

Replacement of fish meal by pangas (*Pangasianodon hypophthalmus*) industry waste in the diet of Indian major carps in growth performance study

Md Ismail Hossain, Fatema Hoque Shikha*, Pami Adhikari, Prianka Jahan

Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh

Abstract

As protein source, fish meal often used in fish feed though among different ingredients it is the expensive one. Pangas waste of fish processing industries mostly discarded or sold in very cheaper prize which can be used as a replacement of fish meal in fish feed formulation. An experiment was conducted to reveal the utilization of pangas industry waste in supplementary diets of Indian major carp's in pond system. To assess the effect of formulated feed, two types of diet namely Diet-2 (formulated feed with pangas industry waste), Diet-3 (formulated feed with plants source ingredients) were prepared while Diet-1 (commercial feed) was purchased from the market and assigned to three treatments viz. T2, T3 and T1. Protein percentage of diets were 30.84% (Diet-2), 28.13% (Diet-1) and 27.32% (Diet-3). The results of the study showed that, the highest weight gain was obtained in *Labeo rohita* (190.62 ± 1.80 g), *Gibelion catla* (202.46 ± 1.84 g) and *Cirrhinus cirrhosus* (101.98 ± 1.25 g) with Diet-1 and with Diet-2 the weight gain of the fishes were 170.68 ± 1.28 g, 196.87 ± 1.82 g and 90.83 ± 1.53 g, respectively. The highest net production of these fishes were estimated 3849.72 kg/ha for Diet-1 followed by Diet-2 (3179.13 kg/ha) and Diet-3 (2997.04 kg/ha). The cost of each kilogram of Diet-2, Diet-3 and Diet-1 were 33.58 BDT, 38.45 BDT and 41.95 BDT, respectively. As the obtained results showed that, feed formulation cost of Diet-2 is lesser than other two diets and growth performance also closer to the commercial diet (Diet-1) therefore, pangas waste can be used in the diets of Indian major carps along with other available feed ingredients in replacement of fish meal as used in Diet-1 (commercial diet).

Keywords: pangas industry waste, replacement of fish meal, Indian major carps

Introduction

Fish meal is a high quality protein source considered indispensable in fish diet because of its superior profile of indispensable amino acids and its value as an attractant. Fishmeal is the most expensive ingredient in formulated feeds and although research is ongoing on the evaluation of alternative and cheaper ingredients [1, 2]. Soybean meal (SBM) has been considered the best protein source to replace fishmeal, due to its wide availability and consistent quality. Despite of its low contents of essential amino acids, plant proteins may contain antinutritional compounds which may affect fish growth [3, 4, 5, 6]. Fish nutritionists, however, sought for alternative protein sources to replace fish meal partially or totally with inexpensive plant and animal sources that are available [7, 8].

In recent years pangas has become one of the most popular commercial species in Bangladesh. The commercialization of pangas culture and processing has lead to profitable venture. Expansion of pangas processing industry has resulted in increased discharge of waste. Waste reduction to zero waste is essential for friendly environment and human health [9]. Pangas fish processing is concerned with proper waste management and with adding value to fish products.

Freshwater aquaculture comprises mainly pond aquaculture especially the polyculture of both native and exotic species. Polyculture is the most common practice of carp culture [10]. For better utilization of different strata and zones of a pond, three or more species must be stocked together. Provision of feed enhances the fish production significantly and production levels of 4-8 tons/ha/year are obtained using a judicious combination of both the feed and fertilizers.

The goal of the present research was to evaluate the growth

performances of finfish such as Indian major carps (*Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus*) in polyculture system. Feed formulated by pangas waste along with different low cost feed ingredients were used in replacement of fish meal.

Materials and methods

Place of the study

The present study was carried out at the ponds of Faculty of Fisheries, Bangladesh Agricultural University.

Selection and collection of fishes

For growth performance study, Indian major carps (*Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus*) were selected and cultured in the experimental ponds of Faculty of Fisheries. Fish fingerlings were collected from the hatchery of Bangladesh Fisheries Research Institute, Mymensingh.

Selection and collection of feed ingredients

To carry out the experiment the selected feed ingredients were collected from local market. Different types of feed ingredients such as rice bran, maize, soybean, wheat bran, molasses, vitamins and minerals premix were purchased from local market of Mymensingh. The main ingredient pangas industry waste (skin, fat, bladder, bone and stomach) were collected from 7-Ocean fish processing industry situated at Trishal, Mymensingh.

Diet formulation and preparation

For performing this experiment, the commercial feed (Diet-1) was used as control and purchased from the local market

and other two types of diets such as Diet-2 (formulated feed with pangas industry waste) and Diet-3 (formulated feed without pangas industry waste/formulated feed with plant ingredients), were prepared in the laboratory.

Preparation of Diet-2 (formulated feed with pangas industry waste)

Table-I shows the ingredients of Diet-2 and Diet-3, used in the present experiment. Diet-2 was prepared by using pangas industry waste and other ingredients which were brought from the local market. The collected wastes were first washed, dried under the sunlight and milled. The selected ingredients were mixed thoroughly. Mixing of ingredients was performed by hand before adding water with stirring to form dough. Finally, mixture made into pellets using a pellet machine. The pellets were sundried. The dried pellets were packed in air-tight water impermeable bags and stored in dry and cool place. The flow diagram of the preparation procedure of Diet-2 is shown in Plate 1.

The supplementary Diet-3 was formulated in the laboratory without using pangas waste (Table 1). All ingredients (except pangas waste) were weighed accordingly. As in

Diet-3, pangas waste was not used, therefore to make the total volume 100, the other ingredients (soybean meal, rice bran, wheat bran, maize etc.) were used in increased amount. Measured ingredients were mixed thoroughly in desired proportions. Pellets were prepared using a mechanical hand pelletizer machine with a 2 mm diameter grid. The formulation protocol of Diet-3 was similar as followed for Diet-2.

