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Growth Responses of Animal and Plant Origin Dietary Lipids on the Survival, Growth and Feed Efficiency of Asian Catfish, *Clarias batrachus* (Linnaeus, 1758) Grow-out

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Abstract

A 84-days long experiment was conducted with a view to observe the effects of different feeds on growth and survival of *Clarias batrachus* grow-out. There were seven treatments (FISOL, BETAL, SOYAL, LINOL, MIXOL, SATOL and NATFO containing Fish oil, Beef tallow, Soybean oil, Linseed oil, Mixed oil (i.e. containing in 1:1:1:1 ratio of Fish oil, Beef tallow, Soybean oil, Linseed oil), Vegetable oil and minced chicken meat as natural food, respectively, each having three replications, stocked with 30 grow-out having an initial average weight 55.83 + 3.14 in a circular plastic pools (capacity 300 L). The six feeds were formulated with basic ingredients (Soybean meal, 35%; soluble starch, 29%; Casein, 19.5%; carboxy - methyl - cellulose, 2%; papain, 0.5%; vitamin and mineral mix, 4.0%) with iso-energetic (19.55 kJ/g, F1-F6) diets and results were compared with natural food fed fishes. Each diet was hand fed two times daily for 84-days to duplicate homogenous groups of 30 fish. The fishes fed with live chicken waste showed significantly poor results ($p > 0.05$) in terms of weight gain and Specific Growth Rate (SGR%) compared to the rest six treatments. The survival was recorded as 100% in all the treatments. Results showed that the growth performance significantly ($p < 0.05$) different with various lipid of animal and plant origin. At the end of the 84-days study the highest weight gain % was recorded in LINOL (F4) as 105.1%. For other treatment weight gain was recorded as 40.3%, 75.4%, 25.6%, 60.2%, 37.0%, and 44.1%for FISOL, BETAL, SOYAL, MIXOL, SATOL and NATFO respectively. The feed efficiency in terms of Feed Conversion Ratio (FCR) recorded as 2.46 to 3.22 among all the feeding trials. It could be concluded, based on the results of this trial, that a diet formulated with a gross energy of 19.55kJ/g is sufficient to promote better feed efficiency and growth performance in *C. batrachus* grow-out however, the best growth was recorded in linseed oil (LINOL) followed by BETAL and MIXOL.

Keywords: *Clarias batrachus*; Dietary lipids; Growth

Introduction

Air-breeding Catfish, *Clarias batrachus*, commonly known as Magur. It is commercially important and high market value fish. Feed management determines the viability of aquaculture as it accounts for at least 40-60% of the cost of fish production [1]. *Clarias batrachus,* is a promising species for aquaculture exploitation with its carnivorous feeding habits. In order to increase growth rate and deposition of energy nutrients in terms of flesh, besides the protein, the research towards the inclusion of cheaper lipid sources has to be studied towards increasing lipid/energy ratios in the diet. Suitable alternative energy nutrients such as oilseed by-products are the most promising sources of lipid and energy for aqua-feed in the future [2]. In aquaculture, dietary lipids play an important role in commercial diets as source of energy, essential fatty acids for growth and development of fish [3]. Fish oil is the major source of dietary lipids in aquaculture nutrition. Fish oil is produced from small marine pelagic fish and represents a finite fishery resource [4]. India have huge potential for the production of cheaper source of lipids from plant and animal origin e.g. beef tallow, Soybean oil, saturated oil etc., which can be utilized as source of lipid in carnivorous fish nutrition. Sarowar et al. [5] have studied the impacts of different diets on growth and survival of *Clarias batrachus* grow-outs. The present study was taken up to evaluate the utilization impact of various dietary lipids on the optimum growth in Magur (*Clarias batrachus*), at grow-out stage.

