence, improving palatability and attract ability of feed is taken into consideration as the important thing while using alternative protein sources in fish (Hirt-Chabbert *et al*.,

2012) [12]. However, ecological considerations may additionally require that the use of feed attractants in feed may additionally emerge as essential. In shrimp processing industry, shrimp head is considered as a waste. But shrimp head meal is a great additive in aquaculture due to rich in protein, free fatty acids, cholesterol, and mineral contents (Fanimo *et al*., 2000) [5]. Shrimp head meal as a nutrient source and palatable feed component due to presence of glycine betaine were described by means of several authors (Hertrampf and Farooq, 2001) [11]. Utilization of shrimp head meal in feed reduce the unit cost of feed, but also would serve as an excellent manner of stopping surroundings pollutants by the way of increasing feed palatability.

The aim of the study is to decide using attractant can show up any effect on feed consumption, growth and feed utilization overall performance of cultured fish. The selected target species is the famous cultured Genetically Improved Farmed Tilapia (GIFT tilapia). Tilapia is especially freshwater fishes and now the third most farmed fish in the global. GIFT tilapia is offering a sustainable supply of food and nutrition as well as earnings and livelihood to the farmers. It can be grown in diverse farming systems and requiring minimum fish meal in its feed. GIFT tilapia is a suitable fish for culture like rapid growth rate, high tolerance to surroundings conditions, easy to spawn, disease resistant and acceptance by consumer make it. In this context, the present experiment is aimed to incorporate shrimp head meal (SHM) as an attractant in the of GIFT tilapia (*Oreochromis niloticus*) and to study its effect in enhancing the acceptability and palatability of feed.

Materials and Methods

The present investigation was carried out to know the comparative efficacy of shrimp head meal as attractant in the diet of GIFT tilapia (*Oreochromis niloticus*, Linnaeus, 1758) on the basis of a 90 days feeding experiment from June, 2021 to August, 2021.

Experimental animal and set up: Good quality GIFT tilapia (*Oreochromis niloticus*, Linnaeus, 1758) fry was procured from State hatchery, Kausalyaganga, Bhubaneswar, Odisha for conducting the experiment. The fishes were transported from Bhubaneswar to the experimental unit in oxygenated polythene bags. They were kept in 2 FRP tanks of 500L capacity containing about 400L of water for acclimatization under aerated condition for about three weeks and were fed with commercial carp feed of 30% CP twice a day at about 5.0% of their biomass. The experimental tanks were washed thoroughly and disinfected by using $KMnO_4$ (25 ppm) and sun-dried before stocking experimental fishes. The tanks were filled with chlorine-free bore well water. Uniform sized fishes with an average weight of 1.049±0.02 g were randomly distributed @ 10 number of fishes each in twelve FRP tanks (200 L water capacity) containing about 100L water.

Rearing, cleaning and siphoning: The GIFT tilapia fries were reared under continuous aeration for 90 days. During the rearing period the faecal matters and the uneaten feed particles were removed daily by siphoning to maintain the water quality. During siphoning about one third water from each tank was removed and was replaced with an equal volume of clean bore well water.

Fish Feed Ingredients: Feed ingredients required for experimental diet formulation such as de-oiled rice bran (DORB), soybean oil cake (SOC), mustard oil cake (MOC) and ground nut oil cake (GNOC) were collected from the local market. The oil cakes were cleaned manually and dried in a hot air oven set at 60ºC for 6-8 hours. After drying, the oil cakes were powered in a pulveriser and kept in air tight containers after proper labelling. Proximate composition analysis of all the ingredients was done following standard method.

Vitamin and mineral mixture and Vitabest were procured from one local veterinary medicine shop. Vitabest comprised of Cod liver oil and Refined Soya oil (1:1) and served as the source of lipid. Nutritional composition per kg of Vitamin and mineral mixture was: Vit A 700000 I.U.; Vit D3 70000 I.U.; Vit E 250 mg; Cobalt 150 mg; Copper 1200 mg; Iodine 325 mg; Iron 1500 mg; Magnesium 6000 mg; Potassium 100 mg; Sodium 5.9 mg; Manganese 1500 mg; Sulphur 0.72%; Zinc 9600 mg; Dl-Methionine 1000 mg; Calcium 25.5 %; Phosphorus 12.75%. Other ingredients were prepared in the laboratory as described below.