Table 1: Ingredients and their amounts used for preparing Diet-2 (formulated feed with pangas waste) and Diet-3 (formulated feed without pangas waste)

Feed ingredients	Percentage of Ingredients	
	Diet-2	Diet 3
Pangas industry waste	40.00	-
Soybean meal	24.00	48.00
Rice bran	10.00	12.00
Wheat bran	10.00	12.00
Maize	13.00	25.00
Molasses	2.00	2.00
Vitamin & mineral mix	0.40	0.50
Salt	0.60	0.50
Total	100.00	100.00



Fig 1: Flow diagram for preparation of Diet-2 (Formulated feed with pangas waste) and other two Diets (where, a-rice bran; b-dried powder of pangas processing waste; c-mixing of ingredients; d- addition of water to the ingredients; e-paste of ingredients; f-ingredients in mincer; g-fed pellet preparation; h-drying of feed pellets; i-Diet-2 (diet with pangas waste); j-Diet-3 (diet without pangas waste); k-Diet-1 (commercial diet)

Commercial diet

Commercial diet (Diet-1) was used in this experiment as a control (Diet-1). It was purchased from the distributor of Krishibid Feed Limited which particularly known as Mega Feed Limited.

Diet management and feeding rates

At the rate of 5% of fish body weight, the feed was supplied in the pond for experimental carp fishes, daily for the first month. Then the feeding rate gradually reduced to 4.5% in the next two weeks and 4% in last two weeks. Feeding rates were adjusted on the basis of fish weight gain on sampling at 10 days interval. The daily ration was divided into two parts. About half of the ration was applied in the morning between 8.30 to 9.30 am and another half in the afternoon

between 4:00 to 5:30 pm.

Sampling of fish and water quality parameters

Sampling of fishes was done at each 10 days of interval to observe the growth of fish and to adjust the feeding rate. Weight of fish was measured by using an electronic balance. Some important water quality parameters such as water temperature (°C), dissolved oxygen (mg/l) and pH were measured during the periods of sampling. The sample collection was done between 8.30 to 9.30 am.

Parameters of quality assessment

Following the methods of the Association of Official Analytical Chemists [11] proximate composition of all individual feed ingredients and prepared feeds of those

ingredients were analyzed in the Fish Processing Laboratory of the Department of Fisheries Technology, BAU with slight modification.

Weight Gain (WG), Survival Rate (SR) and Food Conversion Ratio (FCR) of experimental fishes were measured using the following formulae [12]:

- Weight gain (WG, %) = $100 \times [(final\ weight\ (g) - initial\ weight\ (g)) / initial\ weight\ (g)]$
- Survival rate (SR, %) = $(Final\ no.\ of\ fish / initial\ no.\ of\ fish) \times 100$
- Feed conversion ratio (FCR) = $dry\ feed\ intake\ (g) / [final\ body\ weight\ (g) - initial\ body\ weight\ (g)]$
- On the other hand, Specific Growth Rate (SGR) and Protein Efficiency Ratio (PER) were measured using the following formulae [13].
- Specific growth rate (SGR, % day⁻¹) = $100 \times (\ln W_f - \ln W_i) / t$
- Protein efficiency ratio (PER) = $(W_f - W_i) / D$

Where, W_f and W_i are final and initial weights (g), t is the experimental duration (day) and D is crude protein intake.

Data analysis

Data obtained from the present study were analyzed to assess the composition of different feed ingredients and prepared diets. Data was entered into the MS Excel and simple statistics such as range, mean, standard deviation were done.

Results and Discussion

Proximate composition of experimental diets

The proximate composition of different experimental diets including the control (commercial feed) were analyzed which is shown in Table 2 (percent carbohydrate and fiber contents in diets were not calculated, thus are not presented in the table). There was a slight variation in protein, lipid, ash and moisture content of different diets. The protein content of different diets varied between 28.92% to 32.84% and the Diet-2 contain the highest value (32.84%). The lipid content varied between 5.65% to 12.53% while the highest lipid content (12.53%) found in Diet-2 and the lowest lipid content (5.65%) was found in Diet-1. The highest ash content (12.83%) was found in Diet-2 and lowest ash content (10.17%) was found in Diet-1. The moisture content also varied in diets from 8.21% to 11.31%.

Table 2: Percent (%) Moisture, Crude protein, Lipid and Ash contents of the experimental diets

Contents (%) in Diets	Treatments		
	Diet 1	Diet 2	Diet 3
Moisture	11.31	8.21	10.52
Crude Protein	28.92	32.84	29.63
Lipid	5.65	12.53	5.89
Ash	10.17	12.83	11.53

Protein is the major growth promoting factor in feed. The protein requirement of fish is influenced by various factors such as water temperature, feeding rate, availability and quality of natural foods. In the recent years on the basis of nutrition in freshwater aquaculture have led to the

development of new feed formulations for Indian carp [14, 15]. It was reported that, the proximate composition of factory made feeds are to be 20-30 percent protein, 2-4 percent lipid, 10-15 percent fibre, 30-40 percent carbohydrate and 8-10 percent ash and often are claimed to have been enriched with lysine, methionine, vitamins and minerals [16]. In recent years, feeds from plant origin also have been accepted for Indian major carps as the growth of fishes has been reported to be as good as the traditional feed [17]. It was also reported that, diet containing 40% protein, 9.31% lipid and 10.08% carbohydrate is the best one for a more profitable and successful culture of the Common carp [18]. Those former studies are in agreement with the obtained values of the present study [19]. Usually fish growth will be directly proportional to the level within the range of approximately 20 to 40% crude protein. In terms of growth, food conversion ratio, protein efficiency ratio, survival rate and ratios of protein and lipid deposition in muscle, diet containing 30% protein level revealed a significantly ($p < 0.01$) better performance for the *Labeo rohita* in comparison with other diets containing lower or higher protein levels [20]. The growth performance of rohu and catla was improved by alternating the feeding schedules between high and low protein diets [21]. In diet 30% incorporated protein resulted better results with respect of growth and SGR for *Cyprinus carpio* Var. *Nudus* and *Puntius gonionotus* respectively [22, 23] which is similar with present study. The earlier reports on *Ictalurus punctatus* [24], *Salmo gairdnerii* [25], *Sciaenops ocellatus* [26] indicated 6 to 11% dietary lipid level considered as optimum for fish growth. The present study result confirms that, the lipid content of larvae and fingerling feed should be around 6 to 15%, the oil content would be increased until it reaches 12-15% according to the species and size of the fish [27].

