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STUDY ON THE DIGESTIBILITY AND GROWH POTENTIAL OF ARTIFICIAL FEEDS IN *Catla catla*, *Cirrhinus mrigala* AND *Labeo rohita*

F. Abbas[1], N. A. Qureshi[2], N. Khan, M. Ashraf and K. J. Iqbal[3]

[1]Department of Fisheries and Aquaculture, University of Veterinary and Animal Sciences, Lahore.
[2]Department of Wildlife and Fisheries, Govt. College University, Faisalabad; [3]Department of Life Sciences, The Islamia University Bahawalpur, Bahawalpur

Corresponding Author E-mail: farzana.abbas@uvas.edu.pk

ABSTRACT

Fingerlings of Indian major carps (*Catla catla, Cirrhinus mrigala* and *Labeo rohita*) were reared in quadruplicate in 0.6x0.9x0.6 m glass aquaria in monoculture systems to evaluate the digestibility of artificial feeds for three months. Two artificial feeds experimental (40% protein) and reference (25% protein) were prepared in which chromic acid was added as digestibility marker. Feeds were given H@ 4% of fish wet body weight twice a day. All the three species reared on experimental and control showed an equal growth trend. But when different species were compared among themselves, *Cirrhinus mrigala* yielded significantly higher ($P \leq 0.05$) weight than *Labeo rohita* and *Catla catla*. A similar growth trend was observed in the control group whereas, *Catla catla* grew the least. When digestibility of different nutrients was compared, *Catla catla* in the control group digested protein (76.3±0.4%) equal to that of the experimental group (81.8±4.6%). Dry matter digestibility however, was significantly higher ($P \leq 0.05$) in the experimental group than control. Unlike *Catla catla, Labeo rohita* and *Cirrhinus mrigala* digested protein significantly better ($P \leq 0.05$) in experimental group showing their preference for more protein in formulated feeds. Digestibility of lipids and gross energy values did not differ significantly among species. It means that *Labeo rohita* and *Cirrhinus mrigala* prefer high protein diets than *Catla catla*. In case of acquisition of energy they are all equally efficient however, *Cirrhinus mrigala* is more efficient in extracting, digesting and assimilating different nutrients from artificial diets than *Labeo rohita* and *Catla catla*.

Key words: Indian major carps, Fingerlings, Dry matter, Protein

INTRODUCTION

Aquaculture is an important food source and provides about 12% of the total human food. In the past decade, it has grown rapidly in Asia and hence became an important component of the human diet (Khan *et al.,* 2004; Ashraf *et al.,* 2011; Iqbal *et al.,* 2015). Aquatic organisms, especially fish and crustaceans are considered a rich source of protein and can play a pivotal role in resolving the threatening problem of malnutrition. Therefore, it is a need of the hour to utilize all the available resources to develop the fish industry by the application of all available fish techniques and methodologies (Hafeez-ur-Rehman *et al*., 2017; Iqbal *et al.* 2014). Aquaculture activity in Pakistan is still in infancy and lot need to be done for proper exploitation of the existing fish culture potential and further development for its justified expansion. In current fish culture practices three species of Indian carps viz. catla (*Catla catla* Hamilton), rohu (*Labeo rohita* Hamilton) and mrigal (*Cirrhinus mrigala* Hamilton) are currently cultured at mass scale and they have realized their growth (production) potential and economic importance.

