Effect of *Spirulina* on Growth performance of common carp (*Cyprinus carpio* L. 1758).

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Abstract:

Cyprinus carpio (Common carp) fingerlings, measuring 5.85 ± 0.02 g and 4.2 ± 0.22 mm procured from local fish ponds were brought to the laboratory and acclimatized to the laboratory conditions (12 h: 12 h L/D regime, continuous aeration, periodical exchange of non-chlorinated and nonpolluted water) for a week. During acclimatization the fingerlings were fed on commercial fish feed. The fingerlings were divided into four groups of 10 each and were fed @ 3 to 5% body weight at 6.00 am and 6.00 pm every day. Total Length, Total weight Food conversion efficiency, food conversion ratio, Specific growth rate, Hepato somatic index, Gonndo somatic index in male, Gonado somatic index in female and Spleeno somatic index and were measured in the tissues of fingerlings on day 1, 10, 20 and 30. After the completion of 30 day period, it was observed that the total length total weight increased with increase in time both in control and experimental groups; however the magnitude of increase or decrease respectively in the above variables is more pronounced in *Spirulina* fed fingerlings than in the control groups. Similarly the magnitude of increase in total biomass of *Spirulina* fed fingerlings is highly significant. The results highlight the importance of *Spirulina* as a feed supplement in enhancing the overall growth of fish.

Keywords: *Cyprinus carpio*, *Spirulina*, Supplementary feed, Total length, Total weight, Food conversion ratio, Food conversion efficiency, Specific growth rate, Gonado somatic index, Spleeno somatic index.

Introduction:

Aquaculture is one of the rapidly progressing food production systems in the world, which has emerged as an industry capable of supplying protein rich food to the ever growing human population (Prasad, 1996). Fish is an important dietary animal protein source in human nutrition and thus culture of aquatic species through freshwater fisheries and aquaculture is being encouraged throughout the world. According to nutritionists, fish is an excellent source of protein. Fish flesh contains all the essential amino acid and minerals viz., iodine, phosphorus, potassium, iron, copper and vitamin A and D in desirable concentrations (Sandhu, 2005).

The Common carp (*C. carpio*) is the most important commercial fish in India with a maximum market demand and acceptability as food by the consumers due to their taste and flesh. They contribute about 67% of total freshwater fish production (Parthasarathy and Ravi, 2011) in South India. The aim of the present study is to evaluate the effects of *Spirulina* (*Spirulina maximus*) on survival, growth and biochemical performance of common carp as *C. carpio* over a period of 30 days.

Obviously Aquaculture is meant to increase the weight of fish in the shortest possible time under replicated conditions through provision of low cost feed. Supplementary feed accounts for nearly 40-60% of the total operational cost of intensive farming operations. Of late farm made feeds are extensively used in fish culture in the place of commercial feeds. Farm made feeds facilitate the use of less conventional ingredients which cannot be utilized by commercial feed manufacturers or are not in sufficient or reliable supply. Farm made feeds thus are less expensive and environmentally friendly. Addition of herbal supplements like *Spirulina* to farm made feeds in an added advantage in the sense that it promotes fish growth in a holistic manner. The efficacy of such practice has been tested by measuring growth variables in the fingerlings of *C. carpio.*

Materials and Methods:

Determination of fish growth:

Total Body Weight:

Fish were taken out of the maintenance troughs, numbered by tagging and allowed to jump on a mat of filter papers in a trough to get rid of the adhered water. These fish then were transferred carefully and quickly into pre weighed small clean glass beakers. (Size of the beaker varies in accordance with the size of the fish) and the weight recorded to the nearest mg in a sartorius balance. The difference between the beaker + fish and beaker alone gives the weight of the fish in gms.

Length:

Variations in length were measured by the method of Ravi et al. (1998). Initial and final lengths were recorded using standard scale (1 mm gradation). Gain in length (cm) was calculated by subtracting values of initial length from those of final length.

Weight Gain:

Variations in net weight gain were calculated by the method of Sambhu and Jayaprakas (2001). Initial and final average wet weights were recorded using a standard balance. The net weight gain (g) was calculated as the difference between initial and final average wet weights.

Weight gain (g) = Mean final body weight (g) –Mean initial body weight (g)

Feed Conversion Efficiency (FCE):

FCE is defined as the fish live weight gain per unit of food fed in dry weight. FCE was calculated as follows (Sambhu and Jayaprakash, 2001).

$$\textbf{FCE} = \frac{\text{Live weight gain (g)}}{\text{Food fed (g) dry weight}}$$

Food Conversion Ratio (FCR):

Because feed is expensive, feed conversion ratio (FCR) or feed efficiency (FE) are important calculations for the grower. They can be used to determine if feed is being used as efficiently as possible.