Preparation of fish gut silage and its refinement: To prepare fish gut silage, raw materials were collected from the local fish market. It included dressing waste that is mostly carp guts along with fins, gills and other dressing wastes. Immediately, it was brought to the laboratory under ambient temperature and washed thoroughly in tap water to remove any sand particles if there. Then weighed in bulk and transferring into a plastic bucket. Formic acid was added at a rate of 35 ml per 1 kg of dressing waste mixed thoroughly and left for the liquefaction reaction to set in. The whole content was stirred every alternate day up to 2 weeks till all the content becomes completely liquefied. As the raw material was dominated with carp gut, which comprises of excess fat, refining of silage by centrifugation at 3000 rpm for 5-7 minutes by taking fish silage in 4 no. of 50 ml. centrifugation tubes. The fat that floated in the upper layer was decanted and the left-over silage was collected and used as fish gut silage.

Preparation of fish meal: Locally available cheaper marine fishes (sardines) were carried out from local fish market. The fishes were cleaned manually and dried in a hot air oven set at 60ºC for 12-14 hours and alternate the sides of fishes in trays for uniform drying. After drying the fishes were powdered in a pulveriser and kept in an air tight container after proper labelling.

Preparation of shrimp head meal: Shrimp head wastes were carried out from local fish market. The shrimp head wastes were cleaned manually and dried in a hot air oven set at 60ºC for 12-14 hours and alternate the sides of shrimp heads in trays for uniform drying. After drying the shrimp heads were powdered in a pulveriser and kept in an air tight container after proper labelling.

Formulation and preparation of experimental diets: Proximate composition analysis of all the ingredients were done following standard protocol was used for formulating four no. of iso-nitrogenous and iso-caloric experimental diets having crude protein 35% and labelled as T_0, T_1, T_2 and T_3 (Table 1). The control diet i.e. T_0 was formulated using FS as major source of protein by replacing 75% of FM. The other protein sources in control diets were SOC, GNOC, MOC and

the carbohydrate source was DORB. The experimental diets T_1, T_2 and T_3 were prepared using SHM as attractant @ 1%, 3% and 5% level, respectively by replacing DORB and SOC accordingly. Energy content in the experimental diets was balanced by altering the oil content. Detailed compositions of the experimental diets are given in Table 2.
The required quantity of the respective silage and Vitabest were added and hand kneaded properly followed by addition of water as per the need to get thick dough. Then, the dough was cooked for 15 minutes in a household pressure cooker to gelatinize the starch content and to kill any microbes present. The autoclaved dough was then cooled down to room temperature followed by addition of vitamin and mineral premix and mixing properly by hand kneading. The dough was then pelletized using a hand pelletizer and dried overnight at 60ºC in a hot air oven. After attaining required moisture levels, the dried pelleted feeds were crumbled to an approximate size and packed in well labelled air tight containers for further use.

Rate of feeding: The fishes were fed at 4% of total biomass per day initially and then adjustment was done as per the acceptance of the experimental animals. The daily ration was equally divided into two parts and was given 2 times a day i.e. at 9:00 AM and at 4:00 PM for 90 days. Fortnightly sampling was done to check the health status and increment in weight and daily ration was adjusted accordingly.

Physico-chemical parameters of water: The physico-chemical parameters of the experimental tank water namely: pH, DO, temperature, total alkalinity, hardness and ammonia nitrogen were monitored during experimental period. The parameters were recorded on weekly basis following standard protocol.

Statistical analysis: The data obtained in the present study were analysed by using software SPSS (Statistical package for the social sciences) version 26.0 (IBM, USA). One-way ANOVA and Duncan's Multiple Range Test (DMRT) were used to determine the significance difference between the treatment means at 5% level of significance.