Fish like other animals need balanced nutrition fundamental for the success and sustainability of the aquaculture industry in terms of economics, health, and quality production. Growth rate and quality of fish flesh appears to be limited by the quality and quantity of feed consumed (Ali and Jauncey 2004). In fish culture operations feed costs up to 60% of the total expenditure (Craig and Helfrich, 2002; Li and Wang 2004). Therefore, development of nutritionally adequate and balanced feed for culturable carp species is an immediate need for successful aquaculture practices, which is not possible without the availability of authenticated information on the digestibility of different feed ingredients and feeds. Fish have high dietary protein requirement. The significance of qualitative and quantitative feeds is well recognized and the level of dietary protein is of fundamental importance, because it significantly influences growth, survival and yield of fish. Therefore, considerable research effort is needed to determine the quantity, quality and digestibility of dietary protein necessary to achieve optimum growth performance of fish (Deng *et al*. 2006; Manivannan, and Saravanan. (2012). In South East Asian countries some other researchers who performed similar type of work on the growth and digestibility of *Catla catla, Cirrhinu mrigala* and *Labeo rohita* (Singh, 2000; Kalla *et al*. 2003; Jabeen *et al.* 2004; Salim *et al*. 2004; Khan *et al*. 2005;

Farkhanda *et al.* 2007; Gul *et al.* 2007 and Um-e-Kalsum *et al*. 2009; Hussain *et al.* 2011 and Hussain *et al.* 2014). Nevertheless, studies are quite limited on nutrient digestibility of Indian major carps in our local environment because studies done elsewhere are not always applicable due to variation in the source of ingredients and processing methodologies. They also affect fish behavior differently when the fish is cultured under different environments. Keeping in view the above mentioned constraints the present study is therefore planned to evaluate the digestibility of locally available feed ingredients when they are blended in a feed formula and their effect on growth for Indian major carps.

MATERIALS AND METHODS

Study site: Study was conducted at Research and Training Facilities of Fisheries and Aquaculture, Ravi Campus, Pattoki. Part of the analytical work was completed in Department of Animal Nutrition Laboratory, at city campus, University of Veterinary and Animal Sciences Lahore.

Procurement of fish fingerlings: Fingerlings of the test species (*Catla catla, Cirrhinu mrigala* and *Labeo rohita*) were purchased from Fish Seed Nursery Unit, Manga Mandi, Lahore, and acclimatized for one week in glass aquaria. Fish were treated with 0.5% sodium chloride solution to control ecto-parasites / fungal infections.

Experimental setup and protocol: The fish species were reared individually in quadruplicate in glass aquaria (0.6x0.9x0.6 m) for three months from June to September. Aquariums were filled up to 100 L tube well water. The fingerlings were stocked @ 100 g /aquaria. The average weights of *Catla catla, Cirrhinus mrigala* and *Labeo rohita* in the control were 2.4 ± 0.7, 17.0 ± 6.4 and 20.4 ± 19.7 g and in experimental group 2.5 ± 0.06, 15.0 ± 2.7 and 17.0 ± 2.8 g, respectively at the outset of study.

There were two dietary groups. Diet with 24.5% protein served as control group hereafter also called, "Reference diet (RD)" while that contained 40% protein so called "Test diet (TD)" was fed to experimental group. Both diets were fed to respective groups @ 4% body weight twice a day (Sahzadi *et al.,* 2006; Singh, 2005). Chromic oxide was used as inert marker and incorporated into diets @1% of the feed to determine digestibility of ingredients (Hussain *et al.,* 2011).

Feed ingredients used: Fish meal, soybean meal, maize gluten meal, maize grains, wheat bran, rice polish, molasses, mineral mixtures and vitamin premixes were used for both control and experimental feed formulations and these were procured from chauburgi, Lahore local market (Table 1).

Fish growth: Morphometric measurements (wet fish body weight and total body length) were measured and recorded at the time of stocking. Morphometric measurements were recorded fortnightly to check the growth performance and feed consequences. Additionally, feed conversion efficiency and feed efficiency was also estimated according to following formulae:

Feed Conversion Ratio: (FCR) =Feed intake (g) / Wet weight gain (g)

Feed Conversion Efficiency (FCE) = Wet weight gain (g) × 100 / Feed intake (g)

Fecal matter collection: Fecal matter was regulatory collected from each aquarium with the help of syringe (5.0 ml) after two hours of feeding. The fishes from each aquarium was taken out from aquaria and kept in water tubs until complete defecation and released back to the aquaria. The fecal matter thus collected and dried in petri dishes and stored in plastic jars for future analysis.