Materials and Methods

Experimental diets

Six semi-purified experimental diets were formulated to be iso-energetic (19.55 kJ/g, F1-F6) diets. Weighed dry ingredients and some water were poured into a mixer and the resulting dough processed in

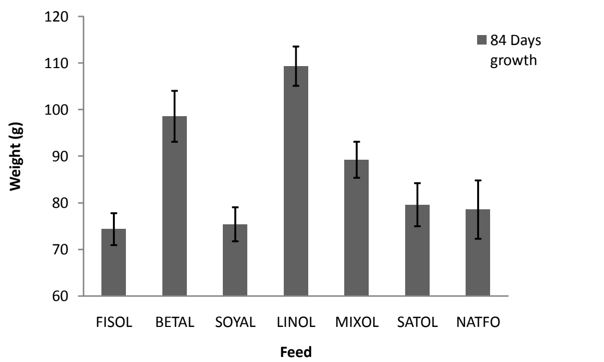

Figure 1: Growth performance of *Clarias batrachus* fed with different lipid sources in basal diet.

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Feed → Ingredients ↓	F-1 FISOL	F-2 BETAL	F-3 SOYAL	F-4 LINOL	F-5 MIXOL	F-6 SATOL	F-7 NATFO
Soybean meal	35.0	35.0	35.0	35.0	35.0	35.0	-
Starch Soluble	29.0	29.0	29.0	29.0	29.0	29.0	-
Casein	19.5	19.5	19.5	19.5	19.5	19.5	-
Carboxy Methyl Cellulose	2.0	2.0	2.0	2.0	2.0	2.0	-
Papain	0.5	0.5	0.5	0.5	0.5	0.5	-
Vitamin							
& Mineral Mix.	4.0	4.0	4.0	4.0	4.0	4.0	-
Fish Oil	10.0	-	-	-	2.5	-	-
Beef Tallow	-	10.0	-	-	2.5	-	-
Soybean Oil	-	-	10.0	-	2.5	-	
Linseed Oil	-	-	-	10.0	2.5	-	-
Saturated Oil	-	-	-	-	-	10.0	-
Live Fish/ Natural Food	-	-	-	-	-	-	100.0
FISOL = Fish Oil; BETAL = Beef Tallow; SOYAL = Soybean Oil; LINOL = Linseed Oil; MIXOL = Mixed Oil (Fish Oil : Beef Tallow : Soybean Oil : Linseed Oil :: 1 : 1 :1 :1 w/w) ; SATOL = Saturated Oil; NATFO = Natural Food							

Table 1: Ingredient composition (w/w) of feeds for *Clarias batrachus*.

a hand pelletizer to make 2 mm diameter pellets. Compounded feed pellets were dried in an oven at 60°C, packed separately and stored at -20°C until used during the feeding trial. The dietary treatments were designated as FISOL (Fish oil), BETAL (Beef tallow), SOYAL (Soybean oil), LINOL (Linseed oil), MIXOL and SATOL (Vegetable oil) containing lipid source @ 10% lipid source in all the five feeds except in MIXOL (containing FISOL, BETAL, SOYAL, LINOL in the ratio of 1: 1: 1: 1 w/w) and results are compared with natural food (NATFO). Table 1 gives the summary of ingredients used in the formulation of experimental diets and proximate composition of all dietary treatments.

Fish rearing and feeding trials

Clarias batrachus grow-outs were hatchery bred at National Bureau of Fish Genetic Resources (NBFGR), Lucknow and shifted to the wet laboratory. Fishes were acclimated to laboratory conditions in a 1500 L capacity Fibre Reinforced Plastic (FRP) tank, feeding on crumbled pelleted feed containing a minimum of 500 g per kg crude protein for one week. Further, fishes were accustomed to aerated, 300 L capacity plastic pools with two - thirds filled with water and covered with plastic covers. Four hundred twenty (Replicate 3 X Feed 7 X Fish 20) grow-out (Av. initial weight 55.83 + 3.14 g) were randomly sampled and distributed into 21 plastic pools (Feed 7 X Replicate 3 = 21 pools) containing about 200 L of water. During the experiment, the fishes were fed twice a day at 10:00 and 17:00 hours *ad libitum* per day. The weighing of fishes during and on termination of the experimentation was carried as determined by Hasan et al. [6]. All fish were starved for 24 h prior to weight measurements. Rearing pools were cleaned every second day and about half of the water was replaced with fresh bore-well water to reduce the nitrogenous waste accumulated. Fishes were weighed individually at the beginning and at the end of the experiment, whereas batch weighing per pool was carried out once every 2 weeks to monitor growth performance in terms of weight gain ratio alongside measuring feed consumption. At the end of the experiment after 12 weeks, surviving fishes were randomly grouped into three per tank and used to determine body indices and carcass proximate composition. Proximate compositions of feeds and fish carcasses were analyzed following Association of Official Analytical Chemists (AOAC) [7] methods. All samples were analysed in triplicate. Dry matter was estimated after drying in oven at 105°C for 24 hours; crude protein (N x 6.25) by the Kjeldahl method after acid digestion; Crude lipid by di-ethyl ether extraction method using Soxhlet apparatus.

