Research Article

Determination of Optimum Dietary Crude Protein Requirement for Maximum Growth of African Catfish (*Clarias gariepinus*)

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Abstract | African catfish was introduced in Pakistan due to its high growth and economic importance. The feeding experiment was performed to find out the optimum level of protein in the diet of African catfish formulated from low cost locally available feed ingredients. This feeding trial was performed on African catfish in twelve fiber glass circular tanks (2000 L water capacity) for period of 12 weeks at the stocking rate of 20 fish/ tank. The experimental design was CRD with 4 treatments having 3 replicates. Four experimental diets containing different levels of crude protein (CP: 40%, 35%, 30% and 25%) levels were prepared. The final weight of fish and weight gain was improved by increasing proteins levels in feed. The fish fed with the feed containing 25% CP level showed minimum weight gain (127.69 g), and followed by feed of 30% CP level (142.4 g), 35 % CP level (168.3 g) and 40 % CP level (173.4 g); although growth parameters of fish feed of 35 and 40% CP level did not differ significantly. The results of cost benefit analysis pointed out that 35% protein level is optimum for African catfish as increasing protein levels beyond 35% increases the cost of feed without affecting the growth rate in a significant way thus reducing the net profitability. It was concluded that dietary protein requirement of African catfish ranged between 35-40% CP. For the commercial production of African catfish 35% crude protein level in the feed was optimum.

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Introduction

The aquaculture system of Pakistan is mainly extensive and in some areas are semi-intensive having low stocking density, culture of low value fish species and low per unit fish production (2.5 ton per ha). It is high time to move towards intensive aquaculture by introducing high value fish species with high growth and export potential. The African catfish was a potential candidate as it can be stocked at higher densities, can attain maximum weight of 16-40 tons/ha. In addition, they have high consumer preference due to fewer bones, good meat, adaptability to wide range of environmental conditions and disease resistance. The African catfish introduced in Pakistan due to its rapid growth (reaching market size of 1 kg

in 5-6 months) and flesh with very few spines.

Fish requires sufficient food supply in the precise proportions and with proper nutritional contents for growth, energy, reproduction, movement and other activities (Umaru *et al*., 2016). In this scenario, formulation of fish feed is of significance as 40-50% of the production costs is represented by this input (Steven and Louis, 2009).

Fish requires sufficient food supply with proper nutritional contents for growth, energy, reproduction, movement and other activities (Umaru *et al*., 2016). Fish needs maximum level of protein in the diet for better growth performance when compared with other cultured animals and this makes fish feed very expensive. African catfish is omnivore that feeds on fish, invertebrates, reptiles and amphibians (Kadye and Booth, 2012). Commercial feed is usually comprised of expensive and high-quality proteins and in addition, its processing, packaging and transport contributes towards its higher costs. One of the main operational expenditures for the Channel catfish and African catfish farming is the cost of feed (FAO, 2012). The precise knowledge on the protein requirement of fish is therefore important for any aquaculture initiative as high-priced protein ingredients are usually needed in greater amounts for the majority of fish species (NRC, 1993).

Since African catfish requires major portion of protein in feed so, there is need to find out the optimum level of protein in its diet with replacement of low cost locally available feed ingredients. Keeping in view the above facts present study was conducted to determine optimum dietary crude protein requirement for maximum growth of *C. gariepinus*.

Materials and Methods

The experiment was performed at Aquaculture and Fisheries, National Agricultural Research Centre, Islamabad. This feeding trial was performed on *C. gariepinus* in twelve fiber glass circular tanks (2000 L water capacity) for period of 12 weeks at the stocking rate of 20 fish/ tank. The experimental design was CRD with 4 treatments having 3 replicates.

Four experimental diets containing different levels of crude protein (CP: 40%, 35%, 30% and 25%) were prepared. The composition and proximate analysis of feeds is shown in Table 1. The fish was fed at the rate of 5% wet fish body weight for four times a day.

Table 1: *The composition and proximate analysis of diet used for African catfish in circular tanks.*

Feed ingredients	25% CP	30% CP	35% CP	40% CP
Fish meal	30	30	30	30
Soybean meal	2	13	20	25
Sunflower meal	5	5	5	5
Canola seed meal	5	5	5	5
Rice Polish	27	17	10	8
Gluten 30%	5	13	10	0
Gluten 60%	0	0	6	17
Wheat bran	22	13	10	6
Vitamin C	0.5	0.5	0.5	0.5
Soybean oil	2	2	2	2
Vitamin premixes	1.5	1.5	1.5	1.5
Total	100	100	100	100
Proximate analysis				
Dry matter	90.2	89.98	92.5	89.82
Crude fat	2.69	3.10	3.60	4.05
Crude protein	23.94	29.84	33.68	39.25
Total ash	9.14	10.4	8.56	7.33
Crude fiber	14.68	12.94	15.94	13.25

