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DISCUSSION

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Ten experimental diets with different protein sources were formulated and used in the 'Jhora' fed fish ponds at the Darjeeling-Pulbazar area of Darjeeling, West Bengal situated in the hills of Eastern Himalayas during the present investigation. The diet code ED01-ED10 represents the number of the experimental ponds and a separate pond was used as the control where no formulated diets were provided. The ten different diets were prepared with ingredients of plant and animal origin keeping the crude protein level at 30.0% (approximately). The major protein source used in different diets are Mustard oil cake (ED01), Silk worm purpal (ED02), Slaughter house waste (ED03), *Nechamandra* leaf meal (ED04), *Nymphoides* leaf meal (ED05), Fish meal (ED06), Soybean meal (ED07), Fish meal (ED08), Goat blood (ED09) and casein gelatin (ED10). The ponds (ED01-ED10) were treated with lime @ 500 kg ha^{-1} and raw cow dung @ 10,000 kg ha^{-1} for initial correction of soil and water quality. Changes in the soil & water quality, plankton density etc. and the efficacy of all these diets on the dynamics of food intake, growth promotion, conversion efficiency and associated biochemical changes in the Indian major carps *Catla catla, Labeo rohita* and *Cirrhinus mrigala* and production of fish due to different diet treatment have been studied and discussed separately.

5.1 Physico-chemical characteristics of soil:

Soil plays an important role in determining the productivity of pond. The chemical characteristics of bottom soil like pH, NPK, Organic Carbon (C), C/N ratio etc. act as important factors in influencing fertility and productivity of a fish pond (Wrobel, 1967).

5.1.1 pH of the soil:

Before fertilization, all the ponds soil were analyzed to find out the level of pH and all of them were found to be acidic in nature. In order to rectify the pH level, liming was done. The dose of lime required varies with the level of pH. In this investigation, lime done recommended by CICFRI workers was followed (Jhingran, 1982). After treatment, it was found that the level of pH gone up slightly in all the experimental ponds. But the alkaline condition did not continue due to continuous influx of 'Jhora' water. Schaperclaus (1959) and Banerjee (1967) observed that a slight alkaline pH is favourable in fish ponds. Productive ponds ranged mostly between slightly acidic and slightly alkaline in reaction although Saha (1978) differs from it.

5.1.2 Nitrogen Content of the soil:

The role of nitrogen in soil as an essential nutrient is well known. It is required in the synthesis of protein. Phytoplankton uses inorganic form of N to fulfil their demand. The depletion of soil N may affect pond productivity. Banerjee (1967), Ghosh (1978) and Saha *et al* (1979) mentioned that 25 - 30 and 50 - 75 (expressed as mg N/100g soil) are favourable, on the average, although above 50 mg N/100g of soil considered as productive level. It has been observed that the level of N was 20 - 40 mg/100g soil in all the experimental ponds. before treatment. However, after liming and manuring the N level increased considerably.

5.1.3 Phosphorus content of the soil:

It is the most critical single element which limits productivity and there exists a correlation between the available soil phosphorus and fish production. According to Banerjee (1967) the level of phosphorus (P_2O_5) 30 ppm is considered poor, 30 - 60 ppm average and 60 ppm as high fish producing capacity. Saha *et al.* (1979) reported that above 6 mg P/100g soil should be productive but below 3 mg P/100g soil is unproductive. In this work the initial level ranged between 13.7 - 14.3 Kg/ha but in all the ponds phosphorus level moved up considerably after treatment. The results indicated the efficiency of the used manure in raising the level of available phosphorus in the soil.

5.1.4 Potassium content of the soil:

Potassium is not a limiting factor and is not necessary to increase fish production. Though it ranks as a major nutrient element along with N and P, its importance was observed by Banerjee (1972), Ghosh (1978) and several other workers. The excessive dose is said to be harmful (Chatterjee, 1978; Saha *et al.*, 1979). In this experiment, the potassium level ranged between 75.1 - 78.3 kg ha^{-1} and inspite of its considerable increase after treatment, no harmful effect was observed.