The protein content of three different diets matched with the suggestion that, herbivorous and omnivorous fish require a diet with 25-35% crude protein [28, 29]. It was reported that, growth and production in fish culture are generally dependent on the daily feed consumption, qualities of feed and feeding frequency. The growth of carp (*Cyprinus carpio*) increases with protein levels and there was an approximately linear increase of growth with feeding level for any given diet [30].

Water quality parameters

The mean value of the temperature measured during the study period, in different treatments ranged from 26.5°C to 29.3°C (Table 3).

The minimum temperature (26.5°C) and the maximum temperature (29.3°C) were observed in March and May, respectively in pond 3. During the experimental period, the mean value of the DO (mg/l) in the different treatments ranged from 3.48 mg/l to 5.32 mg/l (Table 3). The highest DO concentration (5.32 mg/l) and the lowest DO concentration (3.48 mg/l) were observed in pond 3 on March and May, respectively. The mean value of pH of sub-surface water in the experimental ponds during the study periods varied from 6.73 to 8.21 (Table 3). The highest pH value 8.21 was recorded in pond 2 on May and the lowest value 6.73 was observed in pond 1 on March.

Table 3: Monthly variation in the ranges and mean value of water temperature (°C), dissolved oxygen (DO, mg/l) and pH in different experimental ponds

Parameter	Months	Treatments		
		Pond 1 (Mean ± SD)	Pond 2 (Mean ± SD)	Pond 3 (Mean ± SD)
Temperature (°C)	April	26.9 - 28.7 (27.4 ± 0.92)	26.5 - 29.2 (27.4 ± 0.18)	26.5 - 28.6 (27.4 ± 0.99)
	May	27.5 - 28.6 (28.1 ± 0.88)	26.7 - 29.2 (28.1 ± 1.15)	27.2 - 28.8 (28 ± 0.75)
	June	27.4 - 28.8 (28.1 ± 0.65)	27.2 - 29.3 (28.2 ± 1.01)	27.2 - 28.8 (27.8 ± 0.79)
Dissolved Oxygen (DO, mg/l)	April	3.67 - 5.15 (3.86 ± 0.30)	3.94 - 5.32 (4.78 ± 0.61)	3.56 - 5.21 (4.57 ± 0.71)
	May	3.65 - 4.21 (3.85 ± 0.30)	3.55 - 4.84 (4.05 ± 0.67)	3.65 - 4.91 (4.23 ± 0.63)
	June	3.65 - 4.54 (4.02 ± 0.44)	3.48 - 4.71 (4.12 ± 0.61)	3.57 - 4.68 (4.18 ± 0.56)
pH	April	7.67 - 8.12 (7.87 ± 0.21)	7.56 - 7.91 (7.77 ± 0.15)	7.34 - 8.12 (7.67 ± 0.32)
	May	7.68 - 7.87 (7.78 ± 0.09)	7.68 - 7.89 (7.78 ± 0.11)	7.78 - 7.91 (7.83 ± 0.06)
	June	7.87 - 8.21 (8.01 ± 0.15)	7.76 - 7.87 (7.81 ± 0.05)	7.79 - 8.11 (7.92 ± 0.16)

Temperature plays significant role in fish production. It was reported that, the range of water temperature from 26.06 to 31.97°C is suitable for fish culture^[31]. Some researcher reported, the range of surface water temperature from 30.2 to 34°C in polyculture of Indian and Chinese carps^[32,33,34,35]. It was observed that, food intake increases with the increase in temperature up to optimum levels as the energy requirement for maintenance increases. Ideal temperature range for different cold water and warm water species are 14-18°C and 24-30°C respectively^[36]. Indian major carps can tolerate temperature ranging from 10 to 37.8°C^[37]. During study on the diurnal variations in physico-chemical factors and zooplankton in a freshwater pond temperature ranged from 20.5 to 30.5°C^[38]. In a study on the development of low-cost feed for culture of giant freshwater prawn (*Macrobrachium rosenbergii* de Man) in ponds water temperature ranged from 26.0 to 32.4°C which is more or less similar of the present study^[39].

The dissolved oxygen content fluctuated due to photosynthesis process in pond and respiration of the fish. Oxygen consumption varies with different factors such as species, size, activity, season and temperature. It was reported that, cyprinids require 6-7 mg/l oxygen for better growth, but the tolerance level is as low as 3 mg/l for concise periods. It was also reported that, concentration of oxygen above 5 mg/l is indicative of productivity^[40].^[35] Researchers recorded the range of dissolved oxygen in nine ponds of BAU campus, Mymensingh from 2.2 to 7.1 mg/l. Another researcher considered 5.0 to 7.0 mg/l of dissolved oxygen content of water is fair or good in respect of productivity^[41]. The observation of the present study is more or less agreed with the previous findings.

The pH of water is a measure of hydrogen ion concentration and indicator of the water quality (acidic or basic). A good relationship between pH of pond water and fish culture was found and obtained satisfactory results at pH 6.5 to 9.0^[39]. It was reported that, pH 5 to 8 is good for fish culture^[42]. Some researchers reported that, the water having a pH range of 6.5-9.0 is more suitable for fish culture and values above 9.5 are unsuitable. They also suggested that, a pH range of 6.12-8.6 is most suitable for survival of the Indian major carp fry^[43]. Another researcher suggested that, neutral to slightly alkaline pH has been found to be most favorable for fish ponds^[44]. Mean pH values found during the present study throughout the experimental period in different treatments were in the suitable range for carp culture.

Growth performance of experimental fishes

Growth performance of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments in terms of weight gain, (%) weight gain, weight increment in every 10 days, FCR, PER were calculated.

Mean weight gain (g)

The weight gain of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* during experimental period in different treatments was significantly different.

The highest weight gain in *Labeo rohita* (190.62 g), *Gibelion catla* (202.46 g) and *Cirrhinus cirrhosus* (101.98 g) was found for Diet 1.

The lowest weight gain among these three treatments was found for Diet 3. The weight gain for Diet 2 is average compared with Diet 1. The mean weight gain is shown in Table 4.

