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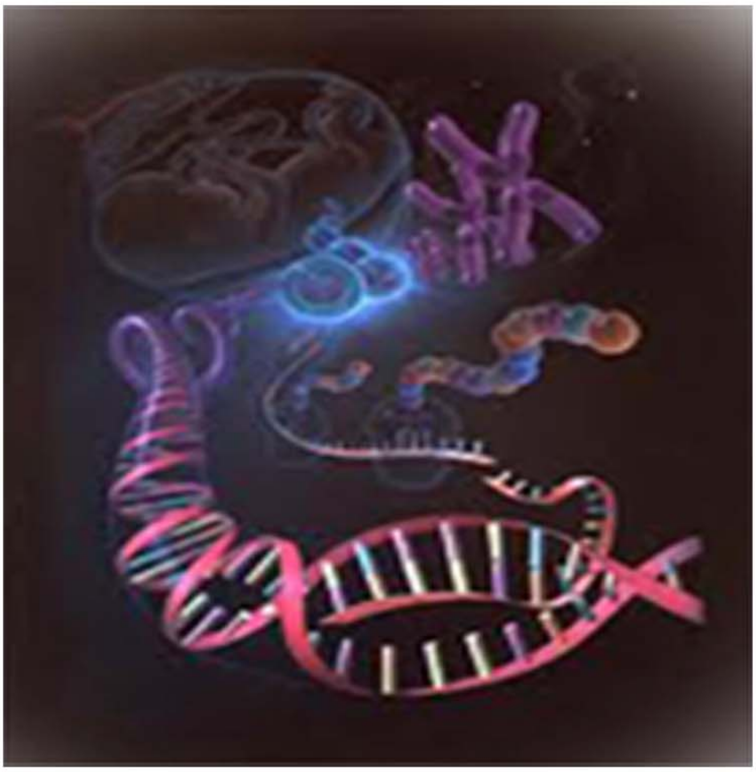

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Research Paper

INFLUENCE OF SPIRULINA FORTIFIED SUPPLEMENTARY FEED ON THE BIOCHEMICAL COMPOSITION OF FINGERLINGS OF THE COMMON CARP, *CYPRINUS CARPIO* (*L.* 1758)

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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 non-polluted 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% body weight at 8.00 am and 8.00 pm every day. Total protein, Total carbohydrate and Total lipid were measured in the muscle and Liver tissues of fingerlings on day 1, 10, 20 and 30. After the completion of 30 day period, it was observed that the total protein in the muscle and total lipid in the liver 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 body length and 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, Biochemical constituents

INTRODUCTION

Diet supplementation is an important aspect in aquaculture management especially in intensive or semi-intensive fish culture, and is promising for increasing fish production (Abdelghany A E, Ahmad M H, Abdel-Tawwab M, Abdelghany A E, Ahmad M H). However, protein is essential for normal tissue function, for the maintenance and renewal of fish body protein and for growth. Due to the high cost of the protein, the feed will be more cost effective if all the protein is used for tissue repair and growth and little catabolized for energy (Gauquelina *et al.*, .2007).

Spirulina is a cyanobacterium that has been commercially cultivated for more than 10 years due to its high nutritional content. Early interest in

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Spirulina focused mainly on its potential as a source of protein and vitamins (James *et al*., 2006). The composition of commercial *Spirulina* powder is 60% protein, 20% carbohydrate, 5% fat, 7% minerals and 3-6% moisture making it a low-fat, low calorie and cholesterol-free source of protein. *Spirulina* protein has a balanced composition of amino acids with concentrations of methionine, tryptopohan and other amino acids almost similar to those of casein although, this depends upon the culture media used (Habib *et al*., 2008). *Sprulina* has high quality protein content (59-65%) which is more than other commonly used plant sources such as dry soybeans (35%), peanuts (25%) or grains (8-9%). A special value of *Spirulina* is that it is readily digestible due to the absence of cellulose in its cell walls and after 18 h >85% of its protein is digested and assimilated (Sasson, 1997). *Spirulina* can be used as a partial supplementation or complete replacement for protein in aqua feeds and is a cheaper feed ingredient than other animal origin (Habib *et al*., 2008).

For example, it can be a suitable food supplement when fed to trout, sea bass, fancy carp, red tilapia, shrimp and molluscs. It has been reported that the alga can be used as an alternative source of protein to improve color, flavor and quality of meat (Al-Badri SHA, 2006). It has been reported that the *Spirulina* has therapeutic effects as a growth promoter, probiotic, and booster of the immune system in animals including fishes (James *et al*., 2006).