5.1.5 Organic carbon and C/N ratio:

Organic carbon and C/N ratio are regarded as important influencing factor for the productivity of pond. In this experiment the percentage of initial organic carbon ranged between 0.22 - 0.29% which has gone up due to application of manure and the values are either optimal or nearly optimal as suggested by Banerjee (1967).

Schaperclaus (1959) has suggested that due to consideration should be given to the C/N ratio while using organic manure. Higher C/N ratio causes quicker decomposition of bottom soil due to bacterial activities. Banerjee reported that the range 10 - 15 would be (1967) the ideal condition for fish pond. Here the C/N ratio ranged between 6.50 and 14.50 which was improved due to manuring and little fall from different plants which indicated the productiveness of the ponds.

5.2 Physico-chemical characteristics of water:

It is well known that the physico-chemical characteristics of water greatly affect the pond productivity. The nature of the soil reflects the nature (quality) of water (Dutta and Kar, 1947). The chemical and physical characteristics of water which are involved in pond productivity are being discussed in the following heads:

5.2.1 pH of the water:

The pH level has influencing effect on the fertility of pond water. Swingle (1947) considered 6.5 - 9.0 as a satisfactory range of fish cultivation. Banerjee (1967) recommended the range between 6.5 and 7.5 as the best for fish culture. According to Nandeesha (1982) the initial fertilization increases the pH level immediately but refertilization has no such influence. Saha *et al.*, (1979) observed that slightly alkaline water and optimum pH level of 7.0 - 8.0 have been found to be productive.

In this investigation before treatment the water was acidic except control and experimental ponds ED08 - ED10 but after treatment with lime the water was recorded to the desired level. Therefore, the treatment of ponds with manure did not cause any marked variation in pH level in both the year and the pH range varied from 6.4 to 7.2. So, it indicates that the quantum of different inputs used did not hamper the optimum level although there is a function in the pH value either due to continuous inflow of Jhora water or may be due to temperature.

5.2.2 Ambient water temperature:

Indian major carps thrive well in water within the temperature range of 18^0C - 36^0C (Jhingran, 1982). In this work the temperature varied between 10^0C in January and 22.50^0C in July. In both 1st and 2nd year experimental trial maximum temperature was recorded during July of every year and gradually decreases to the minimum in the month of January. So, upto the month of November the temperature recorded was favourable for the growth of carps although in lower temperature also IMC can thrive well with slow growth rate.

5.2.3 Dissolved oxygen content of water:

This is one of the most important factor limiting productivity of pond water. Normally IMC requires 6 - 7 mg lit^{-1} of DO_2 at about 20^0C of ambient water temperature. For healthy growth of fish the DO_2 level should not fall below 3 ppm (Saha, 1978) to 5 ppm (Ghosh, 1978). In this present investigation dissolved oxygen content varied from 9.00 ppm to 10.99 ppm. There was a marked variation of DO_2 content being maximum in the month of July and minimum in the month of January of every year. This may be due to fall of temperature in that region. Although the DO_2 level was always better (higher) in all the experimental ponds as recommended by the several workers and this may be due to the continuous flow of 'Jhora' water.

5.2.4 Free carbon dioxide content of water:

Carbon dioxide is present in water in the term of free CO_2, half bound HCO_3 and bound CO_3. Its importance in the formation of H_2CO_3 is well known which is a weak acid. The weak acid and its salt bicarbonate generate a buffer action in the pond water to prevent abrupt fluctuation of pH in the water. It has been found that, during experimental trial the free CO_2 ranged between 6.00 ppm and 6.88 ppm and there is a fluctuation of free CO_2 level without any fashion.