Results and Discussion

Proximate composition of experimental diet: A diet is said to be a good one, when it contains almost all the essential nutrients in a balanced proportion. Out of the three major nutrients, protein is said to be the main component in fish feed formulation and also the most expensive dietary component (Oliva-Teles *et al*., 2020) [21]. The level of incorporation of protein in aqua diet is very important for both growth and economics of fish culture operation. Food rations for tilapia require a high level of protein, which increases the participation of protein sources, which account for most of the total cost of the food fish require more dietary protein than other animals. The complete fish feed contains between 28 and 50% crude protein, depending on the stage of development. The crude protein (CP) requirement of fishes varies from species to species, different stages of life, season, habitat, feeding habit etc. (Hancz, 2011) [9]. The average CP requirement for different fish species such as catfish, tilapia and trout ranges from 28-32 %, 35-40 % and 40-45 %, respectively. Similarly, the CP content required for shrimp species is 30-35 percent.

In the present study, the CP contents (%) of 4 experimental feeds such as T_0, T_1, T_2 and T_3 were 35.02, 35.11, 35.04 and 34.97%, respectively on dry weight basis, which would be optimum in meeting the protein requirement of GIFT tilapia fries used as test animal in this experiment. Further, there was no significant (p>0.05) difference in the CP content among the different experimental diets, which shows that the CP content would not have influenced the findings of this study.
Adequate quantity of lipid in diet not only serves as an important source of essential fatty acids, energy, eicosanoids, phospholipids, sterols and fat-soluble vitamins (Ghanawi *et al*., 2011) [6], but also helps in reduction in catabolism of dietary protein and spare protein for growth (Guo *et al*., 2019) [8]. Appropriate lipid content not only improves feed and nutrient utilization but also helpful in reducing feed cost (Sagada *et al*., 2017) [25]. Mishra and Samantaray (2004) [19] reported that 8.0% dietary lipid content satisfies the lipid requirements in rohu fingerlings, whereas Paul and Giri (2015) [23] documented that the optimum lipid requirement of carps as 9-10% and 4-15% in various fish species (Giri, 2013) [22]. Other findings on lipid requirement include 7.5% for mrigal fry (Marimuthu and Sukumaran, 2001) [17], 14% in hybrid grouper (Rahimnejad *et al*., 2015) [24], 8% in Nile tilapia (Eid *et al*., 2019) [2] and 12 or 15% in northern snakehead fish (Sagada *et al.*, 2017)[25]. In this experiment, the crude lipid content (%) were recorded to be 8.12, 8.14, 8.17 and 8.22 on dry weight basis for T_0, T_1, T_2 and T_3 diets, respectively. The values fall well within the acceptable range of lipid requirement of tilapias.
Carbohydrate is the inexpensive source of energy in fish diet; besides, it also serves as a binder and to improve the pelletizing property of the aqua feed. The digestibility of carbohydrate in fish body depends on the source of carbohydrate and the presence of carbohydrase enzymes in fish body. In certain species, the amount of carbohydrate (NFE) present in a fish diet has the capacity to reduce the protein requirement, since it spares protein for growth (Kathane *et al*., 2017) [15]. According to Wilson (1994) [32] the optimum carbohydrate requirement for growth of spawn, fry and fingerlings of tilapia stand to be 40% and tilapia can efficiently utilize as much as 35-40 percent digestible carbohydrate.
The digestible energy of any diet is dependent on the protein (%), lipid (%) and carbohydrate (%) content present in it. Protein content in the diet serves as the preferred source energy, while lipid content serves as concentrated source of energy and carbohydrate content serves as the inexpensive source of energy to the fish species under culture. Hence, in the absence of adequate amount of non-protein energy sources like carbohydrate and fat in diet, protein is utilized to supply energy for normal body functioning, hampering growth of the fish (Kathane *et al*., 2017) [15]. At the same time, higher energy content in the diet is also undesirable, as it may lead to fat deposition in the peritoneal cavity, liver and other tissues and thus could compromise quality of the flesh and affect shelf life of its products (Sagada *et al*., 2017) [25]. Hence, the feed formulator should balance the protein and digestible energy content in fish diet to get optimum growth of the target fish. The energy requirement of tilapia varies from 300-500 Kcal/100g body weight at 30-40% dietary protein levels (El-sayed and Teshima, 1992) [3].