Table 4: Mean weight gain (g) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in three different treatments for a period of three months

Species	Treatments		
	Diet 1 (Mean±SD)	Diet 2 (Mean±SD)	Diet 3 (Mean±SD)
<i>Labeo rohita</i>	190.62 ± 1.80 ^a	170.68 ± 1.28 ^b	140.99 ± 1.63 ^c
<i>Gibelion catla</i>	202.46 ± 1.84 ^a	196.87 ± 1.82 ^b	191.52 ± 1.81 ^c
<i>Cirrhinus cirrhosus</i>	101.98 ± 1.25 ^a	90.83 ± 1.53 ^b	72.39 ± 1.25 ^c

S.N: The values in the same rows having similar letter (s) do not differ significantly otherwise differ significantly (p<0.05) as per Duncan Multiple Range Test (DMRT).

Present study revealed that, the weight gain of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments ranged from 140.99g to 190.62g, 191.52g to 202.46g and 72.39g to 101.98g respectively during the three months of study period. In a study, researchers found that, the weight of catla, rohu, silver carp and grass carp varied between 187.22 and 267.55 g in polyculture system during

rearing period of 5 months^[45] which is slightly higher than the present study. Another group of researchers found the initial average weights 282g, 293g and 225g for *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and final average weight 349g, 353g and 289g^[46] which is not similar with present findings. One researcher observed the weight gain of rohu, catla and mrigal varied from 143g to 207g, 425g to 689g

and 82.5g to 253.91g in polyculture and integrated culture system [47], which is in between the range obtained for rohu and mrigal in the present study. For catla the range is very higher than the present study. Another researcher found a variation in weight gain for rohu from 118.97g to 125.42g in three months of study period [48] which is more or less

Similar with the obtained value in the present study.

Weight increment (g) of experimental fishes

The highest weight increment of the experimental fishes was found for Diet-1 and the lowest increment was found for Diet-3 which is shown in the Table 5.

Table 5: Weight increment (g) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments during the experimental period

Weight Increment of <i>Labeo rohita</i>									
Treatments	Time (Days)								
	10	20	30	40	50	60	70	80	90
Diet 1 (T ₁)	12.76	13.89	15.61	17.83	18.55	19.97	21.28	22.56	23.61
Diet 2 (T ₂)	11.67	12.76	14.88	16.15	17.35	18.92	19.88	21.15	22.53
Diet 3 (T ₃)	10.32	11.47	13.45	15.47	16.97	17.78	18.28	18.98	19.67
Weight Increment of <i>Gibelion catla</i>									
Treatments	Time (Days)								
	10	20	30	40	50	60	70	80	90
Diet 1 (T ₁)	17.35	18.73	19.74	20.56	21.37	22.89	23.76	24.77	25.79
Diet 2 (T ₂)	15.44	15.76	16.59	17.88	19.54	20.65	21.39	22.33	23.57
Diet 3 (T ₃)	12.27	14.23	16.65	17.87	18.69	18.97	19.43	19.88	20.35
Weight Increment of <i>Cirrhinus cirrhosus</i>									
Treatments	Time (Days)								
	10	20	30	40	50	60	70	80	90
Diet 1 (T ₁)	9.28	10.62	10.84	11.16	11.47	11.78	12.18	12.67	13.78
Diet 2 (T ₂)	7.43	7.89	8.74	9.15	9.89	10.43	10.78	11.55	12.46
Diet 3 (T ₃)	4.51	5.69	6.64	7.25	8.46	8.79	8.93	9.52	10.34

One group of researchers found the daily weight gain of catla, rui and mrigal 0.53g to 0.70g, 0.38g to 0.57g and 0.39g to 0.93g [49] which differ with the results of the present study.

The daily weight gain of catla, rui and mrigal were reported 2.57g to 3.44g, 2.08g to 2.75g and 2.53g to 3.21g respectively by one researcher [50] in BAU campus which is more or less similar with the present study. The weight gain of rohu, catla, mrigal and sharpunti fry were found 43.63 g, 73.44 g, 57.99 g and 51.99 g respectively by another researcher [51] which is higher than the present study.

3.3.3 Percent (%) weight gain

The significantly highest percent weight gain was obtained with *Labeo rohita* (1035.08%), *Gibelion catla* (968.62%) and *Cirrhinus cirrhosus* (991.56%) for Diet 1 (commercial feed). The nearly higher percent weight gain was found with Diet 2 (formulated diet with pangus waste). Clear difference in percent weight gain was found with *Gibelion catla* among the three treatments. In case of *Labeo rohita* and *Cirrhinus cirrhosus* for Diet 1 and Diet 2 observed no significance variation. The values of percent weight gain in different treatments were presented in Table 6.

Table 6: Percent (%) weight gain of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments during the experimental period

Species	Treatments		
	Diet 1	Diet 2	Diet 3
<i>Labeo rohita</i>	1035.08 ± 8.54 ^a	890.65 ± 9.37 ^b	865.75 ± 7.36 ^b
<i>Gibelion catla</i>	968.62 ± 8.37 ^a	861.47 ± 6.95 ^b	766.88 ± 6.24 ^c
<i>Cirrhinus cirrhosus</i>	991.56 ± 7.95 ^a	837.09 ± 6.56 ^b	815.65 ± 6.17 ^b

S.N: The values in the same rows having similar letter (s) do not differ significantly otherwise differ significantly (p<0.05) as per Duncan Multiple Range Test (DMRT)

The result of weight gain (%) obtained in the present study is more or less similar with a literature available on the weight gain (%) of Indian major carps. The percent weight gain for *Gibelion catla*, *Labeo rohita* and *Cirrhinus cirrhosus* were 1879, 1215 and 907 while reared in a semi-intensive pond for a period of 120 days and 704, 902 and 731 respectively for the same species of fishes collected from riverine source [52]. In different treatments of their study, the highest weight gain (%) was found for *Gibelion catla*, which is similar to the findings of other researchers [53].

Specific growth rate (SGR, %/day)

The specific growth rate (SGR, %/day) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments ranged from 2.45% to 2.72%, 2.41% to 2.68% and 2.52% to 2.69% respectively.

The significantly highest SGR value was obtained in *Labeo rohita* (2.72%/day), *Gibelion catla* (2.68%/day) and *Cirrhinus cirrhosus* (2.69%/day) for Diet 1. SGR (%/day) of *Labeo rohita* and *Cirrhinus cirrhosus* in Diet 2 and Diet 3 showed no significant.