5.2.5 Total alkalinity (equivalent to $CaCO_3$):

According to Ghosh (1978), the alkalinity above 15 ppm in pond water is considered productive although Ali Kunhi (1971) stated that in highly productive water the alkalinity should be more than 100 ppm. Many rivers and fish pond fall within the total alkalinity values equivalent to 10.0 - 50.0 ppm of $CaCO_3$. In this investigation the total alkalinity in both the 1st and 2nd year trial varied from 116.1 ppm - 128.3 ppm. So, much improved values are therefore observed in the experimental ponds which indicate that the range is favourable as suggested by other workers.

5.2.6 Plankton density:

Plankton density is an important index of the nutritive condition in the biological productivity of a pond (Mitra and Das 1965). The study of plankton in relation to fish culture began more than a century back in different parts of the world (Ganapati, 1941; Saha *et al*, 1975; Ghosh *et al*, 1979 and several other workers). An essential density of plankton in a fish pond has been reported by Alikunhi (1957) as 1.5 to 2.0 ml of Zooplankton per 45 litre of water. Organic manures are acceptable for producing plankton at a very high rate (Banerjee *et al*, 1969). The rate of production has not been sufficient enough in all the experimental ponds through the period (July - January) for sustained growth of carps. The plankton density recorded during the experimental trial in different ponds ranged between 0.36 - 0.49 ml/45 litre of water. In this way, I have used formulated diet (ED01 - ED10) for introduction of IMC in the foot hills of the Himalayas.

5.3 Stocking density and combination ratio of IMC:

Although mixed culture of Indian major carps is in vogue in India, yet the stocking density and combination ratio in not strictly followed in practice. Further, the density and ratio suggested by different workers differs significantly (Alikunhi, 1957 etc.), Jhingran (1982) opined that the stocking density should be atleast 10,000 + 10% and Gupta (1983) suggested the stocking combination ratio as 3 *catla* : 3 *Labeo* : 4 *Cirrhinus*. In this experiment the stocking density and stocking ratio were @ 20,000 + 10% and 4 *Catla* : 3 *Labeo* : 3 *Cirrhinus* respectively considering the 6 months culture duration and low temperature in the bottom water.

5.4 Feed:

5.4.1 Physical properties and stability of the pelleted diet:

The pellet quality refers to crumbling and water stability of pellets results in rapid disintegration which leads to fouling of the medium i.e. water (Balazs *et al.*, 1973). However, higher stable pellets are not desirable as they increase the cost of production and decrease the availability of bound nutrients (Balazs *et al*, 1973). The water stability test of the different pelleted diets conducted for a period of five hours in the present study indicated that the pellets ED02, ED03, ED07, ED08 were more stable, ED01, ED04, ED05, ED06, ED09 were moderately stable and ED10 was less or low stable. Hastings (1971), Kainz (1977) and Lovell (1983) observed that the stability of the formulated diets is influenced by various factors like feed composition, nature of ingredients, type of processing and moisture content. In the present study, the variation in quality and quantity of the ingredients appear to be responsible for differences in stability among the pellets. The pellets which were highly stable contained different oil cakes (MOC, LOC & GOC) in their composition resulting an increase in fat content and compactness of the pellets. However, all the pelleted experimental diets tested in the present study possessed necessary stability for feeding the fish.

A dense pellet sinks rapidly in water. In this investigation, slow sinking rates were recorded in the case of experimental diets ED03, ED04, ED05 and ED09 varing from 3.02±0.43 cm sec^{-1} (ED09) to 3.45±0.46 cm sec^{-1} (ED04). Slow sinking rates of these pellets may be due to less compactness.

5.4.2 Feed intake:

The average daily dry matter intake (mg 100 g bw^{-1}) by the IMC was higher in case of ED10 followed by ED03, ED02, ED09, ED08, ED06, ED07, ED04, ED05 and ED01. The average dry matter intake with diet (ED10) showed significant difference with other experimental diets. Since all the diets (ED01 - ED09) were moderately to highly stable in water, no relationship between quality of the pellets and average daily dry matter intake by the fish could be established. The difference in feed intake may be due to the quality of the food and the ingredients used there in.