FCR is calculated as the weight of the feed fed to the fish divided by the weight of fish growth (Mustafa and Ridzwan, 2000).

$$\text{FCR} = \frac{\text{Total feed}}{\text{Wet Weight of tissue}}$$

Specific growth rate (SGR):

Specific growth rate was determined by the method of Ravi et al. (1998). After getting the initial and final weights, the specific growth rate was calculated by using the following formula

$$\text{SGR} = \frac{\log_e W_2 - \log_e W_1}{t} \times 100$$

Where

W_1 = Natural log of Mean Initial weight of fishes

W_2 = Natural log of Mean Final weight of fishes

t = Time in days (duration of experimental intervals)

Body indices:

After blood sample collection, all the fish were scarified and soon the abdominal cavity was opened to remove spleen, gonads and liver to be weighed at once. The gonad, liver and spleen indices were calculated as follow:

$$\text{Spleenosomatic index } (SSI) = \frac{\text{Spleen weight (g)}}{\text{Body weight (g)}} \times 100$$

$$\text{Gonadosomatic index (GSI)} = \frac{\text{Gonad weight (g)}}{\text{Body weight (g)}} \times 100$$

$$\text{Hepatosomatic index (HSI)} = \frac{\text{Liver weight (g)}}{\text{Body weight (g)}} \times 100$$

Results:

Figure-3.1 present results on variations in the total body length (cms) of fingerlings of *C. carpio* fed for 30d on control (C1 and C2) and experimental (E1 and E2) diets. It is clear from the results that E1 and E2 diets increased total body length by 10 and 14 percent respectively on day 10; 13 and 16 percent respectively on day 20; and 16 and 17 percent respectively on day 30 compared to the respective control diets (C1 and C2). Figure-3.2 presents results on percent increases in total body length increment (cms) in fingerlings fed for 30d on control (C1, C2) and experimental (E1, E2) diets. It is clear from the results that E1 and E2 diets increased total body length gain (total body length increment) by 9 and 17 percent respectively on day 10; 12 and 23 percent respectively on day 20; 15 and 25 percent respectively on day 30 compared to the respective control diets (C1 and C2). These results show that E1 and E2 diets are more efficient in enhancing total body length and total body length increment than C1 and C2 diets.

Figure-3.3 present results on the total body weight (TBW) of fingerlings of *C. carpio* fed on control (C1 and C2) and experimental (E1 and E2) diets. The results clearly show that there is a significant increase ($P<0.001$) in the total body weight of fingerlings with increase in rearing time from 0 to 30 days both in control and experimental groups with the magnitude of increase being more in fingerlings fed on E1 and E2 diets than in those fed on C1 and C2 diets. Evidently E1 and E2 diets enhanced total body weight (TBW) by 10 and 14 percent respectively on day 10; by 30 and 37 percent respectively on day 20 and by 38 and 42 percent respectively on day 30 compared to the respective C1 and C2 diets (Fig. 3.3). However no significant difference was observed in total body weight between the fingerlings fed on control (C1 and C2) and experimental (E1 and E2) diets on day 1 indicating positive influence of herbal supplemented diets on the growth of *C. carpio* fingerlings. Figure-3.4 present results on changes in weight gain of fingerlings of *C. carpio* fed for 30d on control (C1 and C2) experimental (E1 and E2) diets. It is clear from the results that there is a significant increase (P<0.001) in the weight gain of fingerlings with increase in rearing time from 0 to 30 days both in control and experimental groups with the extent of increase being more in fingerlings fed on E1 and E2 diets than in those fed on C1 and C2 diets (Fig. 3.4). Clearly E1 and E2 diets amplified weight gain percentage by 30 and 59 percent respectively on day 10; by 54 and 61 percent respectively on day 20 and by 53 and 62 percent respectively on day 30 compared to the respective C1 and C2 diets. These results suggest that E1 and E2 diets are more effective in augmenting weight gain of fingerlings than C1 and C2 diets.

Figure-3.5 present results on variations in food conversion ratio of fingerlings of *C. carpio* fed on control (C1 and C2) and experimental (E1 and E2) diets. The results clearly show that there is a significant decrease (P<0.001) in the food conversion ratio of fingerlings with increase in rearing time from 0 to 30 days both in control and experimental groups with the magnitude of decrease being higher in fingerlings fed on E1 and E2 diets than in those fed on C1 and C2 diets (Fig. 3.5). The results also show that E1 and E2 diets significantly (P<0.001) decreased food conversion ratio by 22 and 21 percent respectively on day 10; by 27 and 26 percent respectively on day 20 and by 32 and 30 percent respectively on day 30 with the magnitude of decrease being less on day 1 compared to other sampling periods (Fig. 3.5). These results suggest that E1 and E2 diets have effectively reduced food conversion ratio than C1 and C2 diets.