Difference with *Labeo rohita* and *Cirrhinus cirrhosus* but *Gibelion catla* showed significant variation. The specific growth rate (%/day) of different treatments is presented in Table 7.

Table 7: Specific growth rate (SGR, %/day) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments during the experimental period

Species	Treatments		
	Diet 1	Diet 2	Diet 3
<i>Labeo rohita</i>	2.72 ± 0.01 ^a	2.61 ± 0.02 ^b	2.45 ± 0.04 ^b
<i>Gibelion catla</i>	2.68 ± 0.02 ^a	2.54 ± 0.01 ^b	2.41 ± 0.01 ^c
<i>Cirrhinus cirrhosus</i>	2.69 ± 0.03 ^a	2.53 ± 0.03 ^b	2.52 ± 0.03 ^b

S.N: The values in the same rows having similar letter (s) do not differ significantly otherwise differ significantly (p<0.05) as per Duncan Multiple Range Test (DMRT)

Some researchers reported the mean SGR (%/day) of catla, silver carp and golda in different treatments 1.19 to 1.21%, 1.26 to 1.40% and 1.99 to 2.07% respectively [54] while other researchers reported the mean SGR (%/day) of catla, rohu, mrigal and mahseer in different treatments under polyculture system 1.09 to 1.12%, 1.13 to 1.14%, 1.10 to 1.12% and 1.15 to 1.16% respectively [55]. SGR (%/day) of catla, rui and mrigal varied from 1.34 to 1.62%, 1.66 to 1.89% and 2.51 to 2.68% respectively in the experiment of another researcher [47]. The calculated SGR (%/day) value of the fishes in the present study is higher than the findings mentioned above, which might be due to the differences in time and location of experiment. SGR (%/day) value of *Labeo rohita* fingerlings ranged between 3.11 to 12.21%/day in different treatments of an experiment [53], which is higher than the values obtained in the present study.

Feed conversion ratio (FCR)

Mean feed conversion ratio (FCR) in different treatments ranged from 1.62 to 1.83 (Figure 1). The best FCR value was observed for Diet 1 (1.62 ± 0.11) where Diet 2 (1.69 ± 0.12) showed comparatively better result than Diet 3 (1.83 ± 0.13). Significant variation in FCR value among the treatments were observed.

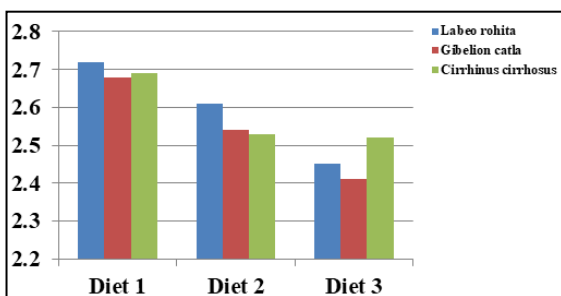


Fig 2: Comparison of mean FCR of diets in different treatments during the experimental period

The obtained mean FCR values ranging from 1.62 to 1.83 in different treatments of the present study are comparable with the FCR values of 1.47 to 1.69[55] for carps in various stocking densities. While a group of researchers [56] recorded a low FCR value of 1.9, other researchers [57] observed higher FCR value of 3.9 for carp in polyculture system even with commercial fish feeds. In an experiment with 7 different diets, researchers [53] found FCR value for *Labeo*

rohita in the range between 0.99 to 1.79. Another researcher [58] reported FCR values in the range from 1.5 to 2.0, good for most of the aquatic organisms. In the present study, the FCR value ranged from 1.62 to 1.83 in three different treatments which is more or less similar with the previous findings.

Protein efficiency ratio (PER)

Mean protein efficiency ratio (PER) in different treatments varied from 2.09 to 2.43 (Figure 2). Significantly best PER value was obtained with Diet 1 (2.43) while Diet 2 (2.25) showed comparatively better result than Diet 3 (2.09) among the three different treatments.

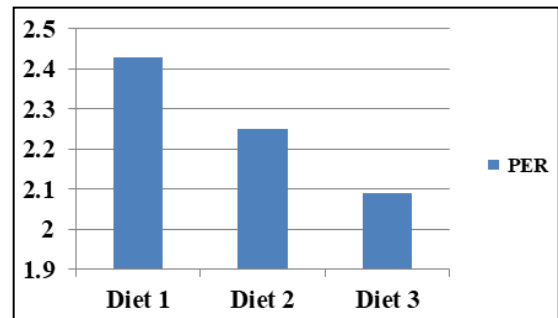


Fig 3: Comparison of mean PER of diets in different treatments during the experimental period

The PER value in different treatments ranged from 2.17 to 2.37 for *Labeo rohita* in a growth performance study where soybean meal was used as a dietary protein source [59]. The mean PER value (ranging from 2.09 to 2.43) in different treatments of the present study is more or less in agreement with the above mentioned result.

Survival rate (%)

The survival rate (%) of different fish species in different treatments was fairly high. It was estimated after harvesting of fish by draining out the ponds. The survival rate (%) was found for *Labeo rohita* (93.89%), *Gibelion catla* (92.87%) and *Cirrhinus cirrhosus* (94.73%) with Diet-1 (Figure 3). There was no significant variation of survival rate among the treatments accept *Labeo rohita* with Diet-1.

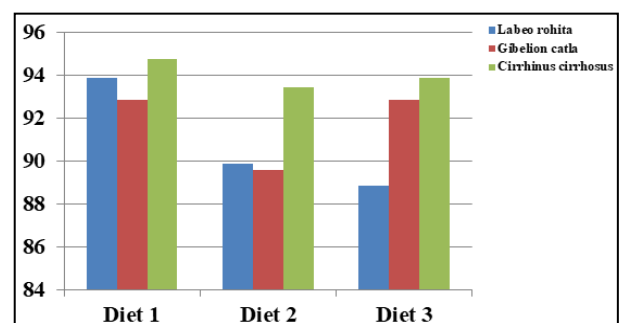


Fig 4: Comparison of survival rate (%) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* in different treatments during the experimental period

Some researchers found the survival rate of carps ranging from 89.23% to 99.23% [60], some reported the range of survival rate from 93.30-100% [61] while another group of researchers [62]. Observed the range of survival rate from 70 to 93.33% of *Cyprinus carpio* fingerlings in different treatments.