5.4.3 Nutrient digestibility:

In general, the digestibility of protein was found to be positively correlated to with the crude protein level of the diets (Austreng and Refstie, 1979; Wannigama *et al*, 1985 and Patra and Ray, 1988). The mean crude protein, crude lipid, carbohydrate and gross energy digestibilities ranged from 78.441 - 87.218, 78.629 - 89.611, 70.187 - 82.021 and 74.033 - 86.932 respectively.

Recent survey of digestibility measurements on warm water fish show that the data for the digestibility of various feeds for fish are still rather incomplete (Hastings, 1969; NRC, 1983; Steffens, 1985). The present investigation shows with respect to various formulated diets, the achievement of crude protein digestibility falls within the range of that by carps (Kirchgessner *et al*, 1986). Since all the diets used almost isotrogenous (except ED10), it is expected that changes in the digestibility of nutrients were dependent on the form of protein source. A low digestibility of protein with the fish meal based diets (ED04, ED05, ED06 & ED08) may be due to the cheap quality of the fish meal used to reduce the cost of the feed as has been reported by Ogino and Chen (1973). Likewise, the crude protein digestibility of other animal protein feeds like feather meal, blood meal etc. is mainly determined by the technical procedure (Kirchgessner *et al.*, 1986). The protein digestibility of other diets with animal protein source (ED02, ED03 & ED09) used during the present study ranged from 81.298 to 86.911 being higher for the diet ED02 (silkworm pupae) followed by ED03 (Slaughter house waste) and ED09 (goat blood meal). Schwarz *et al.*, (1986) recorded a low digestibility of crude protein level by the carp with a high proportion of blood meal in the feed mixture. The crude protein digestibility for the diet ED02 (silkworm pupae) and ED03 (slaughter house waste) did not show much variations. It appears therefore, that the crude protein from these sources are more digestible than that of other animal protein sources. In the present study, high digestibility value of crude protein (86.866%) was obtained for the diet ED07 (prepaerd with solely plant protein source with 50.74% soybean meal). Isolated soybean protein may be digested by carp to over 90.0% (Zeitler *et al.*, 1983), and the crude protein of extracted soybean meal, could be digested to about 84.0% (Atask *et al.*, 1979).

The digestibility of crude lipid for the diet ED01 - ED10 was about as high as that of crude protein in a range of 78.629% to 89.611%. Kirchgessner *et al.* (1986) also recorded a high digestibility of crude fat (83.0%) in carp. A survey of the diets ED01 - ED10 showed that feed mixture containing only plant protein source (ED07) and silk worm pupae (ED02) had high lipid digestibility value (89.115% and 88.128% respectively). The diets containing fish meal as animal protein source showed a lower digestibility of crude lipid. The increased values of lipid digestibility for the diets

ED02 and ED07 may be a result of increased levels of crude lipid in those diets (12.76% and 13.68% respectively).

Digestibility of total carbohydrates has been recorded to maximum for the diet ED02 (82.021%) and minimum for ED08 (70.187%). It should be noted here that the crude fibre is also included in this fraction. It has been observed that all rations containing components rich in crude fibre gave a digestibility of total carbohydrates under 65.0% (Kirchgessner *et al.*, 1986). No relationship between the proportion of total carbohydrates in the feed and their digestibility could be established during the present investigation as has been observed by Kirchgessner *et al.*, (1986) & Patra, 1989 etc. in carp. The digestibility of gross energy also showed a similar trend being maximum for the diet ED07 (86.932%) and minimum for the diet ED04 (74.033%) prepared mainly with *Nechamandra* leaf meal. It is evident from the results on the digestibility of nutrients for the diet ED01-ED10, that the nutrients from the fish meal based diets were poorly utilized by the Indian major carps. The IMC could utilized the nutrients from the Soybean meal diet very efficiently although the growth rate was not satisfactory that may be due to the presence anti-nutritional factor. Among the animal protein source, the nutrients from the silkworm pupae, slaughter house waste and goat blood meal based diets could be utilized more efficiently by the fish.