Figure-3.6 present results on food conversion efficiency of fingerlings of *C. carpio* fed on control (C1 and C2) and experimental (E1 and E2) diets. It is clear from the results that there is a significant increase (P<0.001) in the food conversion efficiency of fingerlings with increase in rearing time both in control and experimental groups. However the quantum of increase is significantly higher in the fingerlings fed on E1 and E2 diets than in those fed on C1 and C2 diets throughout the 30 day period. The results show that E1 and E2 diets significantly increased food conversion efficiency by 7 and 11 percent respectively on day 10; by 16 and 24 percent respectively on day 20 and by 19 and 28 percent respectively on day

30; however, the magnitude of percent increase is much less on days 1 and 10 than on days 20 and 30. These results show that E1, E2 diets are more efficient in enhancing food conversion efficiency than C1 and C2 diets.

Figure-3.7 present results on specific growth rate of fingerlings of *C. carpio* fed on control (C1 and C2) and experimental (E1 and E2) diets. It is clear from the results that there is a significant increase ($P<0.001$) in the specific growth rate of fingerlings with increase in rearing time both in control and experimental groups. However the quantum of increase is significantly higher in the fingerlings fed E1 and E2 diets than in those fed on C1 and C2 diets throughout the 30 day period (Fig. 3.7). Clearly E1 and E2 diets enhanced specific growth rate by 16 and 25 percent respectively on day 1; by 20 and 31 percent respectively on day 10; by 27 and 37 percent respectively on day 20 and by 31 and 41 percent respectively on day 30; however, the magnitude of percent increase is much less on days 1 and 10 than on days 20 and 30 (Fig. 3.7). These results show that E1 and E2 diets are more efficient in enhancing specific growth rate than C1 and C2 diets.

Ffigure-3.8 and figure-3.9 present results on female and male Gonadosomatic index (GSI) of fingerlings of common carp (*C. carpio)* fed on control (C1 and C2) and experimental (E1 and E2) diets. It is clear from the results that E1 and E2 diets significantly increased GSI in female fingerlings compared to the respective control diets (C1 and C2). The results show that there is a significant increase in GSI of female fingerlings fed on E1 and E2 diets by 10 and 16 percent respectively on day 10; 12 and 19 percent respectively on day 20; and 15 and 21 percent respectively on day 30 compared to those fed on C1 and C2 diets (Fig. 3.8). Similarly E1 and E2 diets significantly increased GSI in male in fingerlings compared to the respective control diets (C1 and C2). The results show that E1 and E2 diets significantly increased GSI in male fingerlings by 14 and 24 percent respectively on day 10; 15 and 28 percent respectively on day 20; 20 and 31 percent respectively on day 30. The results however show that E1 and E2 diets are more efficient in enhancing GSI in females than in males both fed on C1 and C2 diets.

Figures 3.10 and 3.11 present results on Spleenosomatic index (SSI) and Hepatosomatic index (HSI) of fingerlings of common carp (*C. carpio)* fed on control (C1 and C2) and experimental (E1 and E2) diets. It is clear from the results that E1 and E2 diets significantly increased SSI in the fingerlings through 30 day experimental period than in those fed on control diets (C1 and C2). The results show that E1 and E2 diets significantly increased SSI by 25 and 43 percent respectively on day 10; 29 and 56 percent respectively on day 20; and 35 and 60 percent respectively on day 30 compared to the respective C1 and C2 diets (Fig. 3.10). The results also show that E1 and E2 diets caused a significant increase ($P<0.001$) in the hepatosomatic index (HSI) by 13 and 20 percent respectively on day 10; 20 and 22 percent respectively on day 20; 22 and 26 percent respectively on day 30 compared to the respective C1 and C2 diets (Fig. 3.11). These results show that E1 and E2 diets are more efficient in enhancing SSI and HSI than C1 and C2 diets.

DISCUSSION:

Carp farming has attained commercial culture status in India and many of its neighbouring countries. With the intensification of culture, feed has become the most important component of the culture system from the viewpoint of both fish production and cost. Fish-meal-based diets generally induce good growth. However, owing to scarcity and escalating cost of fish meal, research on alternative sources is gaining importance (Shetty and Nandeesha, 1988). Microalgae are the useful microorganisms promoting growth performance and protecting the host against pathogens. These microorganisms are included in the diets and show beneficial effects on host's gut microflora and improve food nutritional.