In addition, ß-carotene in *Spirulina* firmly maintains the mucous membrane and thereby prevents the entry of toxic elements into the body. Chlorophyll in *Spirulina* acts as a cleansing and detoxifying agent against toxic substances (James, 2010) The aim of this study is to examine the effects of *Spirulina* on the biochemical composition of the fingerlings of *C. carpio*, an aspect for which only cursory attention has been paid so far not only in other fishes but also in *C. carpio*.

MATERIALS AND METHODS

Fingerlings of *Cyprinus carpio* (*Common carp* L. 1758) (5.85 ± 0.02 g; 4.2 ± 0.22 cm) collected from government fish farm, Tirupati, near Chittoor Dist, AP (India) were brought to the laboratory and acclimatized to the laboratory conditions (12 h :12h L/D regime continuous aeration) for a week. Fish in group-1 (Control-1) are fed with feed containing Rice bran, Ground nut oil cake, Soybean cake and Fish meal (control diet-1). Fish in group-2 (Experimental diet-1) are fed with feed containing control diet-1+*Spirulina*. Fish in group-3 (control - 2) are fed with feed containing Rice bran, Ground nut oil cake, Soybean cake, Fish meal, Coconut oil cake and Prawn meal (control diet-2). Fish in group-4 are fed with feed containing control diet-2+*Spirulina* (Experimental diet-2) (Table 1).

The water quality parameters are estimated include Dissolved Oxygen-4 to 8 ppm, Temperature-28 to 32^{o}C, PH-7.4 to 7.8, Salinity-0.190 g/L, Chlorinity-0.110 g/L, Alkalinity-102 ppm, and Hardness of water-112 ppm. During acclimatization both control and experimental groups were fed twice daily on control and experimental diets for 30d with 25% water change daily.

The total protein content of the tissues was estimated by the method of Lowry *et al.* (1951). The total carbohydrate content was estimated by the method of Carroll *et al.* (1956). Total lipid content was estimated by the method of Folch *et* *al.* (1957). Values were expressed as mean ± SD for six replicates in each group and statistical differences between mean values were determined by one way analysis of variance (ANOVA) followed by the Duncan multiple range test (Duncan, 1955).

RESULTS

The concentrations of Total Protein (TP), Total Carbohydrate (TCHO), and Total Lipid (TL) have been measured in the muscle and liver tissues of *Cyprinus carpio* fingerlings fed for 30 days on control (C1 and C2) and experimental (E1 and E2) diets on day 1, 10, 20 and 30 of the rearing period. Results pertaining to the concentration of total protein in the muscle of *Cyprinus carpio* fingerlings fed on control and experimental diets are presented in Figures 1 and 2. The results clearly show that there is a significant increase in the protein content of the muscle with increase in rearing time both in control and experimental groups. Obviously within the treated/experimental groups, except on day 1, there are significant increases ($P<0.01$) in the total protein content of the muscle in the experimental groups (E1, E2) compared to control (C1, C2) groups (Table 2). For instance E1 and E2 diets enhanced the protein content of the muscle by 18% and 17% respectively on day 10; by 27% and 28% on day 20 and by 31% and 30% on day 30 compared to the respective C1 and C2 diets (Figure 2). However, there are no significant differences in the muscle protein content of the fingerlings fed on E1 and E2 diets on all the specified rearing periods.

Figures 3 and 4 present results on the concentration of total protein in the liver of *Cyprinus carpio* fingerlings fed on control (C1, C2) and experimental (E1, E2) diets. It is clear

Table 1: Proximate Composition of the Ingredients and Experimental Diets (%; on Dry Matter Bases)

Ingredients	Percentage
Rice Bran	21
Ground nut oil cake	10
Soybean cake	10
Fish meal	29
Coconut oil cake	7
Prawn meal	16
Vitamin premix	1
Mineral premix	1
Spirulina	5.00
Total	100
Composition of Mineral Mix	
Calcium	30%
Phosphorus	9%
Magnesium	2,650mg
Cupper	312mg
Cobalt	45mg
Iron	979mg
Zink	2,130mg
Iodine	156mg
Manganese	2,000mg
Selenium	50mg
Methionine	1,920mg
Chemical Analysis	
Crude protein	30.6(%)
Crude Fat	7.28(%)
Crude Fiber	5.26(%)
Ether extract	9.1(%)
Ash	8.3(%)
Gross energy	14.72(%)
Moisture	8-10(%)

Figure 1: Changes in the Levels of Total Protein (TP) mg/gm Wet weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the end of 1d, 10d, 20d and 30 Days