Growth performance parameters: In the present experiment, the results revealed that significant difference (p<0.05) within different experimental diet on growth performance of GIFT tilapia fries. The average initial weight of GIFT tilapia fries at the beginning of the experiments was 1.049±0.022 g, which shows homogeneity in initial fish weight, with negligible variation among the treatment's group. After conducting 90 days of feeding trial, the average weight among the treatment groups differed significantly ($p<0.05$) with the highest growth in T_3 (21.647±0.411 g) and lowest in T_0 (17.279±0.071 g) (Table 3). The highest weight gain was recorded in treatment T_3 (5% SHM incorporation level) followed by T_2 (3% SHM incorporation level). Accordingly, the weight gain (%) varied significantly ($p<0.05$) among the different experimental groups. The highest weight gain (%) was achieved in T_3 (1982.057±10.137 %), followed by T_2 (1740.671±3.772 %). The lowest weight gain (%) was found in T_0 (1462.910±16.089 %) followed by T_1 (1549.740±51.761 %). In the present investigation, the SGR (%) values of different treatment groups were also varied significantly ($p<0.05$). The highest SGR was recorded in T_3 (3.373±0.005%) followed by T_2 (3.236±0.002%). The lowest SGR (%) was found in T_0 (3.054±0.011%) followed by T_1 (3.114±0.035%).

Growth performance of experimental animals in T_3 was better in terms of WG, WG (%) and SGR (%) were noticed, which could be due to the presence of attractant shrimp head meal at 5% level. Among the various ingredients being used in fish feed, shrimp head meal is used as an attractant and increase the feed intake because like other crustacean meals, SHM contains nitrogenous compounds such as free amino acids, peptides and nucleotides especially glycine betaine (Hetrampf and Farooq 2001) [11] that have been identified as feeding stimulants for several species (Smith *et al.*, 2005) [27]. Meyers (1987) [18] stated that crustaceans and mollusks have attractants that contain nitrogenous compounds, for instance, free amino acid, peptides, nucleotides and chitin, which promote consumption and thus increase growth. Sanchez *et al*. (2005) [26] also reported that krill meal improved attractability of a feed and thus enhance the palatability of the diet for pacific white shrimp. Williams *et al*. (2005) [31] reported that, krill and shrimp head meal supplemented in a basal diet improved the *Penaeus monodon* growth performance in a dose-dependent manner. Products obtained from shrimp processing wastes may serve as a useful source of protein and flavoring in feed formulations mainly due to the level of free amino acids. Several authors reported that marine animal additives act as the feed attractants can enhance feed performance by improving the attractability and palatability; which was supported the present findings. Yu *et al*. (2020) [33] indicated that the shrimp extract had a positive effect on growth of red tilapia at a level 3% shrimp extract with 30% soybean meal on juvenile red tilapia.

Feed efficiency parameters: In the present study in GIFT tilapia (*Oreochromis niloticus*) with the shrimp head meal, highest FCR i.e. 2.33 is recorded in control (with no shrimp head meal) followed by T_1 (2.24) at 1% SHM incorporation level, T_2 (2.18) at 3% incorporation level and T_3 (2.07) at 5% incorporation level. The FCR between the control and treatments varied significantly during the experimental period ($p<0.05$). The similar results also reported by previous researchers in Red tilapia with shrimp extract (Yu *et al*., 2020) [33], in African Catfish *Clarias gariepinus* with shrimp waste meal (Nwanna *et al.*, 2003) [20], in Nile tilapia with shrimp protein hydrolysate (Leal *et al*., 2009) [16], in hybrid tilapia *(Oreochromis niloticus x Oreochromis aureus)* with shrimp shell meal (Fall *et al.*, 2012) [4], in Red Tilapia *(Oreochromis mossambicus)* with shrimp head silage hydrolysate and distiller's dried corn grain (Valdez-González *et al.*, 2016) [30] and in Goldfish (*Carassius auratus*) with shrimp head meal (Gowsalya and Kumar, 2018) [7].