In the present study the survival rate (%) of carps ranged from 88.84 to 94.73% which is more or less similar with the above mentioned results. On the other hand, some researchers [63]. Observed that survival rate (%) ranging from 71.43% to 81.40% which were lower than the range found in the present study.

Estimation of fish production

Total net production of fish in terms of kg/ha during the

experimental period is presented in Table 8. The net production of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* was estimated 3849.72 kg/ha for Diet 1 followed by 3179.13 kg/ha for Diet 2 and 2997.04 kg/ha for Diet 3 respectively.

The specie wise highest gross production was found for *Labeo rohita* (1395.87 kg/ha).

Gibelion catla (2078.67 kg/ha) and *Cirrhinus cirrhosus* (765.96 kg/ha) for Diet 1.

Table 8: Total net production of fish in terms of kg/ha during the experimental period

Treatments	Species wise gross production (kg/ha)			Species wise net production (kg/ha)			Total net production (kg/ha)
	<i>Labeo rohita</i>	<i>Gibelion catla</i>	<i>Cirrhinus cirrhosus</i>	<i>Labeo rohita</i>	<i>Gibelion catla</i>	<i>Cirrhinus cirrhosus</i>	
Diet-1	1395.87	2078.67	765.96	1267.97	1868.86	712.89	3849.72
Diet-2	1125.27	1692.19	675.18	1027.58	1535.68	615.87	3179.13
Diet-3	1112.56	1675.15	535.87	997.36	1483.73	515.95	2997.04

3.3.9 Cost analysis of formulated diets

Diet-1 (prepared by Krishibid Feed Limited) is the commercial feed which is used widely in Bangladesh for finfish monoculture/polyculture was brought directly from the whole sell market. The cost of one sack (25 kg) feed was 1090 BDT. The calculated price including carrying cost was 43.60 BDT/kg. The estimated per kilogram cost of two formulated diets and the cost of per kilogram commercial diet are shown in Figure 4.

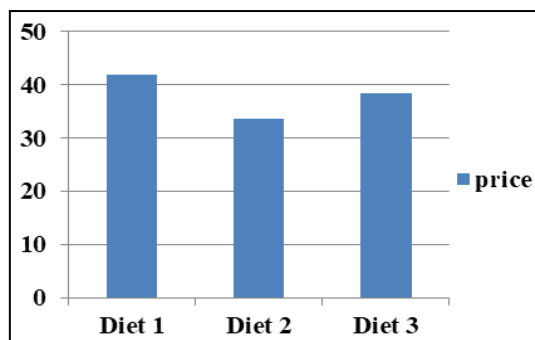


Fig 5: The graphical presentation of price of three different experimental diets

The high protein content in the naturally available feeds provides an inexpensive feed supplement during the initial grow-out period suggested by a researcher [64] which is in agreement with the results of the present study. Some researchers [65, 66] have reported that, fish feeds prepared with ingredients from plant origin have been effective and less expensive. In Diet-2 and Diet-3, pangas waste and plant based protein especially soybean meal was used respectively as protein supplement. Researches [67] observed that, in the recent years, feeds from plant origin have been accepted for Indian major carps as the growth of fishes has been reported to be as good as the traditional feed.

4. Conclusion

The results of the present study show that, along with other available low cost ingredients inclusion of pangas waste in *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* diets not only provided better protein percentage in the diets but minimized the feed production cost in a significant margin. Therefore, the study could be concluded as- in diet preparation for Indian major carps, fish meal can be replaced by pangas (*Pangasianodon hypophthalmus*) industry waste as animal protein source.

5. References

1. Kureshy N, Davis DA, Arnold CR. Partial replacement of fishmeal with meat and bone meal, flash dried poultry by-product meal, and enzyme digested poultry by-product meal in practical diets for juvenile red drum. North. Ameri. Jour. Aqua. 2000; 62:266-272.
2. Lim CE, Lee CS, Webster CD. Alternative protein sources in aquaculture diets. Haworth Press, New York, 2008, 626.
3. Mbahinzirek GB, Dabrowski K, Lee KJ, El-Saidy D, Wisner ER. Growth, feed utilization and body composition of tilapia (*Oreochromis sp.*) fed with cottonseed meal-based diets in a recirculating system. Aquacult. Nutr. 2001; 7:189-200.
4. Davis DA, Miller CL, Phelps RP. Replacement of fishmeal with soybean meal in the production diets of juvenile red snapper, *Lutjanus campechanus*. *J. World Aquacult. Soc.* 2005; 36:114-119.
5. Wang Y, Kong LJ, Li C, Bureau DP. Effect of replacing fishmeal with soybean meal on growth, feed utilization and carcass composition of cuneate drum (*Nibea miichthioides*). Aquacul. 2006; 261:1307-1313.
6. NCR. National Research Council. Nutrient requirements of fish and shrimp. National Academies Press, Washington D.C, 2011, 376.
7. Tacon AGJ, Jackson A. Utilization of conventional and nonconventional protein sources in practical feed. In: Cowey AM Mackie, JG Bell (eds.). Nutrition and Feeding in fish. Academic Press London, 1985, 119-145.
8. Mayano FJ, Cardenett G, Dela Higuera MM. Nutritive value of diets containing a high percentage of vegetable protein in trout, *Oncorhynchus mylissis*. Aquat. Livi. Reso, 1992, 5:23-29.
9. Love DC, Fry JP. Wasted seafood in the United States: Quantifying loss from production to consumption and moving toward solutions. Glob. Envir. Change. 2015; 35:116-124.
10. Davis GH, Bhuiyan AR, Ameen M. Fish production in managed farmer’s ponds with different feeding and stocking regimes. In the proclamation of 4th seminar of Maximum Livestock Production from Minimum Land. Department of Animal Science, Bangladesh Agricultural University, Mymensingh, 1984.
11. AOAC. Association of Official Analytical Chemists. Official Methods of Analysis, 15th edition. Washington D.C., United States of America, 1990, 1230.