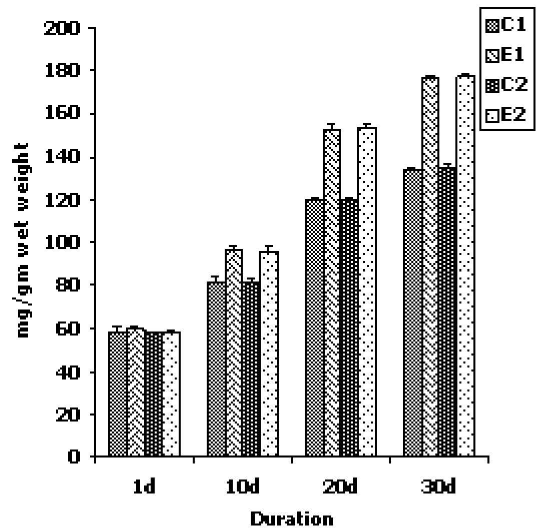


Figure 2: Percent Changes in the Levels of Total Protein (TP) mg/gm Wet Weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the end of 1d, 10d, 20d and 30 Days

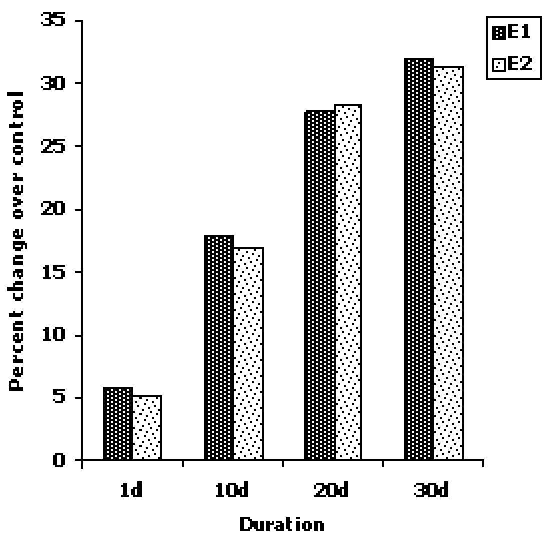


Figure 3: Changes in the levels of Total Protein (TP) mg/gm Wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* fed with Different Diets (C1, C2, E1, E2) at the end of 1d,

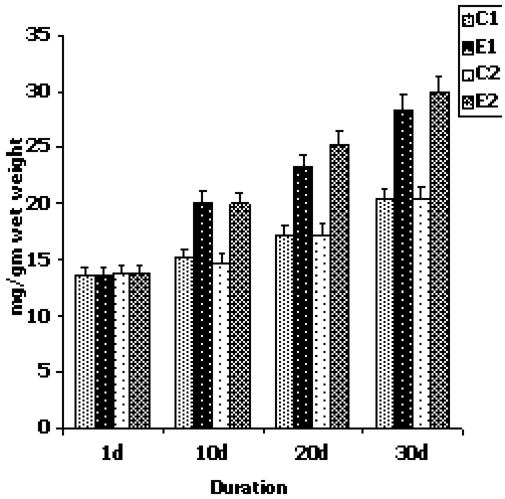
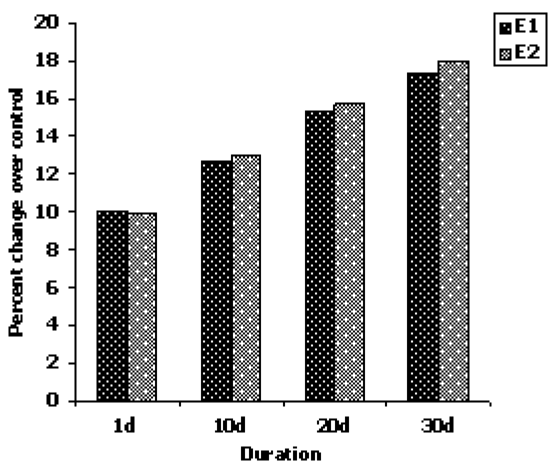


Figure 4: Percent Changes in the levels of Total Protein (TP) mg/gm Wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* fed with Different Diets (C1, C2, E1, E2) at the end of 1d,



from the results that there is a significant increase ($P<0.001$) in the total protein content of the liver with increase in rearing time both in control and experimental groups (Figure 3; Table 2). Apparently there is a significant increase ($P<0.001$) in the total protein content of the liver of fingerlings fed on experimental diets (E1, E2) compared to those fed on control diets (C1, C2)

Table 2: Changes in the Levels of Proteins, Carbohydrates and Lipids in Muscle and Liver Tissues of Fingerlings of *Cyprinus Carpio* Fed With Different Diets (C1, C2, E1, E2) at The End of 1d, 10d, 20d and 30days