5.4 Nitrogen and energy balance:

A higher intake of feed nitrogen over faecal excretion of nitrogen indicated that the fishes were in positive nitrogen balance. Higher N absorption of 290 mg per 100g fish day^{-1} was recorded with the diet ED10 (Halver's synthetic diet) followed by ED03, ED02, ED09, ED07, ED08, ED06, ED01, ED04 and ED05 (*Nymphoides* leaf meal based diet). Nitrogen from the fish meal, goat blood and plant (aquatic macrophyte) based diets was poorly absorbed by the IMC in comparison to that from other diets.

The absorbed feed energies, expressed as Kcal per 100g fish day^{-1} also exhibited a similar trend as observed in case of nitrogen absorption. It appears therefore, that among the different protein sources except the casein-gelatin based diet (ED10), nitrogen and energies from the silkworm pupae, slaughter house waste, goat blood meal and from the plant protein based diet ED07 (soybean meal) were efficiently utilized by the fish.

5.4.5 Feed conversion ratio and protein efficiency ratio:

The feed conversion ratio (FCR) with the diet ED01-ED10 gave the highest conversion ratio with diet ED03 (1.239) and lowest with the diet ED05 (2.211) prepared with slaughter house waste and *Nymphoides* leaf meal as major protein source. The highest protein efficiency ratio was observed with the diet ED03 (2.310) whereas lowest with the diet ED06 (1.309). Lower level of FCR & PER values were recorded with the diet containing either solely the ingredients of plant protein (ED07) or major plant protein ED04 & ED05). The fish meal based diets also showed poor FCR & PER values as compared to the silkworm pupae, slaughter house waste and goat blood meal diets. Protein from plant materials on cheap quality fish meal, therefore, appears to be poorly utilized by the Indian major carps (*Catla, Labeo & Cirrhinus*) than the protein from animal sources.

5.5 **Growth rate of the fish:**

The experimental diets (ED01 – ED10) were prepared at different dietary protein source (approximate crude protein level at 30%) the response of the fish to these diets in relation to growth promotion, biochemical changes and cost of unit production and output will therefore, be discussed separately to determine the better source of protein for preparation of pratical diet for the 'Jhora' fed fish culture of Darjeeling Hills. The diet prepared isonitrogenously, to determine the efficacy of the protein sources (plant or animal) on the performance of the fish. Since all of these diets were isonitrogenous, the changes recorded in the response of the fish are expected due to the source and quality of protein i.e. the availability of essential amino acid. The highest live weight gain was recorded in the fish fed of the diet ED10 (Casein-gelatin based diet) and lowest with the diet ED05 (*Nymphoides* sp. based diets) continue solely the plant proteins. It appears from the results that a diet continue only plant protein source was neutritionaly poor in enhancing the growth rate of the fish (other diets are ED04, ED07). If we compared the growth rate of fish with different animal protein source diet then it is highest with ED03 followed ED02, ED09, ED08, ED06 and ED01.