At end the experiments, all fish were caught with nets, total fish were counted and final weight were recorded. The growth parameters i.e., Weight gain, Percent weight gain, Feed efficiency, Specific growth rate (SGR), Protein Efficiency Ratio (PER), Feed Conversion Ratio (FCR) and Survival Rate was calculated by following formulae:

Weight Gain = Mean final weight of fish – Mean initial weight of fish

Percent Weight Gain= final weight of fish – initial weight of fish/ Initial weight × 100

Protein Efficiency ratio = Weight gain(g)/Protein fed (g)

Feed Efficiency = (Wt. gain/feed offered × 100)

Food Conversion Ratio = (Feed offered/Weight gain)

Specific Growth Rate (SGR) = {[(ln Wf – ln Wi) × 100]/days}.

Wf: final weight, Wi: initial weight

Survival rate = Total number of fish harvested/ Total number of fingerlings stocked × 100

Results and Discussions

The fortnightly growth trend of African catfish fed on diets containing different levels of crude protein showed that growth performance of fish increases gradually with the passage of time (Figure 1). Maximum growth was observed by fish fed by diet of higher protein level. Our results are in accordance with the studies of Machiels and Henken (1985), who reported that growth rate and protein gain increased as levels of protein in the feed increased. The data on growth parameters i.e., average final weight, weight gain, feed conversion ratio (FCR), specific growth rate (SGR), feed efficiency ratio (FE %) and protein efficiency ratio (PER) of African catfish fed on diet containing varying CP levels, is given in Table 2.

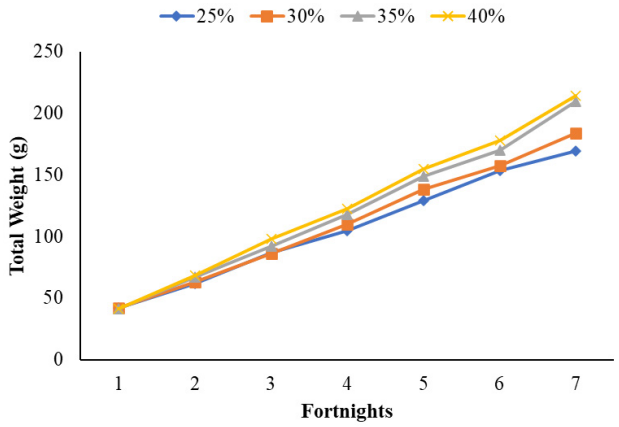

Figure 1: *Fortnightly growth trend of African catfish fed on different diets containing different levels of crude protein. Different letters show treatments differ significantly (P<0.05).*

The final weight of fish and weight gain was improved by increasing proteins levels in feed. The fish fed with the feed containing 25% CP level showed minimum weight gain (127.69 g), and followed by feed of 30% CP level (142.4 g), 35 % CP level (168.3 g) and 40 % CP level (173.4 g); although growth parameters of fish fed with 35 and 40% CP level did not differ significantly.

The growth rate of African catfish was best in the fish fed with diet of high-protein contents (protein 40%) compared to the diet with low-protein (20%). Faturoti and Lawal (1986) reported that 40% crude protein is suitable for normal growth in *Heterobranchus bidorsalis* and *Clarias gariepinus*. The present results revealed that maximum growth rate was achieved at 40 % CP level in terms of weight gain, final weight and specific growth rate. This could be due to the metabolism of excessive amino acids by oxidative deamination which helps in generating energy (Li *et al.*, 2009; Vergara *et al.*, 1996). Similarly, insufficient levels of proteins caused poor growth in various fish species (Giri *et al.*, 2003; Kim and Lee, 2005). The CP levels of 40, 35, 30 and 25% CP in experimental diets did not affect the water quality parameters that continued to remain in appropriate range as described earlier (Buentello *et al.*, 2000).