Tissues		Proteins				Carbohydrates				Lipids			
		1d	10d	20d	30d	1d	10d	20d	30d	1d	10d	20d	30d
Muscle	C1	57.744	81.936	119.3048	133.812	45.408	56.424	58.944	71.256	36.612	55.296	78.3	99.072
		3.298151	2.19287	1.753462	0.731429	0.371806	0.684063	0.59489	0.549595	0.59154	1.802015	3.392644	5.518226
	E1	59.68	96.624	152.388	176.4	50.06333	63.52	68.68133	76.2085	37.14267	67.176	99.108	124.2
		0.981949	1.500643	2.425972	0.59154	0.721739	1.656158	1.58444	1.01991	1.31998	1.413109	7.519055	5.483168
	Change(%)	5.7	17.9261	27.7399	31.8267	2.378	5.487	14.3	18.6	6.7846	17	20.66525	26.57
	C2	57.672	81.987	119.34	135.108	44.448	56.568	59.808	73.92	36.18	55.152	79.56	101.736
		0.760614	1.561272	1.901536	1.398173	0.59489	0.526471	0.504343	5.821353	0.963563	4.650108	2.623014	3.844557
	E2	58.536	95.868	153	177.444	51.25267	62.90533	74.39867	85.24	36.936	65.52	103.716	122.76
		0.511149	2.40301	2.038503	0.903593	1.283307	1.931787	1.659821	2.224696	0.772785	1.329175	3.040668	3.913516
	Change(%)	5.2	16.9307	28.2051	31.3349	1.997	7.17	14.6	18.019	9.8	18	25.36337	30.3619
Liver	C1	13.60333	15.14	17.24	20.36667	56.41317	70.33183	93.624	116.0373	57.94817	83.096	143.1108	155.048
		0.43242	0.588999	0.668491	0.564718	1.04383	8.568861	3.388739	3.563075	0.637948	2.776569	2.938067	2.418012
	E1	13.61833	20.14667	23.255	28.29667	53.951	86.90533	117.5532	144.5635	58.996	121.752	180.0107	199.7472
		0.592939	0.271931	1.461338	0.505318	2.913097	3.416774	5.759709	2.873333	3.695857	3.737903	5.552624	4.300415
	Change(%)	10.02	12.64	15.26	17.36	7.9	23.56472	21.37973	30.61283	9.7	23.48291	28.82927	29.489
	C2	13.865	14.72167	17.28167	20.465	55.76117	66.68483	88.26767	122.263	58.356	87.732	145.826	153.922
		0.467493	0.468547	0.652025	0.395108	1.579363	1.515415	1.949067	4.453833	1.096435	1.850134	2.469777	0.845043
	E2	13.79833	19.98333	25.20833	29.84167	54.718	87.02883	126.7637	148.4025	58.176	123.7857	180.4	199.34
		0.320213	0.508475	0.524115	0.794693	2.058331	3.110403	2.70527	2.497728	0.40217	2.658364	3.963672	2.21763
	Change(%)	9.88	12.92	15.67	17.99	8.6	24.578	25.55883	33.61283	10.9	26.70908	29.50715	36.51967

except the first group. Obviously E1 and E2 diets augmented total protein content of the liver by 12% and 13% respectively on day 10; by 15% and 16% on day 20 and by 17% and 18% on day 30 compared to the respective C1 and C2 diets (Figure 4 and Table 2). However E2 diet enhanced total protein content of the liver significantly than E1 on day 20 and opposite is true for day 30.

Results on the concentration of total carbohydrate in the muscle of fingerlings of *Cyprinus carpio* fed on control and experimental diets are presented in Figures 5 and 6. It is evident from the results that there is a significant increase ($P<0.001$) in the total carbohydrate content of the muscle with increase in rearing time from 1 to 30 days both in control and experimental groups

(Figure 5). Obviously there are significant increases (P<0.001) in the total carbohydrate content of the muscle of fingerlings fed on experimental diets (E1, E2) compared to those fed on control diets (C1, C2) on day 10, 20 and 30 but not on day 1. Apparently E1 and E2 diets enhanced total carbohydrate content of the muscle significantly by 13% and 22% respectively on day 10; by 17% and 24% on day 20 and by 18% and 21% on day 30 compared to the respective C1 and C2 diets (Figure 6) shown in Table 2. However E2 diet increased total carbohydrate content of the muscle significantly than E1 diet on days 10, 20 and 30.