Proximate analysis: The feces were dried and analyzed for the estimation of various macro-nutrients which were expelled out undigested. Both experimental diets and feces were homogenized in pestle and mortar independently and then analyzed following AOAC (2010). Dry matter (DM) was determined by oven drying at 105^0C for overnight, crude protein (CP) by micro-kjeldhal analysis method and gross-energy by oxygen bomb calorimeter. Crude fat was determined by Bligh and Dyer (1959) method using Soxhelt apparatus. Chromic oxide was estimated by using acid digestion method (Divakaran *et al.* 2002). Apparent digestibility coefficients of nutrients for each diet were determined by standard method of Maynard and Loosli (1969). Data collected was statistically analyzed to assess the significant differences between two groups (Steel *et al*. 1996), using Minitab version 13.2 statistical package.

Monitoring of physico-chemical parameters: Physico-chemical parameters viz. dissolved oxygen, water temperature, pH, total dissolved solids (TDS), electrical conductivity (EC) and salinity of water were monitored on daily basis using DO meter (YSI 55 Incorporated, Yellow Springs, Ohio, 4387, USA), pH meter (LT-Lutron pH-207, Taiwan) and electrical conductivity meters (Condi 330i WTW 82362 Weilheim Germany) respectively.

RESULTS

The feed formulations and proximate composition of feeds and fecal matter and Chromic oxide is presented in table 1-2.

Growth: The final average weight gain and length of *Catla catla* group was 4.4 ± 1.3 g and 7.6 ± 1.01 cm in

control while the experimental group was 5.6 ± 0.19 g and 8.2 ± 0.17cm. In *Cirrhinus mrigala* final average weight gain and lengths in control was 32.0 ± 5.1 g and 16.3 ± 1.3 cm while for the experimental group was 34 ± 4 g and 16.3 ± 0.46cm, respectively. During present study final average weight gain of *Labeo rohita* in control and experimental group were 32.0 ± 16.0 g and 36 ± 7 g while the lengths were 16.0 ± 3.9 cm and 18 ± 1.33 cm respectively (Table 3). The highest weight gain was observed in *Cirrhinus mrigala* followed by *Labeo rohita* and *Catla catla* in experimental group (TD). The lowest growth was observed in *Catla catla* with reference diet (RD) and growth differences among the three species were not significant ($P > 0.05$) when compared with control group.

Regression equations for experimental diet showed that maximum linear increase was for test diet followed by reference diet (Figs.1 - 3). High value of R^2> 0.90 for reference and experimental diets showed that the diets were significantly related with the increase in body weight and body length of fish. The higher average body weight with test or experimental diet showed that the three test species of fishes grow better with high protein diets.

Digestibility studies: Statistical analysis of nutrient digestibility revealed that there was a significant difference ($P \leq 0.05$) observed in crude protein and dry matter digestibility between the two diets. Protein and dry matter digestibility were significantly higher ($P \leq 0.05$) for experimental diet than control in *Labeo rohita* and *Cirrhinus mrigala* but non-significant ($P > 0.05$) in *Catla catla.* The highest protein digestibility was recorded in *Labeo rohita* for experimental diet and the lowest in the *Catla catla*. The other nutrients did not show any significant difference ($P \leq 0.05$) between experimental and reference diet (Table 4).

Comparison of FCR and FCE: Food conversion ratio of test and reference diets revealed significant differences ($P \leq 0.05$) between themselves. The FCR values of test or experimental diet was significantly better than reference diets (Table 5). Similarly feed conversion efficiency of test diet was also found comparatively better than reference diet for all the species (Table 5).