Feed efficiency ratio implies how efficiently feed has been utilized. Simply, it is feed conversion efficiency ratio. In the present experiment on shrimp head meal in silage-based diet in GIFT tilapia (*Oreochromis niloticus*) highest FER (0.48) has been recorded in 5% shrimp head meal incorporation level which is just reverse to that of the FCR. The other FER level is 0.45 at 3% incorporation level, 0.44 at 1% incorporation level and 0.42 at control (with no shrimp head meal). The FER values were significantly differed between the control and treatments ($p<0.05$). The similar outcome has been noticed by the previous authors in African Catfish *Clarias gariepinus* with shrimp waste meal (Nwanna *et al.*, 2003) [20], in hybrid tilapia *(Oreochromis niloticus*x *Oreochromis aureus)* with shrimp shell meal (Fall *et al.*, 2012) [4], in Red Tilapia *(Oreochromis mossambicus)* with shrimp head silage hydrolysate and distiller's dried corn grain (Valdez-González *et al.*, 2016) [30] and in Goldfish *Carassius auratus* with shrimp head meal (Gowsalya and Kumar, 2018) [7].

Protein efficiency ratio reflects how dietary protein has been utilized to get better growth. In the present experiment, highest PER has been achieved in 1.37 in 5% shrimp head meal incorporation level followed by 1.30 in 3%, 1.26 in 1% and 1.22 in control (with no shrimp head meal) diet. Protein efficiency ratio of GIFT tilapia showed significant difference within the treatments ($p<0.05$). Jatomea *et al*., (2002) [14] reported that the higher feed intake and the best feed conversion ratio and protein efficiency ratio were recorded when the diets contained 0, 10% and 15% shrimp head silage as a replacement to fish meal for Nile tilapia fry and higher replacement gradually decreased those parameters. The similar pattern of present result has been obtained by earlier authors in African Catfish *Clarias gariepinus* with shrimp waste meal (Nwanna *et al.*, 2003) [20], in Nile tilapia with shrimp protein hydrolysate (Leal *et al*., 2009) [16], in Red Tilapia *(Oreochromis mossambicus)* with shrimp head silage hydrolysate and distiller's dried corn grain (Valdez-González *et al.*, 2016) [30].

In the present study on shrimp head meal in GIFT tilapia, maximum survival rate (96.67%) was observed in 5% followed by 93.33% in 3% incorporation level, 90% in 1% incorporation level and 83.33% in control (with no shrimp head meal) diet. Similar trend in survivability were also earlier reported in Red tilapia with shrimp extract (Yu *et al*., 2020) [33], in African Catfish *Clarias gariepinus* with shrimp waste meal (Nwanna *et al.*, 2003) [20], in Nile tilapia with shrimp protein hydrolysate (Leal *et al*., 2009) [16]. Hence, it can be inferred from the present study that the growth performance and feed efficiency parameters of GIFT tilapia (*Oreochromis niloticus*) was the best when the feed contains shrimp head meal as (at 5%) attractant. Since the above stated silage and shrimp head meal can be prepared anywhere, at any scale, by any man, its use in fish feed formulation. Hence, the study suggests to use of fish silage as fish feed ingredient has the potential to reduce environmental pollution by recycling the organic carbon present in low cost fishes and by-catches that are usually not consumed and thrown on the beaches and shrimp head meal as attractant produced from shrimp processing waste.

The cost of production of 1kg feed of individual experimental diet given in Table 4 and the ingredient price recorded from the local market is given in Table 5. In this study the price of control diet per kg feed was found to be Rs. 36.09/-, whereas by replacing de-oiled rice bran and soybean oil cake protein of the control diet (T_0), with shrimp head meal at 1%, 3% and 5% as attractant the feed cost per kg reduced by 6.11%, 11.18% and 15.61% in T_1, T_2 and T_3 diet, respectively. Tanuja *et al*. (2017) [29] have reported decrease in feed cost by 4.08%, 14.31% and 13.75% after incorporating 2.5%, 5% and 10% acid ensilage, respectively in the diet of *Labeo rohita* fingerlings. Similarly, Soltan *et al*. (2017) [28] noted 7.92%,16.14%, 29.31% and 32.97% reduction in feed cost by replacing 25%, 50%, 75% and 100% FM, respectively in the diet of Nile Tilapia (*Oreochromis niloticus*). However, the feed cost per kg body weight gain of fish was found to be Rs. 84.09/- for control diet (T_0), which decreased to Rs. 79.95/-, 76.78/- and 71.93/- for T_1, T_2 and T_3 diet respectively for gain of 1 kg fish weight. This is due to the higher FCR values of the stated feeds. However, the cost of feed per kg body weight gain of fish for T_3 diet was Rs. 71.93/-, which is showing 14.46 % reduction against control diet (T_0). From the above results, it can be summarized that cost-effective diet for GIFT tilapia (*Oreochromis niloticus*) can be formulated like T_3 by using shrimp head meal from shrimp head waste as the attractant.