Feed performance was evaluated on the basis of Specific growth rate = {[(loge final body weight-loge initial body weight)/time] x 100}, food conversion ratio= (dry food intake/live weight gain), average daily gain = (growth/experiment duration), survival rate = [(initial no. of Fishes/final no. Fishes) x 100] and weight gain (%) = {[(final weight - initial weight)/initial weight] x 100}. Variations in weight gain (%), SGR, FCR, PER after feeding of the test diets were analyzed by one-way ANOVA and Tukey's multiple range test and their mean differences by Least Significant Differences (LSD). Duncan's multiple Range test was used to determine which treatment means differed significantly ($P < 0.05$) using SPSS version 16.0. Water analyses were carried out following methods APHA [8].

Results

Various water quality parameters (HIMEDIA Kit): water temperature, pH and Dissolved Oxygen (DO), total alkalinity were observed and found to be least affected by different treatment feeds. The values of all the parameters of ambient water, i.e. temperature, pH, DO and alkalinity were almost similar for all the feeding treatments during the experimental period and were well within the optimal range. The water quality recorded for water temperature, pH, dissolved oxygen and total alkalinity as 24 + 2°C, 6.8 - 7.6, 6.8 - 7.5 ppm and 136 – 139 ppm, respectively.

During the feeding trial, the fishes readily accepted the diets, and survival rates were 100% in all the feeding trials. The growth responses under different treatments are given in Table 2 and 3 and Figure 1. Initial body weight of the various dietary groups did not vary significantly, but the performances were significantly different ($p < 0.05$) in terms of weight gain, SGR, FCR, PI and survival %. At the end of the 84-days study the weight gain was recorded as 74.34 ± 3.43g, 98.56 ± 5.47g, 75.38 ± 3.65g, 109.33 ± 4.22g, 89.23 ± 3.87g, 79.59 ± 4.62g and 78.54 ± 6.26g for FISOL, BETAL, SOYAL, LINOL, MIXOL, SATOL and NATFO respectively. The highest growth recorded in LINOL followed by BETAL, MIXOL. The SGR, FCR and PI ranged between 0.12 to 0.37 %, 2.46 to 3.22 and 0.18 to 0.67 respectively. Results are shown in Table 3. The proximate composition of fish flesh is shown in Table - 4. HSI

Feed	In weight (g)	Fn weight (g)	Weight gain (g)	% Weight gain
F1 (FISOL)	53.00 ± 3.10^a	74.34 ± 3.43^d	21.34	40.3
F2 (BETAL)	56.20 ± 2.50^a	98.56 ± 5.47^e	42.36	75.4
F3 (SOYAL)	60.00 ± 2.80^b	75.38 ± 3.65^d	15.38	25.6
F4 (LINOL)	53.30 ± 3.60^a	109.33 ± 4.22^c	56.03	105.1
F5 (MIXOL)	55.70 ± 4.10^a	89.23 ± 3.87^b	33.53	60.2
F6 (SATOL)	58.10 ± 3.90^b	79.59 ± 4.62^a	21.49	37.0
F7 (NATFO)	54.50 ± 2.00^a	78.54 ± 6.26^a	24.04	44.1

Means in a given column having the same letter superscript are not significantly different at ($p < 0.05$) by ANOVA and Duncan multiple range test.

Table 2: Initial and final weights and lengths, weight gain and percent weight gain of the *C. batrachus* grow-out of different treatments during 84 days experimental period.