The high price and scarcity of fish meal has generated a considerable amount of research into possible partial or complete subsitution by other high protein sources for dietary fish meal with variable results (Jauncy, 1982; Patra and Ray, 1988; Silva and Gunasekera, 1991). New, 1986 reported growth rate depression in plaice and channel catfish through the partial substitution of fish meal by soyaben meal, even when limiting amino acids in soyaben mean were supplemented to the levels found in the fish meal, same observations were recorded by Faturoti *et al.* 1996 with major carps, tilapia and Clarias. Jackson *et al.* 1982 observed lower growth rates then the control in tilapia at the 100% plant protein diet although the present investigation recorded lowest growth with the control diet. Venkatesh *et al.* 1986 reported a lower growth rate with the plant protein based oil cake diet in *Clarias batrachus*, incorporation of plant protein sources in place of fishmeal in diets has led to poor growth of carps, but addition of the deficient amino acids and fat or balancing of amino acids by combining plant and animal protein sources has reversed this trends (Viola and Rappaport, 1979; Viola *et al.* 1981; Nandeesha *et al.* 1987; Patra 1993; Alam *et al.* 1996). Viola and Arieli (1983) concluded that soyaben meal can be used to replace upto the half of the fish meal in tilapia feeds of 25% protein content without requiring any other supplements, the same observation was recorded by Patra *et al.* 2000. The results of the present investigations also indicate that complete replacement of the animal protein source by the plant protein source is not advisable for better growth of the fish. New (1986) suggested that a high dietary protein level can only be attained through the use of ingredients which in themselves have a protein content greater than 50%.

The fish fed with the diet ED03 containing 36.32% slaughter house waste, 37% rice bran and 24.79% mustard oil cake registered better growth throughout the experimental period than the ED01 containing 33% fish meal, 33% wheat bran and 33% mustard oil cake. The fish fed with the diet ED02, ED09, ED08 showed growth in terms of percent weight gain followed the fish fed the diet ED03. Dried silk worm pupae (34.93%), goat blood (5%), good quality fish meal (80%) formed the major source of protein in the diet ED02, ED09 and ED08 respectively. The fish fed with the diet ED01 (33% fish meal) and experimental diet 4 & 5 registered poor growth as compared to the other diet like ED02, ED09, ED08 and ED06. Fish meal or fish protein concentrate have always been considered the most satisfactory source of protein for inclusion in formulation of fish fin because of the results which they give and the similarity of their amino acid profile to that with the known amino acid requirement of various species of fish (New, 1986). But the variation in price, composition and quality of the fish meal can pose problems in their formulation. This might be a result of using large proportions of small unwanted trash fish, fish heads and tails over heating during processing or in proper storage conditions (Tan and Lee, 1975). Total replacement of fish meal with other sources of animal and plant origin has always not mate with success. Owing largely to the deficiencies of one or more essential amino acids in the protein source used (Viola *et al.* 1982, 1983; Tacon, 1981; Viola and Arieli, 1983; Bhat *et al.* 1986; Faturoti *et al.* 1996 etc.). However, partial replacement of fish meal with plant and animal source has resulted in almost equal and higher growth in comparison with fish meal based diets in different fish species (Gropp *et al.* 1976; Akiyama, *et al.* 1984; Viola and Zohar, 1984; Nandeesha *et al.* 1987; Patra, 1989). Comparatively better growth of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were recorded with the non-fish meal diets (ED10, ED03, ED02, and ED09) indicates that the slaughter house waste diet (ED02) compare well with that with the silk worm pupae (ED02), goat blood (ED09) and casein-gelatin based synthetic diets (ED10). Viola and Zohar (1984) did not find any alteration in the growth performance and body composition of *Oreochromis* when half of the fish meal was replaced with poultry meat meal. Venkatesh *et al.* (1986) however, recorded reduced growth rate in *Clarias batrachus* with the meat meal based diet. Lovell (1983) stated that fibre is beneficial for digestibility and absorption of nutrients in research diets. The superior growth of *Catla*, *Labeo* and *Cirrhinus* with the diet ED03, therefore, appears to be due to a comparatively high content of crude fibre (13.13%) in the same. Jayaram and Shetty (1980) reported best growth of catla with a diet containing non-deoiled silk worm pupae as compared to fish meal based diet and attributed to same to the higher fat level of the test diet. Venkatesh *et al.* (1986) also recorded a better growth of *Clarias batrachus* with a silk worm pupae based diet. A comparatively better growth of the fish with silk worm pupae base diet (ED03) as compared to that with the fish meal-based test diet (ED01), may also be attributed to a high crude lipid content in the diet. Inclusion of blood meal in the practical diets of the fish has been reported by a number of workers (Fowler and Banks, 1976; Metailler *et al.* 1977; Asgard and Austreng, 1986; New, 1986 and Patra, 1989). Fowler and Banks (1976) and Asgard and Austreng (1986) recorded better growth of rainbow trout and salmon respectively with the diets containing protein from the blood of cattle in comparison to the diets without blood. New (1986), however, apprehended the danger of amino acid imbalance due to use of blood meal in the practical diet for the fish. The results on growth of fish with the goat blood meal diet (ED09) in the present investigation indicated a better performance as compared to that with the fish meal based diets. Since no study regarding amino acid composition of the goat blood was made, it was not possible to draw any conclusion about the lower growth rate of fish on the goat blood meal based diet as has been stated by New (1986).