In terms of specific growth rate (SGR) and feed conversion ratio (FCR), it appears that CP levels in 40% and 35% were better followed by CP levels 30% and 25% CP. Feed efficiency of African catfish fed 40% and 35% CP feed was higher than that of fish fed 30% and 25% CP feed. The best SGR (1.8%/day) was obtained at 40% and 35% CP levels. The relationship of SGR with respect to body weight is shown in Figure 2. The 35% protein was recorded optimal for African catfish as increasing further protein level increases the cost of feed and reducing the profit. Previously, Keremah and Baregha (2014) have reported similar trend whereby final weight gain, percentage weight gain and specific growth rate improved by improving the dietary protein level in feed. Studies on FCR values for all treatments ranges from 2.1-2.4 and did not differ significantly (P<0.05) and these observations are found consistent with the studies on carnivorous fish species such as the estuary

Table 2: *Growth parameters of African catfish fed on diet containing varying CP levels (S.D: 20 fish/tank).*

Parameters	25% CP	30% CP	35% CP	40% CP
Initial weight (g/fish)	41.82±0.93a	41.7±0.82a	41.30±0.96a	41.10±0.78a
Final body weight (g/fish)	169.51±0.90c	184.1±0.90b	209.6±0.42a	214.5±0.87a
Weight gain (g/fish)	127.69±0.10c	142.4±0.65b	168.3±0.21a	173.4±0.67a
Food conversion ratio (FCR)	2.4±0.45a	2.3±0.55a	2.1±0.41a	2.1±0.48a
Specific growth rate (SGR)	1.55±0.25c	1.67±0.23b	1.80±0.21a	1.83±0.22a
Protein efficiency ratio (PER)	4.0±0.43a	3.33±0.41a	2.85±0.37b	2.50±0.35b
Feed efficiency (FE %)	41.74±0.22b	43.10±0.31b	45.67±0.24a	45.89±0.36a

Means with different letters differ significantly.

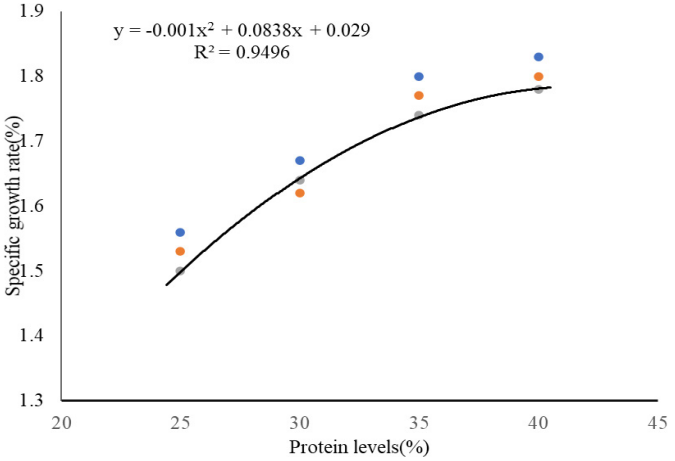

Figure 2: *Relationship of dietary protein levels and SGR for A. catfish fed on diets of different protein levels.*

grouper *Epinephelus salmoides* (Teng *et al*., 1978) and striped bass, *Morone saxatilis* (Berger and Halver, 1987) fed with formulated diets. Mohanty and Samantaray (1996) and Lochmann and Phillips (1994) reported similar results for gold fish (*Carassius auratus*) juveniles fed at protein levels of 21.2-34.5% and snakehead (*Chana striata*) fry using casein or other varied protein sources having 30-60% CP level. In this study slightly decreasing trend of PER by increasing protein could also accounts for PER to be consistent with other studies on *Cyprinus* sp. (Ogino and Saito, 1970), gilthead sea bream (Sabaut and Luquet, 1973), Florida red hybrid tilapia species (Clark *et al*., 1990) and Nile tilapia (Siddiqui *et al*., 1988).

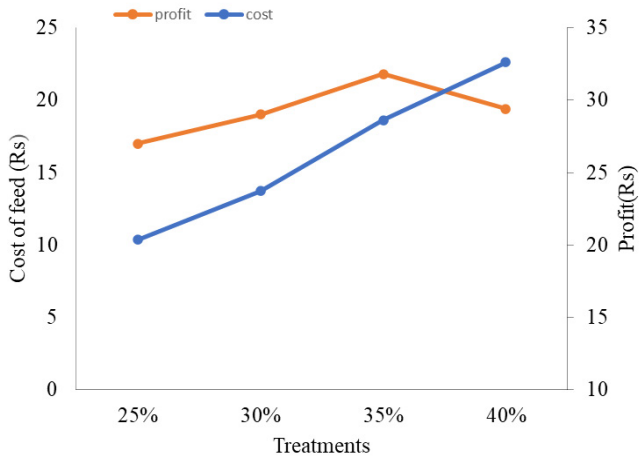

Figure 3: *Relationship between cost and profit at different crude protein levels in feed of African catfish.*

Although significantly higher rate of growth was observed with 40% levels of CP as compared to other protein levels. However, on the basis of cost calculation, feed having 35% CP was found more economical compared to feed with 40% CP. These results of cost benefit analysis pointed out that 35% protein level is optimum for African catfish as increasing protein levels beyond 35% increases the cost of feed without affecting the growth rate in a significant way thus reducing the net profitability (Figure 3). The present findings were similar to earlier studies on same species using fish meal as a source of protein with 35% CP level (Morenike and Akinola, 2010; Keremah and Baregha, 2014). The lowest cost of production of *C. gariepinus* at temperature 28°C was achieved at 36% protein level in fish feed (Al-Deghayem *et al*., 2014).