All the diets were nearly isonitrogenous and isocaloric. However, with the increasing level of *Spirulina* in the diet, the growth of fingerlings of common carp has increased accordingly. Microalgae have been found to be a good source of protein for fish. *S. Platensis* has been identified as a potential protein source for animal feed owing to its high protein content and presence of essential amino acids, vitamins and minerals. In addition, this species has been reported to have no cell, which results in imported digestion and absorption (Becker and Venkataraman, 1984; Nandeesha et al., 1998). Deccan mahseer, *Tor Khudree*, recorded good growth when fed with diets containing *S. Platensis* in place of fish meal. An earlier study by Nandeesha et al. (2001) also revealed that *S. Platensis* could be used as a sole source of protein in common carp diets. Improvement in growth of fish by dietary inclusion of *Spirulina* has been reported earlier in a few species (Nakazoe et al., 1986; Mustafa et al., 1994). Detailed investigations on the utilization of microalgae as feed for fish were carried out in Israel wherein it was seen that fish grew better on algae enriched diets than on any conventional fish feeds (Sandbank and Hepher, 1978).

Results of this study substantiate the fact that algae have direct growth promoting effects on *C. carpio* which is in accordance with the reports of Seenivasan et al. (2012) and

Parthasarathy and Ravi (2011). *Spirulina* is being commercially cultivated because of its high nutritional content and as a supplement with many health and economic benefits for humans and in aquaculture (Tongsiri et al., 2010). Results of this study also corroborate with many earlier reports on benefits of using *Spirulina* as part of aquaculture diet for various commercially important food fishes. In the present study, enhanced growth increment and feed utilization in terms of SGR and FCR was significant in *C. carpio* fed with E1 and E2 diets.

In general growth rates of fish are highly variable and, in many cases, seem to be limited by availability of food. Periods of feed restriction or feed scarcity resulting in growth retardation or loss of weight do not appear to affect the ability of fish to grow when they are returned to full rations. Conversely there is evidence to suggest that fish may show periods of rapid weight gain, commonly known as compensatory or catch-up growth, following periods of feed restriction. The importance of feed utilization in relation to compensatory growth has been highlighted in several fish species (Bull and Metcalfe, 1997; Rueda et al., 1997; Jobling and Johanson, 1999). Several investigators have suggested that compensatory growth could be exploited in the commercial production of fish to manipulate rates of weight gain or to improve growth efficiency with the inclusion of herbal ingredients such as *Spirulina* in the formulated feeds (Ogino, 1980; Jones and Farrell, 1992; Arzel et al., 1998).

The results of this study have clearly shown that *Spirulina* supplemented formulated diets have significantly enhanced the total body length of *C. carpio* fingerlings when compared to control diets (Fig. 3.1). Although both control and experimental diets increased total body length over the 30d period the magnitude of increase was significantly higher in fingerlings fed on E1 and E2 diets. It is interesting to note that the total body length at the end of 30th day increased approximately 5 times in the fingerlings fed on C1 and C2 diets as against 10 times in those fed on E1 and E2 diets. These results suggest that *Spirulina* might have contributed to positive growth by enhancing growth parameters Abdelhamid et al. (2009). Similar results have also been obtained in the present study. The present results also show that there is a significant increase in the total length increment of *C. carpio* fingerlings fed on E1, E2 diets than those fed on C1, C2 diets (Fig. 3.2) on par with total body length increment. Nandeesha et al. (1998). Interestingly, the total length at the end of 30th day is approximately 20 times in the fingerlings fed on C1, C2 diets as against 40 times in those fed on E1, E2 diets, suggesting that *Spirulina* included in the supplemented formulated diets might be responsible for such an increase in total body length increment.

The results of this study have clearly shown that *Spirulina* supplemented formulated diets have significantly enhanced the total body weight of *C. carpio* fingerlings when compared to control diets C1 and C2 (Fig. 3.3). Although both control and experimental diets increased total body weight over 30d period the magnitude of increase was significantly higher in fingerlings fed on E1, E2 diets. It is interesting to note that the total body weight at the end of 30^{th} day increased approximately 6 times in the fingerlings fed on C1, C2 diets as against 9 times in those fed on E1, E2 diets. These results suggest that *Spirulina,* a component of supplemented formulated diets, might have contributed to the growth by enhancing protein synthesis. The present results agree with the findings of Stanley and Jones, (1970) who fed bigmouth buffalo, blue tilapia and grass carp on blue-green algae, *S. platensis* (Nordstedt), to improve fish growth. Similar results have also been reported in other fish viz. trout and common carp fed on *Spirulina* supplemented diets (Atack and Matty, 1979; Atack et al., 1979; Mustafa and Nakagawa, 1995) attributed the increase in total body length and weight of fish fed on *Spirulina* supplemented diets to an increase in protein assimilation and feed utilization. Yone et al. (1986) suggested that microalgae, especially *Spirulina*, might have stimulated assimilation of nutrients into body constituents enhancing the total body weight and body length.