5.6 Proximate composition of the fish flesh:

The composition of the fish flesh can be affected by various factors such as geographical location, season, sex, maturity, species food etc. of which maturity and food ingested are the most important (Love *et al.*, 1959; Vasavan, 1960; Jafri *et al.*, 1964; Khawaja, 1966; Shima and Nakada, 1974; Parova, 1976; Reimers and Meske, 1977; Viola and Amidan, 1978; Austreng and Refstie, 1979; Srikar *et al.*, 1979; Reinitz and Hitzet, 1980; Reintz and Yu, 1981; Venugopal and Keshavanath, 1984; Zeitler *et al.*, 1984; Alexis *et al.*, 1986; Patra and Ray, 1988b; Patra, 1993; Patra *et al.*, 2000). A knowledge of the carcass composition of the fish allows the optimum feeding rations to be determined as well as optimum nutrients conversion in *connection with the quality demands of consumers.* However, feeding intensity and nutrients formulation have the strongest influence of carcass composition.

In the present investigation, the influence of different dietary protein sources on the body, composition of the Indian major carps, *C. catla, L. rohita* and *C. mrigala* have been studied and discussed separately.

The moisture content in the muscle of the fish with the diets ED01 to ED10 varied from 77.37% to 82.45% in *Catla*, 77.56% to 82.66% in *Labeo* and 78.24% to 83.44% in *Cirrhinus*. The fish reared in the control pond however, showed a little higher moisture content. Since all of these diets (ED01 – ED10) were isonitrogenous, no relationship between the protein content in the diet and the moisture percentage in the muscle could be established. However, an inverse relationship between the moisture and fat content in the fish muscle was observed. The values of moisture and fat in the muscle with these diets also showed a greater degree of consistency totalling upto nearly 80%. No significant difference in the moisture of muscle was observed due to inclusion of different protein sources in the diet.

The average ash content in the muscle of Indian major carps fed with the diets ED01 – ED10 varied from 3.00% to 4.25% in *Catla*, 3.11% to 4.21% in *Labeo* and 3.11% o 4.08% in *Cirrhinus* respectively. The muscle ash content of fish reared in the control pond however, did not show much variation as compared to that with the experimental diets. In these feeding trials no definite relationship between the level of ash content in the feed and muscle could be discerned. The inconsistent results observed regarding ash content of muscle may be due to the differences in the quality of ingredients used for formulation of the diets (Patra, 1989).

The total protein content in the muscle of the fish fed with the diets ED01 to ED10 ranged from 9.49% to 10.59% in *Catla*, 10.01% to 10.93% in *Labeo* and 9.11%

to 9.75% in *Cirrhinus* respectively. Since the diets ED01 – ED10 were isonitrogenous, the difference in the muscle protein content in various groups of Indian major caps may be expected to be related to the differences in protein quality. The maximum crude protein level in the muscle obtained in the diet ED10 may be related to slightly higher protein level in the diet. The results with the other diets indicated that the muscle protein content increased in the fish fed with a diet ED03 containing slaughter house waste as the major protein source. The results with the other diets showed almost same percentage of crude protein levels in the muscle of the fish fed. ED02, ED09, ED08, ED06, ED01, ED07, ED04 and ED05. The muscle of fish fed in the diet ED06 containing exclusively plant protein source had the lowest crude protein deposition except ED01. It appears therefore, that the Indian major carps could not utilised the plant protein efficiently which resulted lowest deposition of protein in the muscle (Patra, 1989, 1993; Patra *et al* 2000).