Table 3: *Carcass composition of African catfish fed with diets containing different protein levels. Means with different letter differ significantly (P<0.05).*

Parameters	25% CP	30% CP	35% CP	40% CP
Carcass (%)	58.1b	62.7a	64.4a	65.5a
Moisture (%)	71.69a	72.18a	71.74a	72.54a
Dry matter (%)	28.31a	27.82a	28.26a	27.46a
Crude protein*	43.50b	47.42b	52.71a	53.98a
Crude lipid*	5.01b	6.27b	10.31a	11.48a
Ash*	5.63b	7.51a	7.96a	8.01a

** Percentage of dry matter.*

The data on proximate composition of Carcass of African catfish is given in Table 3. Crude protein in the African catfish fed with diets containing 40% and 35% CP were higher (P<0.05) followed by the fish fed diets with 30 and 25% CP levels, respectively. Various researchers (Faturoti and Lawal, 1986; Faturoti, 2000; Aderoulo and Akenermi, 2009) have reported that carcass proteins and lipids level is increased in African catfish using fishmeal and 40% CP. According to Lin and Shiau (1995), carcass composition should reflect the diets as it was observed from results of present study. The catfish fed with diet having 40 to 44% protein showed significant positive performance as compared with fish offered diets of 32 to 36% CP (Kiriratnikom, 2012). In this study higher levels of crude lipids were observed in fish fed with 35 and 40% CP compared to 25 and 30% CP level which is in disagreement with the findings of Davis *et al*. (1993) who reported that fish fed with lower levels of proteins have more fatty acid contents than those fed with higher levels of proteins. In addition, ash content in the fish fed at 40% CP was also higher compared to the fish fed with feed at 25% CP level as reported earlier by Ali *et al*. (2014).

Table 4: *Water quality parameters during experimental trial of African catfish.*

Parameters	25% CP	30% CP	35% CP	40% CP
Temperature (°C)	28.3±0.7	27.2±0.4	28.4±0.2	28.0±0.2
Dissolved oxygen (mg L^{-1})	5.7±0.37	6.6±0.26	5.9±0.34	6.0±0.87
pH	7.6±0.02	7.2±0.04	7.0±0.07	7.7±0.09
Electrical conductivity (µs/cm)	154.6±1.32	151.1±2.10	156.30±1.9	158.60±3.6
Alkalinity (mg L^{-1})	164.3±17.2	158.6±16.8	161.9±23.4	163.8±25.9
Hardness (mg L^{-1})	170.8±8.75	169.5±16.2	165.2±13.2	168.1±9.5

In this study all fish survived easily during the whole experiment. No mortality was observed during the whole experimental trial. The high rate of survival might also be due to the favorable conditions of water body, the good health condition of the fish stocked, the quality and quantity of the feeds used and also, the acceptance of feeds by the fish. The high survival validates the report of Otubusin (2000).

The data on limnological features during farming are given in Table 4. The values were in acceptable range for culture of African catfish (Viveen *et al*., 1985). In addition, oxygen levels for the size air breathing African catfish used used in this study may not be considered critical (Haylor and Oyegunwa, 1993).

Conclusions and Recommendations

It was concluded that dietary protein requirement of African catfish ranged between 35-40% CP. For the commercial production of African catfish 35% crude protein level in the feed was optimum.

Novelty Statement

African catfish was indigenized in Pakistan; after the successful transportation and acclimatization of African catfish in local environment; the optimization of dietary crude protein requirement of African Catfish introduced in Pakistan is necessary for efficient management, increase in fish production and to maximize the return on investment.

Author's Contribution

Hasina Basharat: This paper is a part PhD study; she performed this research study.
Muhammad Ramzan Ali: Supervised research, help in experimental setup and data analysis and manuscript writing.
Aziz Ahmed: Helped in experimental setup and data collection.
Mubeen Fakhar: Helped lab analysis, reviewed and edited the manuscript.
Aleem khan: Reviewed and edited the manuscript.

Conflict of interest
There is no conflict of interest among the authors of the manuscript.

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