Physico-chemical parameters: The overall minimum and maximum ranges of key physico-chemical parameters were recorded as, dissolved oxygen (DO) 1.02 - 6.41 mgL^{-1}, pH 6.5 - 7.79, temperature 18.8 - 33.8 °C, salinity 0.8 -1.0 mgL^{-1}, total dissolved solids (TDS) 1419 - 1999 mg L^{-1} and electrical conductivity (EC) 0.94 - 2.31 micro Siemens cm^{-1}, respectively.

Table 1. Feed formula and percentage composition of feed ingredients for test diets (experimental diets).

	Test / Experimental diet		Reference diet	
Ingredients	**%Composition**	**% Crude protein**	**% Composition**	**%Crude protein**
Fish meal	20	10.0	24	12
Soybean meal	30	13.5	-	-
Maize gluten (60%)	24	14.4	30	7.5
Wheat bran	5.0	0.7	-	-
Rice polish	3.0	0.36	45	4.95
Maize grains	8.0	0.78	-	-
Molasses	8.0	0.24	-	-
Mineral mixture	1.0	-	-	-
Vitamin mixture	1.0	-	1.0	0
Total	**100**	**39.98**	**100**	**24.45**

Table 2. Proximate analysis of Experimental diet and Reference diet.

Diets	**Crude protein %**	**Dry matter %**	**Crude fat %**	**Gross energy %**	**Cr_3O_2 %**
Test diet (TD)	40	93.1	10	4.1	0.81
Reference diet (RD)	24.45	89.1	8.5	3.6	0.87

Table 3. Summary of initial and final average weight and lengths of three Indian major carps.

Fish Species	Diets	Initial Avg. Wt. (gm)	Final Avg. Wt. (gm)	Initial Avg. length (cm)	Final Avg. length (cm)
C. Catla	TD	2.5±0.06	5.6±0.19[a]	6.09±0.05	8.2±0.17[a]
	RD	2.4±0. 7	4.4±1.3[a]	6.1±0.5	7.6±1.01[a]
C. mrigala	TD	15.0±2.7	34.0±4.0[a]	12.4±0.79	16.3±0.46[a]
	RD	17.0±6.4	32.0±5.1[a]	13.5±0.8	16.3±1.3[a]
L. rohita	TD	17.0±2.8	36.0±7.0[a]	10.5±0.64	18.0±1.33[a]
	RD	20.4±19.7	32.0±16[a]	10.3±3.9	16.0±3.9[a]

[*] Figures with different superscripts are significantly different ($P \leq 0.05$).

Table 4. Percent nutrient digestibility of experimental and reference diets in three fish species of Indian major carps.

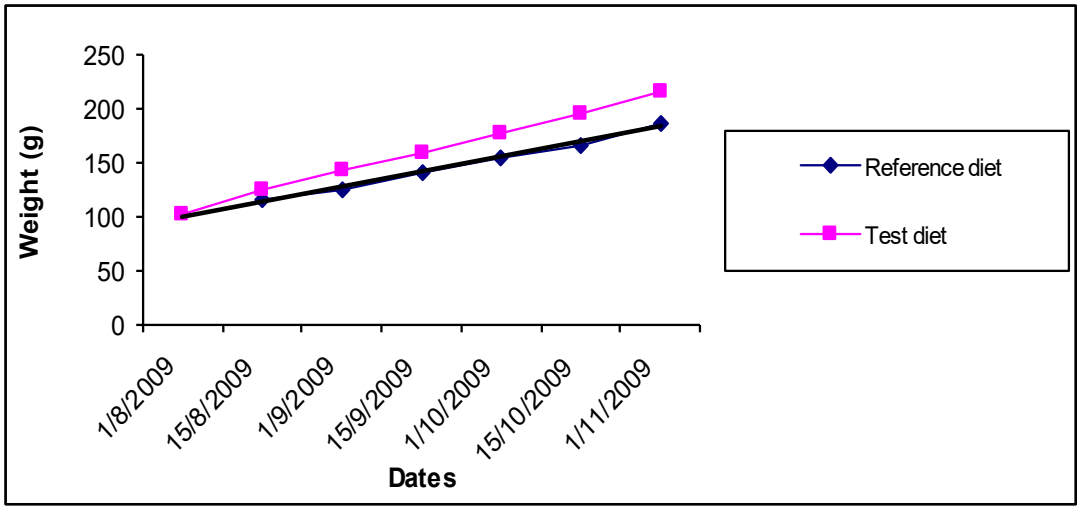
Fish species	Diets	Crude protein %	Dry matter %	Crude fat %	Gross energy K Cal/g
C. catla	TD	81.8±4.6[a]	41.8±1.9[a]	81.8±3.9[a]	61.3±6.6[a]
C. catla	RD	76.3±0.4[b]	50.0±0.0[b]	78.0±0.0[a]	54.0±0.0[a]
C. mrigala	TD	82.8±4.2[a]	35.3±1.4[a]	80.8±4.2[a]	58.3±5[a]
C. mrigala	RD	76.9±0.2[b]	52.5±0.7[b]	79.0±0.0[a]	58.0±0.0[a]
L. rohita	TD	83.4±3.5[a]	37.8±1.2[a]	81.3±1.5[a]	61.5±2.6[a]
L. rohita	RD	78.7±0.2[b]	56.3±0.4[b]	79.0±0.0[a]	63.0±0.0[a]