Matty and Smith (1978) showed that the growth rate reached optimum level with diets containing algal protein. Appler and Jauncey (1983) reported that the diet containing algal-meal protein produced highest growth rates in *C. glomerate*. Yone et al. (1986) found an increase in growth, feed utilization and muscle lipid, when 5% *Ascophyllum* meal was fed to 1 year old red sea bream. Lazo et al. (2000) reported that growth was significantly higher when reared in the presence of algae (zooplankton supplemented with algae L-A). Fiogbe et al. (2004) showed that the dietary Azolla meal level at 5% had a significant effect on the final body weight of *C. carpio*. Mustafa et al. (1995) mentioned that inclusion of 5% *Ascophyllum nodosum*, *Porphyra yezeoensis* and *Ulua pertusa* in the diet of fingerlings of red sea bream led to an increase in body weight. Jun et al. (2004) reported that growth rate of larval *Oreochromis niloticus* fed on *Spirulina* after the onset of exogenous feeding had resulted in the best growth performance. Obviously the results of the present study are in consonance with the above findings and, interestingly, E2 diets have more potentiating effect on total body length and weight than E2 diet compared to the control diets.

Results presented in Table-3.2 showed that E1 and E2 diets had positive effect on body weight of *C. carpio*. These results are in agreement with those of Montgomery and Gerking (1980) who showed that algae is the source of dietary protein. It has also been reported that *Spirulina* and other algal species have positive effects on growth, feed utilization and physiological condition Mustafa and Nakagawa, (1997). Moreover Stanley and Jones, (1970) showed that *Tilapia aurea* fed on blue-green algae had optimum body weight gain. Nakagawa and Kasahara, (1986) and Wassef et al. (2002) found that average body weight gain was significantly higher in 5% algae-fed group.

The results also show that there is a significant increase in the net weight gain of *C. carpio* fingerlings fed on E1, E2 diets than those of fingerlings fed on C1, C2 diets (Figure-3.4) on par with total body weight gain. Interestingly the total weight gain at the end of 30th day is approximately 20 times in the fingerlings fed on C1, C2 diets as against 36 times in those fed on E1, E2 diets suggesting that *Spirulina* included in the supplemented formulated diets might be responsible for such an increase in total body weight gain.

The results also show that there is a significant decrease in the food conversion ratio (Figure-3.5) of *C. carpio* fingerlings fed both on E1, E2 diets compared to those fed on C1, C2 diets. However the magnitude of change both in food conversion ratio and in food conversion efficiency (FCE) was significantly higher with E1, E2 diets compared to C1, C2 diets. Similar results have been reported in other fishes also with regard to FCR and FCE (Quinton and Blake, 1990). It is generally known that a lower FCR and higher FCE always promote growth in a fish species and the results of the present study are in consonance with this general observation. In summary it can be said that *Spirulina*, included as a herbal supplement in the feed, appears to influence the physiological processes in such a way that *C. carpio* fingerlings have shown much better performance as far as growth is concerned. The feed conversion ratio of *Tilapia aurea* (Steindachner) and bigmouth buffalo fed on blue-green algae was (Stanley and Jones, 1976; Atack et al., 1979) reported to have decreased when *Spirulina* meal was used as the sole protein source.

The present results confirm those of El- Sayed (1992) and Fiogbe et al. (2004) who reported an increase in specific growth rate in *O. niloticus* with incorporation of azolla (source of algae) in the diet. They attributed this increase in specific growth rate to an increase in food intake and diet digestibility. However, the positive role of dietary algae on SGR (% /day) of the fish was reported by some researchers such as Britz (1996) who showed that *Spirulina* (algae) spp. produced a significantly higher specific growth rate. Davies et al. (1997) also reported a satisfactory SGR per day with inclusion of *Spirulina* in diets.

The present study showed that dietary supplementation with *S. platensis* influenced feeding and growth parameters in *C. carpio*. Perhaps, due to improved feed intake and nutrient digestibility. Moreover, this species of *Spirulina* contains several nutrients especially vitamins and minerals that may promote fish growth. According to growth performance in the present study E2 feed (*Spirulina* diet) was considered to be the best feed for *C. carpio* as the weight gain and specific growth rate were increased and FCR decreased with the concentration of *Spirulina.* In many fresh water fishes the feed conversion ratio is known to decrease with increasing dietary protein content (Shetty and Nandeesha, 1988).