Figures 7 and 8 present results on the total carbohydrate content of the liver of *Cyprinus carpio* fingerlings fed on control (C1, C2) and experimental (E1, E2) diets. The results clearly show that there is a significant increase (P<0.001) in the total carbohydrate content of the liver with increase in rearing time both in control and

Figure 5: Changes in the levels of Total Carbohydrate (TCHO) mg/gm Wet Weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the end of 1d, 10d, 20d and 30 Days

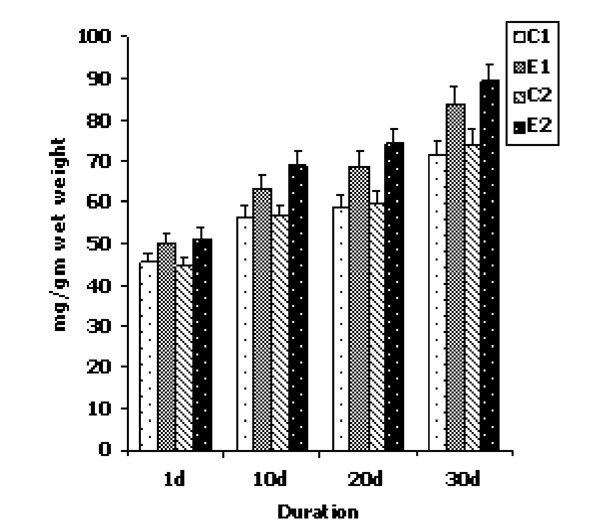
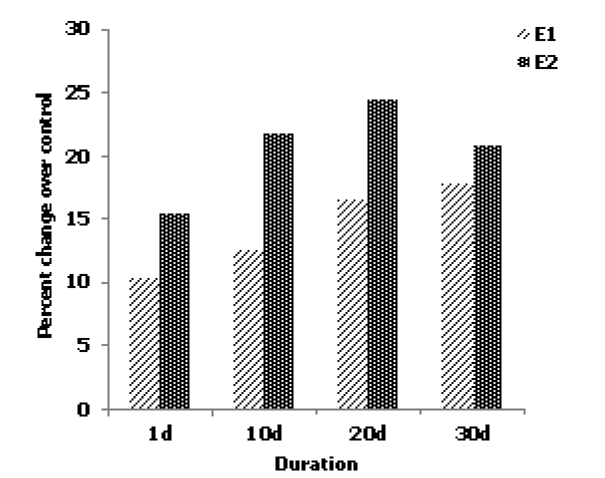


Figure 6: Percent changes in the levels of Total Carbohydrate (TCHO) mg/gm wet Weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days



experimental groups (Figure 7). Apparently there is a significant increase (P<0.001) in the total carbohydrate content of the liver of fingerlings fed on E1 and E2 diets compared to those fed on C1 and C2 diets. The results show that E1 and E2 diets caused a significant increase (P<0.001) in the total carbohydrate content of the liver by 24%

Figure 7: Changes in the levels of Total Carbohydrate (TCHO) mg/gm wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days

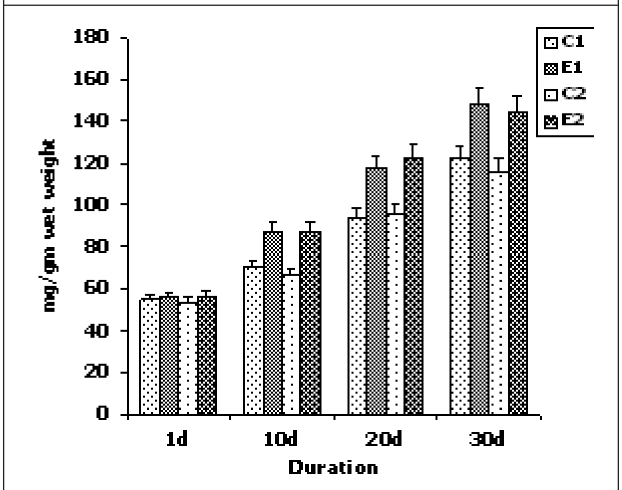


Figure 8: Percent Changes in the levels of Total Carbohydrate (TCHO) mg/gm wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days

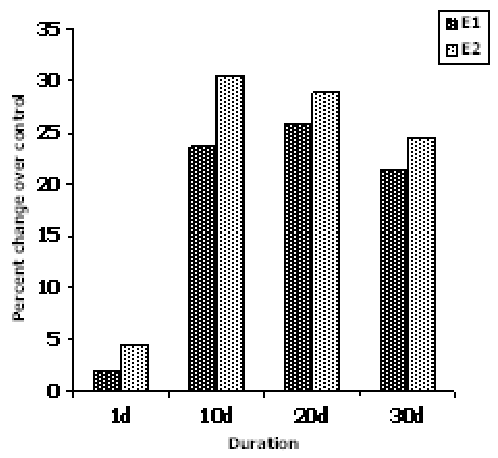


Figure 9: Changes in the levels of Total Lipids (TL) mg/gm wet Weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days