The highest crude lipid content was recorded in the muscle of Indian major carps in the diet ED10 and lowest with the diet ED02 in case of *Catla*, ED09 and ED03 in *Labeo* and ED01 & ED03 in *Cirrhinus* respectively. The muscle of the fish fed with the diets containing animal protein source did not show much variation in lipid content. Protein / energy relation (Winfree and Stickney, 1981) and lipid level (*Viola and Amidan, 1978; Jayaram and Shetty, 1980). In the diet known affect the fat* content of the body. No such relationship could be discerned during the feeding experiments with these diets. Similar observations were recorded by Patra, 1989, 1993; Patra *et al.* 2000.

5.7 Production of fish:

In intensive fish culture, in addition to the initial high capacity investment, the cost involved in the necessary inputs during the course of culture is also comparatively high. Among the inputs, feed becomes the costliest item in cases where fish yield depends mainly on the supply of high quality pelleted feeds. Thus, the net income that can be obtained depends on the cost incurred in the supply of fish. The highest output in six months was recorded with diet ED10 (3047.61 kg ha^{-1}) followed by ED03 (2564.12 kg ha^{-1}), ED02 (2418.33 kg ha^{-1}), ED09 (2303.05 kg ha^{-1}), ED08 (2197.88 kg ha^{-1}), ED06 (2011.47 kg ha^{-1}), ED01 (1922.64 kg ha^{-1}), ED07 (1730.86 kg ha^{-1}), ED04 (1607.59 kg ha^{-1}) and ED05 (1595.22 kg ha^{-1}) respectively during second year experimental trials. In the first year trials, although the rate of production was slightly low as compared to the second year but followed the same trend of total production. It is clear from the present investigation that the higher production is related to the good quality protein source and obviously the animal protein in the diet. Lower rate of production was obtained with the diet prepared with solely the plant protein or substituted by low quality fish meal.

5.8 Cost of production and net output:

An attempt has been made during the present study to evaluate the comparative cost effectiveness of the experimental diets in order to estimate the net income that can be derived using these feeds. Since the objective was to ascertain the comparative cost effectiveness, not only the cost of feeds was taken into account but also the cost of other inputs involved were considered for the estimation of cost per unit production (Rs Kg^{-1}), gross value of output (Rs.) and net value of output (Rs.).

The highest cost per unit production was obtained with the diet ED01 (125.30 Rs.Kg^{-1}) followed by ED06, ED07, ED01, ED08, ED02, ED09, ED03, ED04 and lowest with diet ED05 (6.50 Rs. Kg^{-1}). The net value of output was recorded highest with the die ED03 (25599.78 Rs. ha^{-1}) in six months followed by ED04, ED05, ED09, ED02, ED08, ED01, ED06, ED07 and lowest in ED10. The net value of output was negative with the synthetic casein-gelatin waste diet ED10 (-30913.32 Rs. ha^{-1}) in six months. The same results were recorded during the experimental trials. Hence, the use of synthetic diet is not economical as a supplementary diet for Indian major carps. Thus, the present investigation indicates that on the basis of net output value, the slaughter house waste diet is much superior for the high production or compare to the others. Although the results suggested that the people of Darjeeling Hills may use aquatic weeds as well as goat blood and silk worm pupae may use for the production of Indian major carps catla, rohu and mrigal in the 'Jhora' fed fish pond, so far as cost effectiveness of the diet is concerned.