Feed	In weight (g)	Fn weight (g)	SGR %	FCR	PI (g)	Survival %
F1 (FISOL)	SGR %	FCR	PI (g)	Survival %		
F2 (BETAL)	56.20 ± 2.50^a	98.56 ± 5.47^e	0.29	2.68	0.50	100
F3 (SOYAL)	60.00 ± 2.80^b	75.38 ± 3.65^d	0.12	3.22	0.18	100
F4 (LINOL)	53.30 ± 3.60^a	109.33 ± 4.22^c	0.37	2.46	0.67	100
F5 (MIXOL)	55.70 ± 4.10^a	89.23 ± 3.87^b	0.24	2.91	0.40	100
F6 (SATOL)	58.10 ± 3.90^b	79.59 ± 4.62^a	0.16	3.10	0.26	100
F7 (NATFO)	54.50 ± 2.00^a	78.54 ± 6.26^a	0.19	2.52	0.29	100

Means in a given column having the same letter superscript are not significantly different at ($p < 0.05$) by ANOVA and Duncan's multiple range test

Table 3: Average Initial and final weight, specific growth rate (SGR), food conversion ratio (FCR), Per day Increment (PI) and survival rate (%) of *C. batrachus* grow-outs fed various experimental diets for 84 days.

Parameters (g.100g^{-1} DM)*	In Values	F1 (FISOL)	F2 (BETAL)	F3 (SOYAL)	F4 (LINOL)	F5 (MIXOL)	F6 (SATOL)	F7 (NATFO)
Moisture (Wet wt. basis)	78.1 + 2.3^b	76.4 + 5.2^b	74.1 + 3.1^a	73.5 + 6.2^a	74.5 + 4.2^a	72.6 + 1.9^a	73.8 + 6.1^a	74.4 + 4.2^a
Crude Fat*	7.2 + 0.5^a	8.1 + 0.4^b	8.9 + 0.2^c	8.1 + 0.6^b	8.0 + 0.2^b	7.9 + 0.3^b	8.0 + 0.5^b	7.0 + 0.2^a
Crude Protein*	60.1 + 4.5^a	62.3 + 4.1^a	65.1 + 2.3^b	64.7 + 1.5^b	64.2 + 1.3^b	66.0 + 2.6^b	63.2 + 2.1^a	63.8 + 3.1^a
Dry Matter*	21.4 + 6.1^b	22.2 + 3.1^b	23.8 + 4.1^a	25.7 + 2.8^a	24.3 + 4.4^a	25.4 + 5.1^a	24.2 + 3.8^a	24.2 + 1.8^a
HSI	1.9 + 0.3^a	1.8 + 0.09^a	1.9 + 0.1^a	2.1 + 0.4^b	2.0 + 0.2^b	2.1 + 0.3^b	1.9 + 0.2^a	1.8 + 0.3^a
VSI	2.7 + 0.2^d	2.9 + 0.3^d	3.2 + 0.1^c	3.4 + 0.2^a	3.5 + 0.4^a	3.8 + 0.4^B	3.3 + 0.3^a	3.5 + 0.6^a

Mean Values in same period with different superscript letters are significantly different ($p < 0.05$). HIS= Hepatosomatic index; VSI= Viscerosomatic index.

Table 4: Whole body proximate composition (g.100g^{-1} DM*) and indices of *Clarias batrachus* grow-out fed with feeds containing different lipids for twelve week.

and VSI ranged between 1.8 ± 0.09 to 2.1 ± 0.4 and 2.7 ± 0.2 to 3.8 ± 0.4 respectively.