[*] Figures with different superscripts are significantly different ($P \leq 0.05$).

Table 5. Comparison of FCR and FCE Values for *Catla catla, Cirrhinus Mrigala* and *Labeo rohita.*

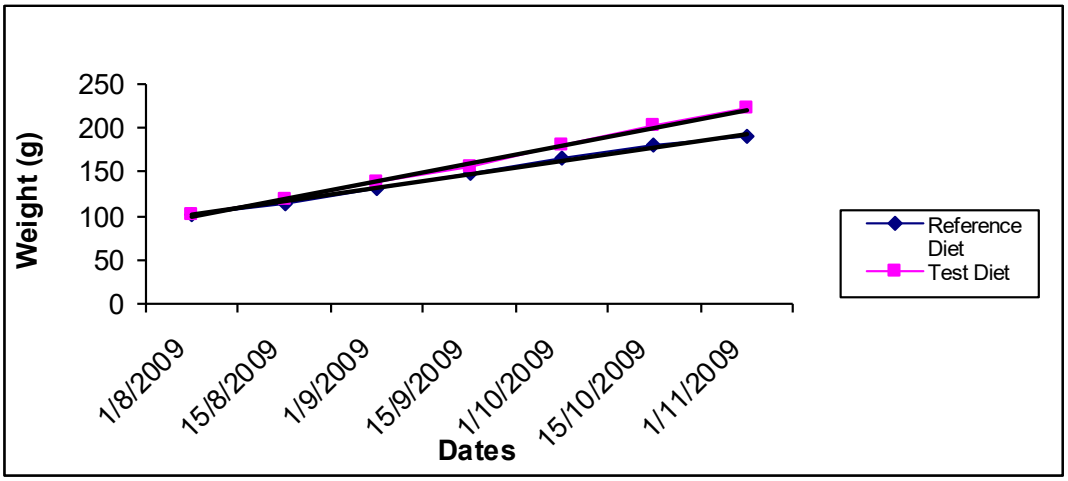
Fish species	Diets	Initial wt. (g)	Final wt. (g)	Weight gain (g)	FCR	FCE
Catla catla	TD	101.7±0.3	216.8±7.6	115.2±7.8	3.5±0.42[a]	29±4.2 [a]
	RD	99.5±1.2	187.0±2.1	87.5±4.8	3.8±0.30[b]	26.0±0.12[b]
Cirrhinus mrigala	TD	100.7±2.4	221.7±8.3	121±10.7	3.4±0.57[a]	29.6±5.1[a]
	RD	102.5±2.0	195.0±2.0	93.5±2.1	3.8±0.11[b]	26.0±0.21 [b]
Labeo rohita	TD	110.2±0.8	213.7±5.0	113.5±5.8	3.5±0.49[a]	28.5±4.95[a]
	RD	102.0±1.8	192.0±3.5	90±3.9	3.9±0.12[b]	25.0±0.13 [b]

[*] Figures with different superscripts are significantly different ($P \leq 0.05$).