Table 1: Proximate composition of experimental diets (on dry weight basis)

Sl. No.	Experimental Diet	Moisture (%)	Total dry matter (%)	Parameters (as % of dry matter)						Digestible energy (kcal/ 100 g)	P/E ratio (mg /kcal)
				Crude protein	Ether extract	Crude fiber	Ash	NFE	Total organic matter		
1	T_0	10.98	89.02	35.02	8.12	9.16	15.62	32.08	84.38	341.48	102.55
2	T_1	10.96	89.04	35.11	8.14	9.20	15.65	31.90	84.35	341.30	102.87
3	T_2	10.86	89.14	35.04	8.17	9.25	15.59	31.95	84.41	341.49	102.61
4	T_3	10.81	89.19	34.97	8.22	9.32	15.48	32.01	84.52	341.90	102.28

Table 2: Proximate composition of experimental diets (on wet weight basis)

Sl. No.	Experimental Diet	Moisture (%)	Crude protein (%)	Ether extract (%)	Crude fiber (%)	Ash (%)	NFE (%)
1	T_0	10.98	31.17	7.23	8.15	13.90	28.56
2	T_1	10.96	31.26	7.25	8.19	13.93	28.40
3	T_2	10.86	31.23	7.28	8.25	13.90	28.48
4	T_3	10.81	31.19	7.33	8.31	13.81	28.55

Table 3: Growth performance and feed efficiency parameters of different treatments

Parameters	T_0	T_1	T_2	T_3
Initial weight (g)	1.033±0.011	1.069±0.023	1.053±0.025	1.049±0.030
Final weight (g)	17.279±0.071	17.790±0.212	19.087±0.036	21.647±0.411
Weight gain (g)	15.238±0.077	16.210±0.348	18.050±0.032	20.607±0.395
Weight gain (%)	1462.91±16.08	1549.74±51.76	1740.67±3.77	1982.05±10.13
Daily weight gain (g)	0.157±0.0009	0.168±0.004	0.189±0.0003	0.217±0.004
Total feed fed (g)	35.59±0.299	36.4±0.046	39.47±0.406	42.82±0.836
SGR (%)	3.054±0.011	3.114±0.035	3.236±0.002	3.373±0.005
FCR	2.33±0.029	2.24±0.045	2.18±0.023	2.07±0.016
FER	0.42±0.005	0.44±0.009	0.45±0.004	0.48±0.003
Protein Fed (g)	12.46±0.104	12.79±0.016	13.830±0.142	14.973±0.292
PER	1.22±0.015	1.26±0.025	1.30±0.014	1.37±0.011

Table 4: Cost of feed ingredients (Rs. / Kg) in the local market

Ingredients	Cost (Rs) /kg
Fish meal	75.00
Fish gut silage	15.00
Ground nut oil cake	45.00
Mustard oil cake	35.00
Soyabean oil cake	50.00
Deoiled rice bran	17.00
Lipid	70.00
Vit and Mineral	190.00
Maida	40.00
Shrimp head meal	10.00

Table 5: Calculation of feed cost based on ingredient cost

Treatments	Feed cost/kg. feed	Reduction (%) in feed cost/kg feed	Feed cost/kg. weight gain of fish	Reduction (%) in feed cost/ kg. wt. gain of fish
T_0	36.09	0.00	84.09	0.00
T_1	35.69	1.11	79.95	4.93
T_2	35.22	2.41	76.78	8.69
T_3	34.75	3.71	71.93	14.46

Conclusion

The growth parameters and survival rate of GIFT tilapia in all the treatments with shrimp head meal showed a significant increase compared to control. The addition of shrimp head meal to diets produced the best FCR, which is significantly better than the control. It is suggested that culture of GIFT tilapia (*Oreochromis niloticus*) along with shrimp head meal as attractant is better for growth and survival of the species. The present study reveals that shrimp head meal as attractant at 5% incorporation level showed highest feed intake and subsequent higher growth performance than control

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