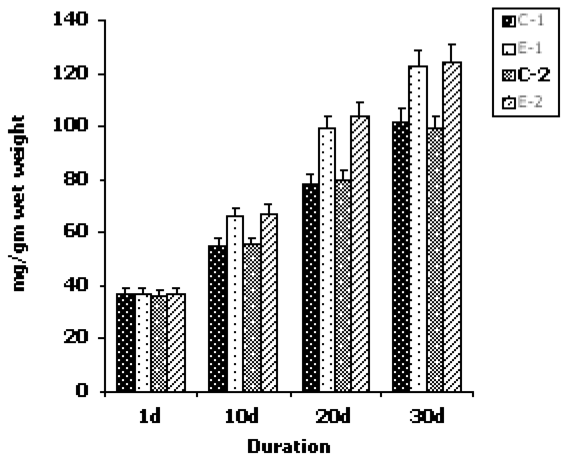
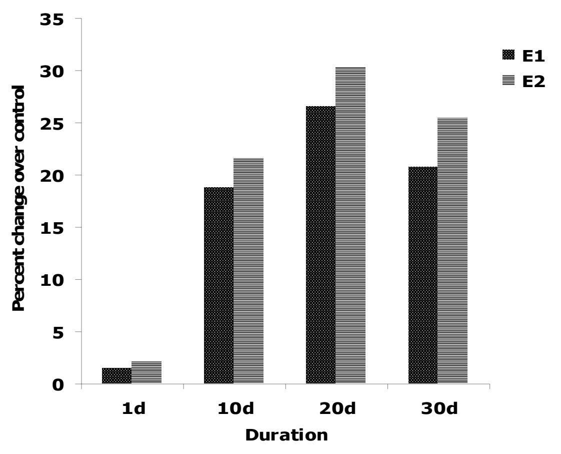


Figure 10: Percent Changes in the levels of Total Lipids (TL) mg/gm wet Weight in Muscle Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days



and 31% respectively on day 10; by 26% and 29% on day 20 and by 21% and 25% on day 30 compared to the respective C1 and C2 diets (Figure 8). Interestingly E2 diet enhanced the total carbohydrate content of the liver significantly than E1 diet on days 10 and 20 but not on day 30 (Figure 8).

Results pertaining to the concentration of total lipid in the muscle of *Cyprinus carpio* fingerlings fed on control (C1, C2) and experimental (E1, E2) diets are presented in Figures 9 and 10. It is evident from the results that there is a significant increase ($P<0.001$) in the total lipid content of the muscle with increase in rearing time from 1 to 30 days both in control and experimental groups (Figure 9). Clearly there are significant increases ($P<0.001$) in the total lipid content of the muscle of fingerlings fed on experimental diets (E1, E2) compared to those fed on control diets (C1, C2) on days 10,20 and 30 but not on day 1. Obviously E1 and E2 diets enhanced total lipid content of the muscle by 19% and 22% respectively on day 10; by 27% and 30% on day 20 and by 21% and 25% on day 30 compared to the respective C1 and C2 diets (Figure 10). It is further observed that E2 diet increased the total lipid content of the liver significantly than E1 diet on day 20 compared to days 10 and 30.

Results on the concentration of total lipid in the liver of fingerlings of *Cyprinus Carpio* fed on control and experimental diets are presented in Figures 11 and 12. The results clearly show that there is a significant increase (P<0.001) in the total lipid content of the liver with increase in rearing time from 1 to 30 days both in control and experimental groups (Figure 11). Evidently there is a significant increases (P<0.001) in the total lipid content of the liver of fingerlings fed on experimental diets (E1, E2) compared to those fed on control diets (C1, C2) on days 10, 20 and 30 but not on day 1. It is clear that E1 and E2 diets enhanced total lipid content of the liver by 23% and 27% respectively on day 10; by 24% and 26% on day 20 and by 29% and 30% on day 30 compared to the respective C1 and C2 diets (Figure 12). Interestingly no significant differences were observed in the total lipid content of the liver as a function of treatment of fingerlings with E1 and E2 diets on days 10, 20 and 30.