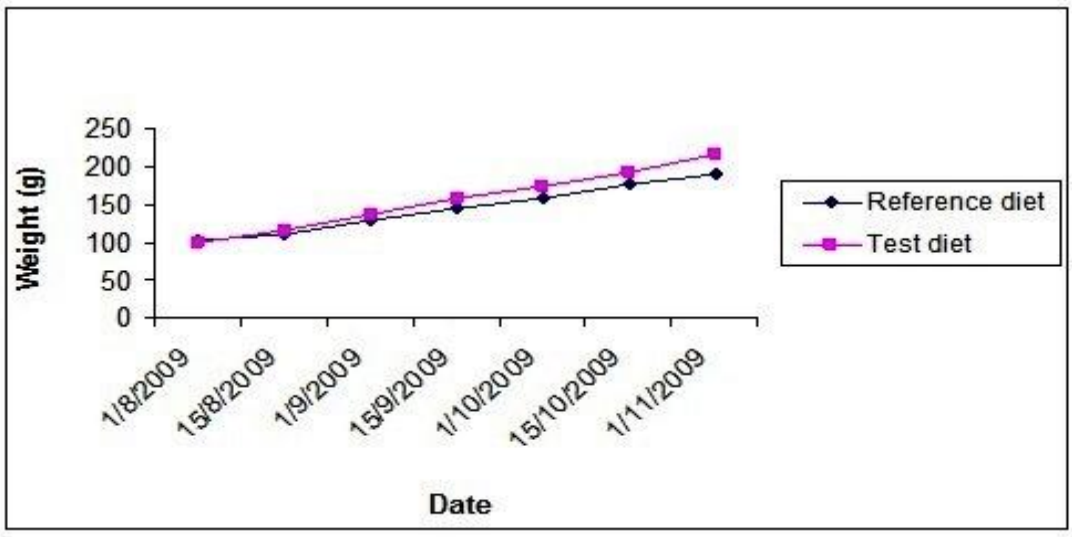
TD = 18.61x +85.629
R2 = 0.9976
RF = 14.114x +85.486
R2 = 0.9917

Fig. 1. Rate of growth with time in *Catla catla*



TD = 20.471x +77.771
R2 = 0.9973
RD = 15357x +86.14
R2 = 0.9952

Fig. 2. Rate of growth with time in *Cirrhinus mrigala*



TD = 19.214x +78.857
R2 = 0.9979
RD = 15.036x +84
R2 = 0.9942

Fig. 3. Rate of growth with time in *Labeo rohita*.

DISCUSSION

Fish growth: Statistical analysis revealed that effect of diets on fish body weight, total body length and FCR was significantly different. Present study revealed that growth performance of three Indian major carps (*Catla catla, Cirrhinus mrigala* and *Labeo rohita*) was higher with lower FCR values on test diet that contained high protein in comparison to reference diet with low protein percentage. Although the trend remains different but overall increase was found linear. The higher average body weight with test or experimental diet showed that the three test species of fishes grow better with high protein diets which might be the presence of required nutrients. Similarly, Abid and Ahmed (2009) reported significantly higher growth when fish was fed with higher protein feed. Jabeen *et al.* (2004) observed highest growth in *Cirrhinus mrigala* fingerlings when fed on fishmeal than cotton seed meal, which may be due to higher protein contents and also amino acid profile.