Data presented in Table-3.4 and figures-3.8, 3.9, 3.10 and 3.11 show that the GSI, HSI and SSI increased significantly with increase in rearing time from 0-30d in *C. carpio* fingerlings fed on E1, E2 diets compared to those fed on C1, C2 diets. Similar results have also been reported by Fournier et al. (2003) and Lunger et al. (2006) who reported that HSI increased because of inclusion of *Spirulina* in the diet. However Nakagawa, (1997) reported that there were no significant differences (P<0.001) in HSI among the sea bream fed dietary *Ascophyllum* meal.

The quality of red sea bream and striped jack, *Caranx delicatissimus*, was reported to have improved by feeding algae included feed (Nakagawa and Kasahara 1986; Watanabe et al., 1990). Dietary algae were also effective in improving the flavour and texture of cultured fish (Hirano and Suyama, 1985). Feeding with *Spirulina* improved muscle firmness, texture and taste of red sea bream and striped jack (Liao et al., 2009; Mustafa et al., 1994a, b). Furthermore, the algal carotenoids contributed to improve colouration of the skin and flesh of cultured fish (Sommer et al., 1992).

The present study suggests that *S.Platensis* could be used as a sole source of dietary protein in common carp to improve growth performance. Innovation of cost-effective technologies for cultivation of *S. Platensis* (Venkataraman et al., 1980; Saxena et al., 1989) would help exploitation of this alga as a fish feed ingredient.

Fig-3.1: Percent changes in the levels of final length (cms) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

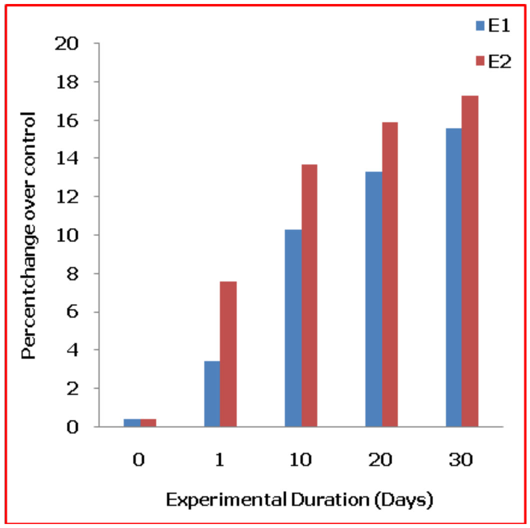


Fig-3.2: Percent changes in the levels of length increment (cms) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

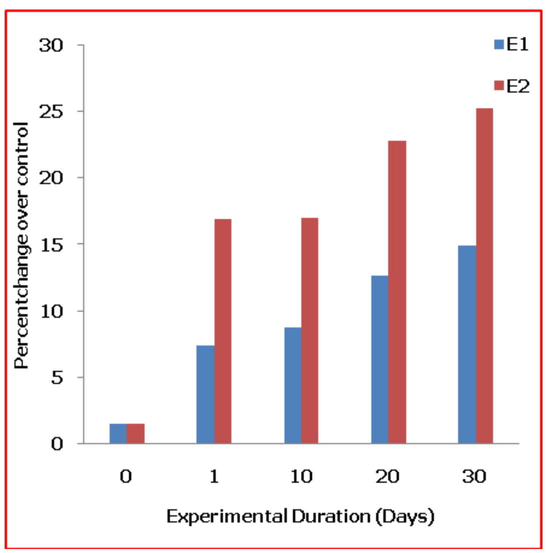


Fig-3.3: Percent changes in the levels of Final weight (gms) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

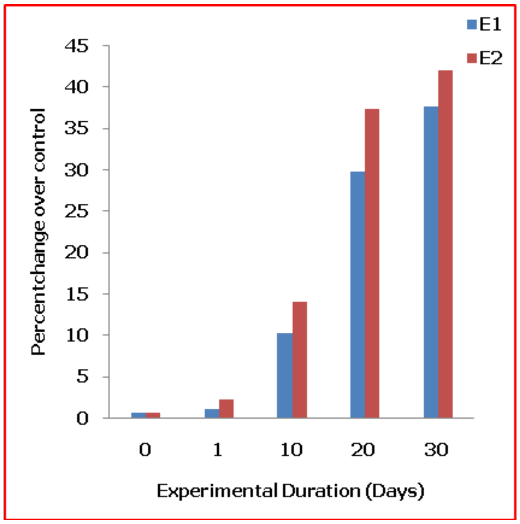


Fig-3.4: Percent changes in the levels of Weight gain (gms) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