Figure 11: Changes in the levels of Total Lipids (TL) mg/gm wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days

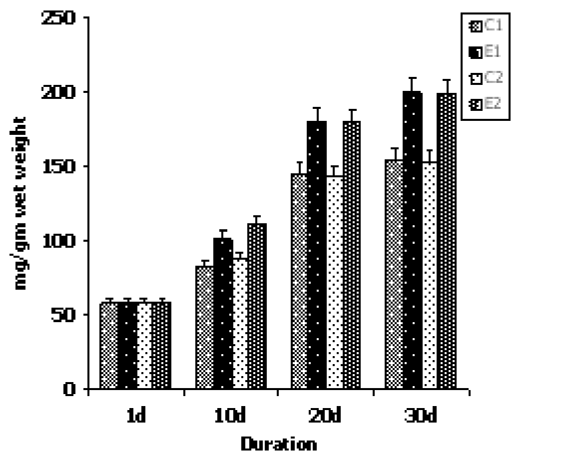
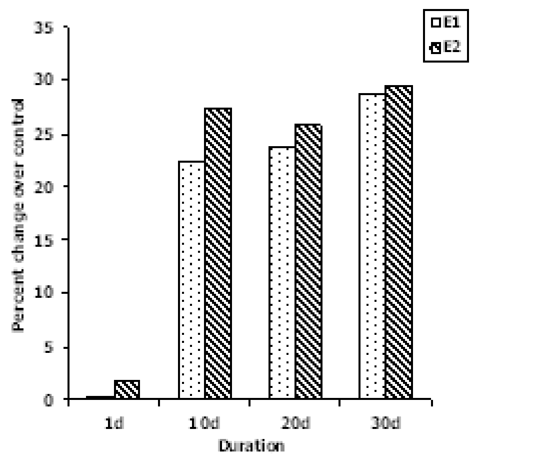


Figure 12: Percent Changes in the levels of Total Lipids (TL) mg/gm wet Weight in Liver Tissues of Fingerlings of *Cyprinus carpio* Fed with Different Diets (C1, C2, E1, E2) at the End of 1d, 10d, 20d and 30 Days



DISCUSSION

Proteins are indispensable for growth and maintenance of life in all living beings. Prior research in carps has demonstrated that the requirement for protein was similar at production levels ranging from 20 to 40% (Coddington and Rodriguez, 1995). Even within carps the requirement for protein varies widely in different as well as in individual species at different life history stages. Thus, there is an increasing need to determine the nutritional requirements of several carps to be able to formulate an effective and economically efficient diet.

With a steady increase in fish farming in India during recent years there is a great demand for compounded feeds. It is widely reported that carps require more than 35% protein for metabolic activities, but unfortunately research inputs in this area have been very much limited. In general the nutritional requirements of any animal may be met from different types of locally available feed ingredients. Therefore knowledge on the locally available feed ingredients is of prime importance as far as multi ingredient diets are concerned.

Common carp is an ideal species for mass culture in freshwater ecosystems. Development of a balanced artificial diet is most essential for successful rearing of common carp. It has been reported that only those diets which are low in both protein and total energy have resulted in decreased weight gain (Lee and Putnam, 1973; Garling and Wilson, 1976). The optimum amount of dietary protein and energy, therefore, play a key role in the growth of fish.

After protein, total carbohydrate and total lipid represent the third most abundant group of organic compounds in the animal body. Carbohydrates are the most economical source of dietary energy and are known for their protein sparing action. Besides, being an important source of dietary energy, carbohydrates play an important role in glycogen storage and formation of steroids and fatty acids in fishes (Chung, 1991). It has been reported that total carbohydrate can play a significant role in determining the quantitative requirement of protein and lipid while it can be utilized for metabolic energy needs of the animal (Pascual *et al.,* 1983; Ali, 1993) and, protein and lipid, can be spared for more important and essential body functions and growth.

A recent trend in the formulation of fish feeds is to use higher levels of lipid in the diets. Increasing dietary lipid can help reduce the high costs of formulated feeds by partially sparing protein in the feeds. Dietary lipids are an important source of energy and the only source of essential fatty acids needed by fish for normal growth and development. Fish can readily metabolize lipids which provide 9.38 kcal/g energy and can spare protein for growth improving Net Protein Utilization (NPU).

As the commercial feeds available in the market are becoming costlier by the day, it is all the more essential to formulate feeds with locally available and cheap feed ingredients. It is in this context that this study assumes significant.