Discussion

In general, fishes utilize dietary lipid poorly. For instance, Furuichi and Yone [9] noted depressed growth and feeding efficiency in red sea bream, *Pagrus major*, and common carp, *Cyprinus carpio* fed diets with high carbohydrate and low lipid contents. The optimum level of dietary nutrients should enhance maximum growth and feed efficiency [10] and so the decrease weight gain and the specific growth rate may due to higher energy content and high carbohydrate and lipid content in the diets [11]. An inverse relationship between growth and dietary lipid/ energy was reported by Daniels and Robinson [12] in juvenile red drum, *Sciaenops ocellatus*. Knowledge of the optimal level of protein and protein-sparing effects of non-protein nutrients such as lipids and carbohydrate can be used effectively in reducing feed costs [7]. Lin et al. [13] reported that better SGR may have partly resulted from better carbohydrate and lipid utilization by Magur grow-out feeding strategy and carbohydrate source. Furthermore, Magur grow-outs tended to be fatter indicating that they may be able to better utilize lipids for growth. The better lipid utilization by Magur grow-outs may be related to differences of their natural diets. Magur is carnivorous in nature [14] and it mainly feeds on a carnivore diet containing some carbohydrates during the grow-out stages, mainly on zooplankton [15], which contains little digestible lipid and carbohydrates. Our SGR values are comparable with those values of De Silva et al. [16]. Although the carcass protein, carbohydrate, and lipid contents increased after feeding the test diet, there was no appreciable change in body composition of the following treatments.

Lipids are a concentrated and highly digestible source of energy [17] and favoured over carbohydrate as an energy source [18,19]. The control diet was devoid of lipids and so the proteins might have been used for energy production and not for growth.

Deposition of high lipid contents in the fishes fed higher amounts of lipid may be due to the availability of sufficient energy in those diets [20]. Fatty carcasses of fishes at higher dietary lipid and carbohydrate levels were also reported by Wee and Ng [18]. Inversely, higher amounts of dietary carbohydrate usually retard growth [21]. The requirements of dietary lipid vary among different species according to their mode and habits of feeding. Lin et al. [13] reported that the capacity to utilize different lipid sources varies among fishes species. Tilapia [22], yellow tail [23] and channel catfishes [24] grew better when fed a lipid with enriched carbohydrate diet. On the other hand, there was no significant difference in net weight gain between lipid and starch fed white sturgeon [25]. According to the researchers the air breathing did not intake the purified diets [26,27]. The best growth performance and feed utilization was gained in LINOL followed by BETAL, MIXOL, SATOL groups and the decline in growth in the FISOL and feed utilization with different dietary lipid above this level was observed in present study. Similar results have been reported in turbot [28,29], salmon [30], rainbow trout [31], Carp [32]. However, some reports showed no effect of dietary lipid on body weight gain in juvenile turbot [33] and Atlantic halibut [34]. Martino et al. [35] reported in Surubim, a carnivorous freshwater fish in Brazil, that fish weight gain increased with dietary lipid from 60 to 180 g per kg. Although many species like salmonids, sea bass or rainbow trout, where a protein sparing effect of lipids has been well demonstrated [36- 39], an increase in dietary lipid level from 40 to 120 g per kg does not appear to improve protein utilization in grass carp with no clear protein sparing effect of dietary lipid. Peres & Oliva-Teles [40] believed this lack of protein sparing effect by dietary lipid may be related to the high protein level of the diet and according to Dias et al. [39], the beneficial effects of an increase of the lipid level from 100 to 180 g per kg in sea bass diets were significant only with a low protein diet, but not with a high protein diet. But in the present study, although the dietary protein content was relatively high, when lipid level was below 40 g per kg, the protein utilization increased with the lipid level. This suggests, even in high protein diets, the protein sparing effect by lipid is possible within a low upper limit. This was further proved by the lowest protein retention in the lipid-free diet group. The significant decreased lipid retention with the increased dietary lipid levels, suggest an increased proportion of lipid used for energy. This agrees with Cho & Watanabe [41] who observed in rainbow trout, that the highest lipid diet did not promote the highest lipid retention. Peres & Oliva-Teles [40] also reported decreasing lipid retention when dietary lipid increased from 120 to 300 g per kg. Lipid utilization demonstrated by Akand et al. [42] for stinging catfishes, *H. fossilis*: by Hasan et al. [6] for Asian catfishes, *Clarias batrachus*: by Hasan et al. [43] for Indian major carps and by Habib et al. [17] for *Puntius gonionotus*. The relationship of body lipid content with protein and moisture contents is a common phenomenon in fishes, and our results are comparable to those of Stansby and Olcott [44]. Based on the results of the present investigation, it is estimated that types of lipid effects on the growth performance of the grow-outs of *Clarias batrachus* however, the best growth recorded in linseed oil fed fishes followed by tallow rich feeds.

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