12. Samad APA, Hua NF, Chou LM. Effects of stocking density on growth and feed utilization of grouper (*Epinephelus coioides*) reared in recirculation and flow-through water system. *Afri. Jour. of Agri. Resea.* 2013; 9(9):812-822.
13. Oh S-Y, Kim M-S, Kwon J Y, Venmathi Maran BA. Effects of Feed Restriction to Enhance the Profitable Farming of Blackhead Seabream *Acanthopagrus schlegelii* in Sea Cages. *Ocea. Scie. Jour.* 2013; 48(3):263-268.
14. Mohanty SN, Swamy DN, Tripathi SD. Growth nutritional indices and carcass composition of Indian major carp by *Catla catla* and *Labeo rohita*, fed four dietary protein levels. *Aquacul. Hunga. (Szarras).* 1990; 6:211-217.
15. Paul BN, Nandi S, Sarkar S, Mukhopadhyay P. Dietary essentiality of phospholipids in Indian major carp larvae. *Asian Fishery Science.* 1998; 11:253-259.
16. Nandeesh MC. Aquafeeds and feeding strategies in India, pp. 213-254. In M.B. New, A.G.J. Tacon and Csavas I (eds.). *Farm made Aquafeeds. Proceedings of the FAO/AADCP Regional Expert Consultation on Farm made Aquafeeds, 14-18 December 1992, Bangkok, Thailand.* FAO-RAPA/AADCP, Bangkok, Thailand, 1993, 434.
17. Patnaik KS, Das KM. Utilization of some aquatic weeds as feed for rearing carp spawn and fry. In *Proceedings of the Symposium on Inland Aquaculture.* Central Inland Fisheries Research Institute, Barracpore, India, 12, 1979.
18. Ahmad M, Qureshi TA, Singh AB, Manohari S, Borana K, Chalk RS. Effect of dietary protein, lipid and carbohydrate contents on the growth, feed efficiency and carcass composition of *Cyprinus carpio communis* fingerlings. *Int. Jour. of Fish. and Aquat.* 2012; 4(3):30-40.
19. Akiyama MD. Feeding and management of warm water fish in high density culture. *ASA Technical Bulletin, AQ,* 1999, 46.
20. Singh PK, Gaur SR, Chari MS. Effect of Varying Protein Levels on the Growth of Indian Major Carp Rohu, *Labeo rohita* (Hamilton). *Int. Jour. of Zool. Rese.* 2006; 2:186-191.
21. Nandeesh MC, De silva SS, Murthy DK, Dathasri K. Use of mixed feeding schedules in fish culture; Field trends on Catla, Rohu and Common carp. *Aquaculture Research.* 1994; 25(6):659-670.
22. Rahman MM, Paul SK, Rahman SM, Rareque AMHB, Shahin MAA. Growth and survival of leather carp (*Cyprinus carpio* Var. *Nudus*) fry fed with different protein content feeds. *South Asian Jour. Agri.* 2006; 1(2):17-23.
23. Tareque AMHB, Alam MM, Rahman MM, Rahman MM, Rahman SM. Effect of some formulated feeds on the growth and survival of Thai sharpunti (*Puntius gonionotus*) fry. *Bang. Jour. Mar. Sci. and Fish.* 2009; 1(1):21-31.
24. Dupree HK, Gaugliz EJ, Houle CR, Halver JE, Tiews K (eds.). Effects of dietary lipids on the growth and body composition of channel catfish, *Ictalurus punctatus*. In *Proceedings of world Symposium on finfish nutrition and fish feed technology.* Hamburg, Berlin. 1979; pp. 87-101.
25. Watanabe T, Takeuchi T, Ogino C. Studies on the protein sparing effect of lipids in rainbow trout, *Salmo gairdnerii*. In *Proceedings of world Symposium on finfish nutrition and fish feed technology.* Hamburg, Berlin. 1979; pp. 114-131.
26. Ellis SC, Reigh RC. Effects of dietary lipid and carbohydrate levels on growth and body composition of juvenile red drum, *Sciaenops ocellatus*. *Jour. Aqua.,* 1991; 4: 383-389.
27. Andras W, Bueno PB, Altan O, Jeney Z, Reantoso M, Xinhua Z, Anrooy RV. Better management practices for carp production in Central and East Europe, the Caucasus and Central Asia. *FAO Fisheries and Aquaculture Technical Paper, Ankara,* 2011; 566: 62-63.
28. Wilson RP, Halver JE. Growth and feed utilization of *Oreochromis niloticus* fingerlings fed with diets containing soybean and cassava peelings. 2005; 3: 6-8.
29. Mookerjee HK, Mazumdar, SR. On the life history, breeding and rearing of *Anabas testudineus* (Bloch). *Jour. Dep. Sci. Cal. Univ.* 1946. ; 2: 101-140.
30. Chakraborty SC, Chowdhury SA, Chakraborty S. *Asian Fisheries Science, Asian Fisheries Society, Manila, Philippines,* 1999; 12: 297-308.
31. Boyd CE. *Water quality management for pond fish culture.* Elsevier Scientific Publishing Company, Amsterdam, Netherlands, 1982; pp. 318.
32. Mollah MFA, Haque, AKMA. Studies on monthly variations of plankton in relation to the physico-chemical conditions of water and bottom soil of two ponds. II. Zooplankton. *Bangl. Jour. Fish.* 1978; 1: 99-103.
33. Rahman MS, Chowdhury MY, Haque MA, Haq MS. Limnological studies of four ponds. *Bang. Jour. Fish.* 1982; 2-5: 25-35.
34. Dewan S, Wahab MA, Beveridge MCM, Rahman MH, Sarker, BK. Food selection, electivity and dietary overlap among plantivorous Chinese and Indian major carps fry and fingerlings grown in extensively managed, rain-fed ponds in Bangladesh, *Aquaculture and Fisheries Management,* 1991; 22: 227-294.
35. Wahab MA, Ahmed ZF, Islam A, Rahmatullah SM. Effect of introduction of common carp, *Cyprinus carpio* (L) on the pond ecology and growth of fish in polyculture. *Aquacult. Res.* 1995; 26: 619-628.
36. Cho CY, Slinger SJ. In: *Apparent digestibility measurement in feed stuff for rainbow trout* (Eds.), 1980.
37. Jhingran VG, Pullin RS. A hatchery manual for the Common, Chinese and Indian major carps. *ICLARM Studies and Reviews,* 1985; 3: 191.
38. Ali S, Rahman AK, Patwary AR, Islam KHR. Studies on the diurnal variations in physico-chemical factors and zooplankton in a freshwater pond. *Bang. Jour. of Fish.* 1982; 2-5:15-23.
39. Hossain MA, Siddique MAL, Miaje MAH. Development of low-cost feed for culture of giant freshwater prawn (*Macrobrachium rosenbergii* de Man) in ponds. *Bang. Jour. of Fish. Reso.* 2000; 4(2):127-134.
40. Banerjee SM. Water quality and soil condition of fish ponds in some states of India in relation to fish production. *Indi. Jour. of Fish.* 1967; 14:115-144.
41. Roy K. Effect of stocking density on the growth of carps in ponds, MS Thesis, Department of Aquaculture,