The results of this study clearly demonstrated the positive influence of herbal supplemented formulated feeds on the growth of *Cyprinus carpio* fingerlings. It is quite evident from the results that the protein content of the muscle and liver of the fingerlings increased with increase in time from 1 to 30 days indicating the positive influence of the formulated feeds on growth (Figures 1 to 4). However E1 and E2 diets seem to have a more potentiating effect on the total protein content of the muscle and liver than C1 and C2 diets on days 10, 20 and 30. The fact that E1 and E2 diets have *Spirulina* as a component could be the reason which probably explains the significant increase in the total protein content of the muscle and liver compared to C1 and C2 diets without *Spirulina* as an integral component. Similar results have been reported in other fresh water fish where herbal supplemented diets greatly enhanced the total protein content of the fish (Stefens, 1981; Wilson *et al.*, 1985, Jayaram and Beamish, 1992). One plausible explanation that could be offered is that *Spirulina* might have improved digestive processes by stimulating digestive enzymes activity resulting in better food conversion efficiency leading to accumulation/ synthesis of greater amounts of protein in the muscle and liver. Another possible reason could be the effect of *Spirulina* on other macronutrients like total carbohydrate and total lipid resulting in protein sparing effect. That the E1 and E2 diets containing *Spirulina* as a constituent do have a beneficial effect on the total protein content and, thus on the growth, has been demonstrated in this study.

Herbal supplemented formulated feeds also influenced total carbohydrate content of the muscle and liver of *Cyprinus carpio* fingerlings. The results clearly show that the total carbohydrate content of the muscle and liver of fingerlings increased gradually with increase in rearing time from 1 to 30 days (Figures 5 to 8) indicating that the herbal supplemented formulated feeds had a positive effect on the total carbohydrate content. Obviously E1 and E2 diets seem to have more pronounced effect on the total carbohydrate content of the muscle and liver than C1 and C2 diets on day 10, 20 and 30. This could be ascribed to the fact that *Spirulina* is a component of E1 and E2 diets and might be responsible for the recorded increase in the total carbohydrate content when the fingerlings are fed on E1 and E2 diets. It is reported that omnivores, like carps, may utilize carbohydrates as energy source and create protein sparing effect unlike carnivores (Morris, 2001; Hemre *et al*., 2002). Several studies have shown that high energy diets increase carbohydrate concentrations leading to an increase in total lipid resulting again in protein sparing effect (Lee *et al*., 2002; Luzzana *et al*., 2002; Yamg *et al.*, 2003). Hemre (2001) reported that approximately 15% of the carbohydrate ingested will be stored as liver glycogen and around 8-15% will be stored as muscle glycogen. Apparently *Spirulina* which is a component of E1 and E2 diets might have stimulated the digestive enzymes leading to better digestion. The net result of this process may lead to better conversion rates and, thus, accumulation of total carbohydrate in the muscle and liver. It has been demonstrated in several fishes that accumulation of total carbohydrate results in protein sparing effect (Cho and Kaushik, 1990; Rasmussen, 2001; Kikuchi and Takedra, 2001). The results of this study have shown that E1 and E2 diets, having *Spirulina* as an ingredient, have enhanced total carbohydrate in the muscle and liver which, probably is beneficial to the fish.

Just like in the case of total protein and total carbohydrate *Spirulina* supplemented herbal diets enhanced total lipid content of the muscle and liver of *Cyprinus carpio* fingerlings on day 10, 20 and 30 indicating a positive relationship between *Spirulina* supplemented diet and total lipid content (Figures 9-12). The results clearly show that E1 and E2 diets significantly increased total lipid content of the muscle and liver than C1 and C2 diets. It is very well known that total lipid in fish provide essential fatty acids, phospholipids and energy to fish to promote growth (Sargent *et al.,* 1999). Dietary lipid, just as dietary carbohydrate, can act as an energy source to spare protein for energy and also increases palatability (Huang *et al.,* 2001; Chaiyapechara *et al*., 2003). Enhanced total lipid in body tissues has been reported in rainbow trout diets (Brauge *et al.,* 1994) and *Tilapia zilli* (El- Sayed and Garling, 1988) fed on herbal supplemented diets. The increase in total lipid has been attributed to enhanced biochemical processes in the digestive tract and enhanced absorption and assimilation of the ingested diet. Similarly *Spirulina* might have also enhanced digestion, absorption and assimilation of the ingested food in *Cyprinus carpio* fingerlings leading to an increase in the total lipid content of the muscle and liver of *Cypinus carpio* fingerlings than in those fed on control diets without *Spirulina*. It has been shown that enhanced body lipid contributes to better growth by sparing protein (Serranno *et al.*, 1992; Wilson, 1994).

In summary the results on the total protein, total lipid and total carbohydrate in the muscle and liver of *Cyprinus carpio* fingerlings fed on herbal supplemented formulated diets clearly show that *Spirulina* has increased all the three major nutrients by enhancing digestive processes leading to better absorption and assimilation of injested food. It has been reported that *Spirulina* further prevents the systemic absorption of mycotoxins and support the growth of beneficial bacteria in the intestines thus improving the health and overall growth of fish.

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