According to Abdel-Tawab, (2012) higher protein contents have significant effects on the growth and survival of fish. Similarly, Hafeez-ur-Rehman *et al*. (2018) reported maximum feed utilization, growth, best egg quality and body composition in 40% CP containing feed group, followed by 35% CP, 30% CP and control in *Channa marulius.* In another, Khan *et al.* (2014) observed the effect of artificial feeds containing 30%, 35% and 40% crude protein levels on genetically male tilapia (GMT) and reported maximum growth on 40% crude protein level. According to Iqbal *et al.* (2014) protein is not the only nutrient that enhances growth but there are some other factors viz. feed quality, its acceptability to the fish and water quality which are equally important for optimum growth.

Digestibility of nutrients: Apparent digestibility Co-efficient (ADC) of dry matter provides a measure of the total quantity of a feedstuff that is digested and absorbed. The digestibility of dry matter in the present study was higher in reference diet than experimental diet for all the species. Eusebio *et al*. (2004) and Salim *et al*. (2004) in their studies has reported the apparent digestibility values of dry matter in the range of 84-89% and 66-77% respectively but were relatively higher than the values reported by Gul *et al*. (2007) (32-35 %). According to the Liu *et al.* (2015) apparent digestibility coefficients (ADCs) of dry matter and energy decreased in gibel carp (*Carassius auratus gibelio*) when fishmeal replaced with soybean meal. Jimoh (2014) stated that apparent digestibility coefficient for organic matter, protein, energy, lipid, fibre, carbohydrate in *Clarias gariepinus* fed processed seed meal based diets were more superior than those fed by raw sesame seed meal by Fagbenro *et al.* (2013) and comparable with the results obtained for fish fed control diets.

The apparent digestibility for crude protein in the present study was similar to values reported by Hossain and Jauncey (1989), Pike *et al.* (1990) and Zhou *et al.* (2004). Liu *et al.* (2015) observed higher protein apparent digestibility co-efficient for high soybean meal substitution than those of fishmeal groups. The difference in protein digestibility may be due to differences in chemical composition, origin and processing of various feed ingredients, method of feces collection and fish species studied (Koproco *et al.* 2004). The high apparent digestibility of test diet with 40% protein level might be due to better availability of different macro and micro ingredients on account of reshuffling and variable percentage of various ingredients during feed formulations which improved the nutritional value of experimental diet when compared with reference diet (24.45% protein level). All three species of Indian major carps, *Catla catla, Cirrhinus mrigala* and *Labeo rohita* are known to effectively utilize protein from plant as well as animal sources. Studies of Law (1986) on grass carp (*Ctenopharyngodon idella*) and that of Wilson and Poe (1985) on channel cat fish (*Ictalurus punctatus*) further confirm our findings on three Indian major carps during current research work.

The apparent digestibility of crude fat in the present study was much close to the values reported by NRC (1993) which range from 85-95% for fish meal. Similarly crude fat digestibility values reported by Jalal *et al.* (2000) (81.35 ± 3.64%) also confirm our results. However, the fat digestibility of current study was higher than the value (68%) reported by Gaylord and Gatlin (1996). Smith *et al*. (1980) stated that since only a small amount of fat remains in the feces, estimates of its digestibility can be highly variable. The apparent gross energy digestibility in the present study was also comparable to that reported by other researchers (91% by Cho *et al*. 1982 and 91.5% by Smith *et al.* 1980).

It has been concluded from the present study that all three species of Indian major carps, *Catla catla, Cirrhinus mrigala* and *Labeo rohita* are known to effectively utilize protein from plant as well as animal sources. The *Cirrhinus mrigala* showed higher growth followed by *Catla catla* and *Labeo rohita* under both the experimental and reference diets. This higher growth in *Cirrhinus mrigala* might be due to its bottom feeding habit and higher feed intake. Artificial feed offered during study period was mash and not a floating pellets that when applied sink readily and available to *Cirrhinus mrigala*. The highest protein digestibility was observed in *Labeo rohita* followed by *Cirrhinus mrigala* and *Catla catla.* However, the nutrient digestibility of reference diet was lower as compared to the experimental diet.

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