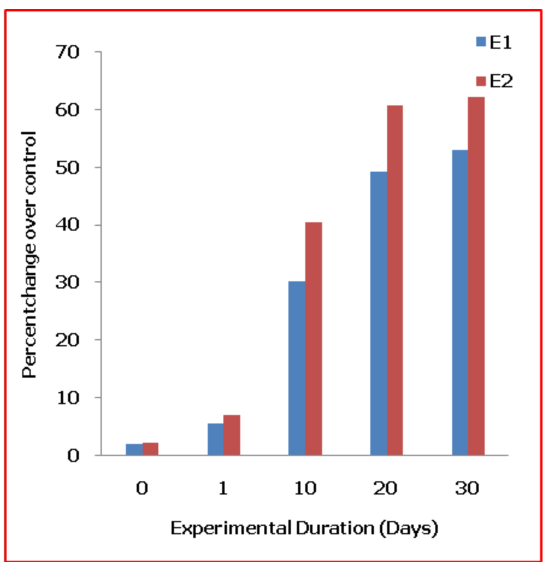


Fig-3.5: Percent changes in the levels of Food conversion ratio (FCR) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

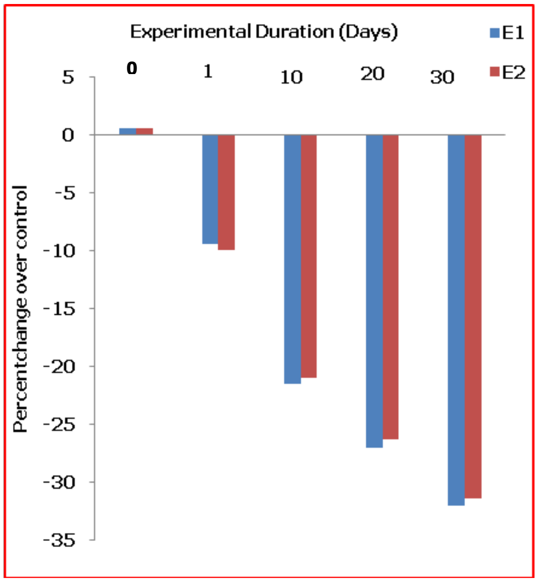


Fig-3.6: Percent changes in the levels of Food conversion efficiency (FCE) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

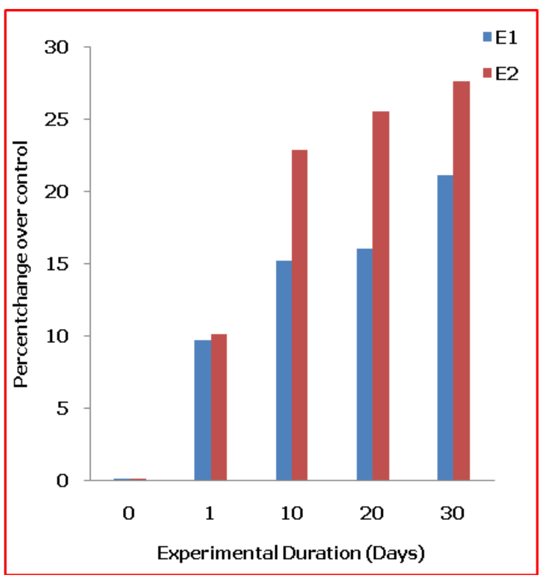


Fig-3.7: Percent changes in the levels of Specific growth rate (SGR) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

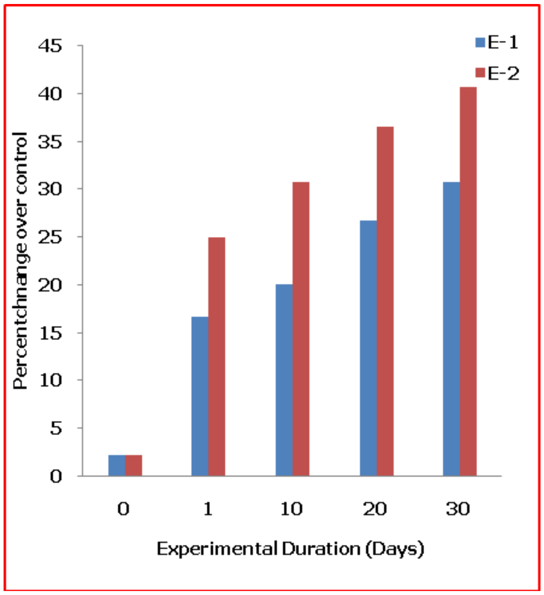


Fig-3.8: Percent changes in the levels of Gonadosomatic index (fGSI) in female of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.