- Bangladesh Agricultural University, Mymensingh, 2001.
42. DoF. Matshya Saptah Shankalan, Directorate of Fisheries, Bangladesh, 1998.
 43. Das S, Bhattacharya BK, Goswamy UC. Effect on extreme pH on survivability of Indian major carps. Jour. Inland Fish. J. Soc. India, 1995; 27(2):105-109.
 44. Swingle HS. Relationships of PH of pond water to their suitability for fish culture. Proceedings 9th Pacific Science Congress. 1967; 10:72-75.
 45. Ahmed I, Varghese TJ. Compatibility of *Macrobrachium rosenbergii* (de Man) for polyculture with major carps. In: Proceedings of National Symposium on Freshwater Prawns *Macrobrachium* species, Cochin University Science and Technology, Cochin. 1992; 197-199.
 46. Iram A, Ahmed N, Amir I, Hussain T, Saif F, Naz S, *et al.* Growth Performance of Indigenous and Exotic Fish Species after Yearling Stage in Polyculture System. Middle-East Jour. Sci. Res. 2013; 16(2):256-263.
 47. Islam MR. Comparative growth rate of fishes in poly culture and integrated culture system, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, 1996, 38-41.
 48. Ahmed T. Composite culture of carps in fertilized ponds, MS thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, 2001.
 49. Saha C, Mohapara BC, Giri SS. Central Inst. of Fresh Water Aquaculture. J. Aquaculture in the tropics. Kausalyagana, Bhubaneswar 751002, Orissa, India, 1997.
 50. Rahman MM. Effect of stocking size on the growth, survival and production of carps under polyculture system, MS thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, 1996.
 51. Bhandari RK. Optimization of supplementary feeding rate for the composite carp culture in Bangladesh, MS Thesis, Department of Aquaculture, Faculty of Fisheries, BAU, Mymensingh, 1998, 67.
 52. Hossain MA, Amin MR, Islam MS, Hoque MM. Comparative growth performance of riverine and hatchery produced Indian major carps (*Catla catla* Ham., *Labeo rohita* Ham. and *Cirrhinus mrigala* Ham.). Bang. Jour. Zool. 1999; 27:65-73.
 53. Abid M, Ahmed MS. Growth Response of *Labeo rohita* Fingerlings Fed with Different Feeding Regimes under Intensive Rearing. Jour. of Ani. and Pln. Sci. 2009; 19(1):45-49.
 54. Jasmine S, Molina M, Hossain MY, Jewel MAS, Ahamed F, Fulanda B, *et al.* Potential and Economic Viability of Freshwater Prawn *Macrobrachium rosenbergii* (De Man, 1879) Polyculture with Indian Major Carps in Northwestern Bangladesh. Our Natu. 2011; 9:61-72.
 55. Rahman MA, Rahman MR, Rahman MS. Evaluation of growth and production of the mahseer, *Tor putitora* (Ham.) in polyculture with indigenous major carps, 2007, 161-175.
 56. Das P, Kumar D, Guha Roy MK. National demonstration on composite fish culture in West Bengal. Jour. Inland Fish. Soc. India. 1975; 7:112-115.
 57. Sinha M, Saha PK. Efficacy of commercial fish feed for composite fish culture. Jour. of Inla. Fish. Soci., India. 1980; 12(2):51-55.
 58. Stickney RR. Aquaculture, an introduction text, CABI publication, Cambridge, USA. 2005, 265.
 59. Jahan DA, Hussain L, Islam MA, Naima A. Evaluation of Soybean Meal as a Dietary Protein Source on the Performance of *Labeo rohita* (Ham.) Spawn Reared under Pond Condition. The Agricul. 2013; 11(2):14-20.
 60. Miah MS, Uddin MS, Shah MS. Effect of stocking rations on the growth and production of fishes in mixed polyculture system. Bang. Jour. Fish. 1997; 20(1-2):135-138.
 61. Tihamiyu OL, Ayuba OV, Victor TO, Umar S. Effect of Various Levels of Raw *Citrullus Lanatus* Seed Meal Diets on Growth Performance of *Cyprinus Carpio* Fingerlings. Jord. Jour. of Biol. Scie. 2014; 7(4):269-274.
 62. Rahman SM, Shahin MAA, Chisty MAH, Rahman MM, Tareque AMHB, Hasan MM, *et al.* Growth Performance of Mirror Carp (*Cyprinus carpio* Var. *Specularis*, Lacepede, 1803) Fry Fed with Varying Protein Content Feeds. Our Natu. 2012; 10:17-23.
 63. Hossain MA, Amin MR, Islam MS, Hoque MM. Comparative growth performance of riverine and hatchery produced Indian major carps (*Catla catla* Ham., *Labeo rohita* Ham. and *Cirrhinus mrigala* Ham.). Bang. Jour. Zool. 1999; 27:65-73.
 64. Edwards P. Traditional Asian Aquaculture. In. Burnell G & Allan G (eds.) New Technologies in Aquaculture. Woodhead Publishing Limited, Cambridge, 2009, 1029-1063.
 65. Dorsa WJ, Robinson EH, Poe WE. Effect of dietary cottonseed meal and gossypol on growth of young channel catfish. Trans. of the Ameri. Fish. Soci. 1982; 3:651-655.
 66. Ofojekwe PC, Ejike C. Growth response and feed utilization in the tropical (*Oreochromis niloticus*) fed on cottonseed based artificial diets. Aquacul. 1984; 4:27-36.