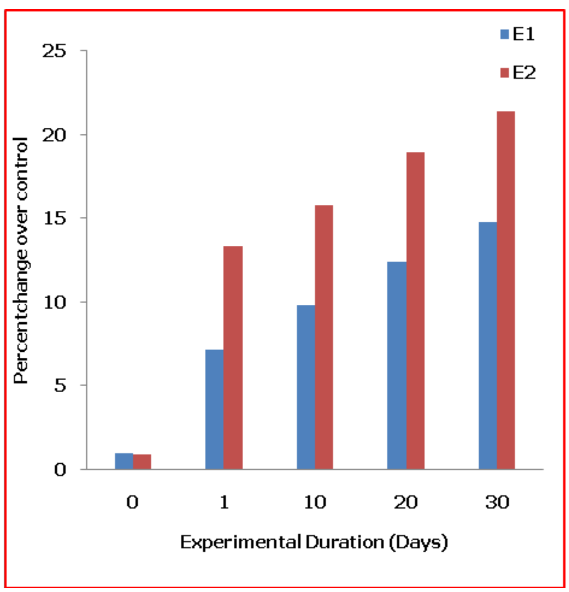


Fig-3.9: **Percent changes in the levels of Gonadosomatic index (mGSI) in male of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.**

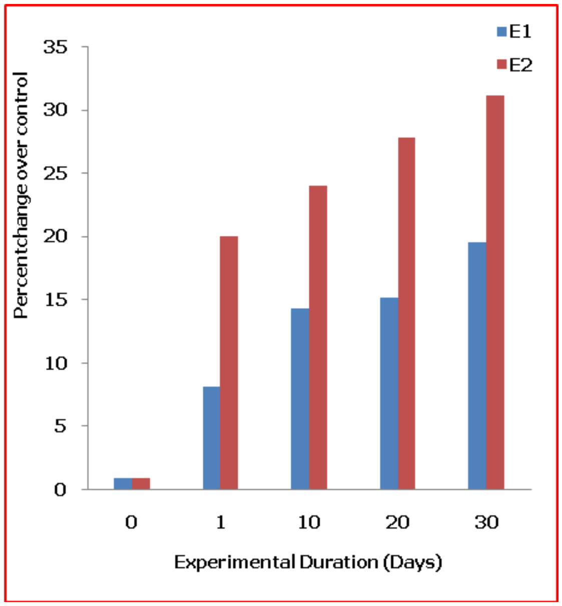


Fig-3.10: **Percent changes in the levels of Hepatosomatic index (HSI) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.**

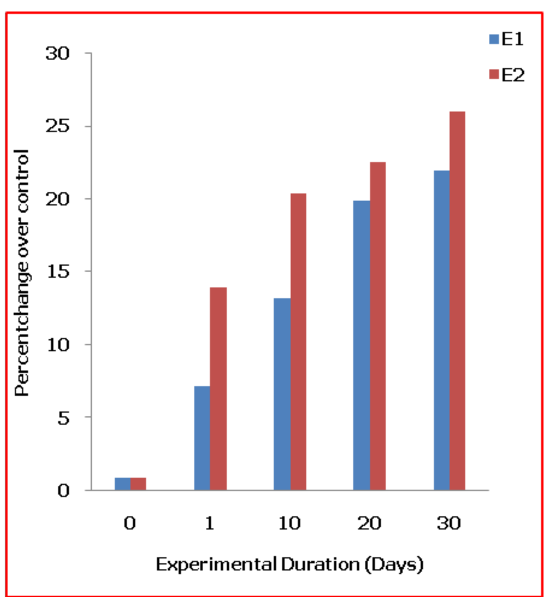
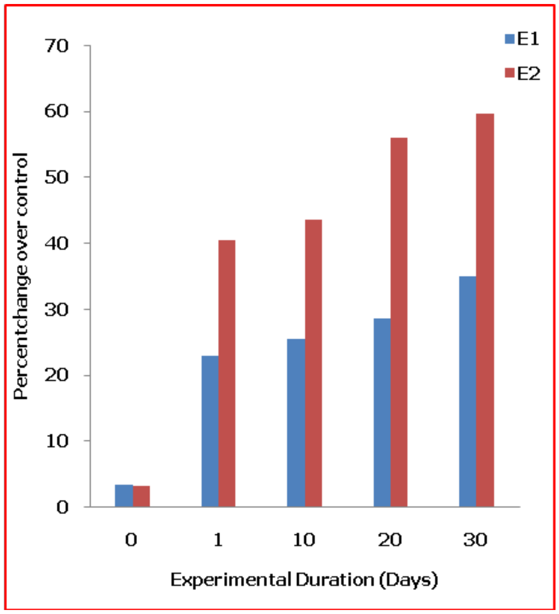


Fig-3.11: Percent changes in the levels of Splenosomatic index (SSI) of *Cyprinus carpio* fingerlings fed with different diets (C-1, E-1, C-2 and E-2) at the end of 1, 10, 20 and 30days.



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