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Influence Of Animal And Plant Source Dietary Lipids On The Growth Performance And Proximate Composition Of Major Carps

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ABSTRACT

The present study was conducted to investigate the impact of different percentages of animal and plant origin dietary lipids level on growth performance and body composition of major carps. Four plant and animal origin fats supplemented experimental diets of different levels of lipids viz. 0%, 3%, 6% and 9% were made. Twenty-one treatments were made with different levels of animal, plant and combination of animal and plant dietary lipids, where twenty fingerlings were stock in each experimental tank. Animal-based saturated (ABS), unsaturated (ABUS), plant- based monounsaturated (PBMU), polyunsaturated (PBPU) and the combination diets were prepared using different percentages of animal and plant based dietary lipids. Growth performance (weight gain, total length and fork length)and food conversion ratio was recorded monthly. The body composition in terms of crude protein, crude ash, crude fat and moisture were determined. Results showed that weight gain, total length and fork length in cirrhinus mrigalawas significantly higher as compared to other two carp species.Significant ($p < 0.05$) increase in both parameters at 6% and 9%dietary lipid levels as compared to the fish fed on 0% and 3%. The Cirrhinus mrigala showed significantly higher crude protein in 6% ABS dietary lipids followed by Labeo rohita and Catla catla. The significant higher moisture content and crude ash were recorded in L. rohita in 3% ABUS and 9% animal and 6% plant dietary lipids,whereas, C. catla showed the significant higher crude fat contents in 9% ABUSdietary lipids.In conclusion, C. mrigala shows significant improvement in growth performance. Similarly, fishes fed on animal-based dietsand in combination diet, showed consistently significant ($p < 0.05$) increase in crude protein, crude fat,moisture and crude ash with the increasing levels of dietary lipids from 0 to 9%.

Key words: Growth performance, Fork length, Crude protein,Crude fat

1. Introduction

Fish is a significant nutritious food and is considered as one of the major sources of quality animal protein. It provides approximately 26.2% of high-quality protein and is a fast-growing food source in Asia as well as other developing countries.[1] Fish is also considered as an excellent source of protein due to its high digestibility i.e., 85-90% and balanced amino acid profile.[2] Proteins play a vital role in the growth and development of body tissues as well as synthesis of enzymes and hormones which are essential for different biochemical processes of the body. Fish is a good source of polyunsaturated fatty acids (PUFA) like omega 3 and 6 which produces beneficial effects on the health of human beings. It is also considered as an efficient source of different vitamins and minerals which act as important constituents of different biochemical processes of the body.[3] Due to its high nutritional value, it is also involved in resolving the problem of malnutrition in humans as well.[4]

Aquaculture sector is one of the most significant and fastest growing industries in terms of fisheries production to meet the increasing demands of sea food. The production of aquaculture is constantly increasing since 1950 worldwide. It is estimated that 50% of the total fish production comes from aquaculture industry.[5,6] The total fisheries production is 171 million metric tons which is constantly increasing since 2012.[6]

Pakistan has a great potential towards aquaculture as this sector is in growth phase. It is the most recent practice here. There are approximately nine fish species which are cultured in Pakistan commercially.[7]These species include seven warm water and two cold water fish species. The estimated total aquaculture production of major carps is 87%. Aquaculture in the developing countries like Pakistan and India has a great potential as they are highly dependent upon this sector for quality meat production.[8]

Major carps are the most extensively cultured fish species in Pakistan and India. They are also the primary cultured fish species of south Asia. Major carps include Labeo rohita, Catla catla and Cirrhinus mrigala. Labeo rohita is commonly cultured among other major carp species due to its high-quality meat, rapid growth rate, good taste and resistance against diseases.[9] Cirrhinus mrigala is commonly known as mori. It is one of the significant cultured specie in Pakistan, it is mainly herbivorous and bottom feeder. It is dominant cultured fish specie in Indian sub-continent as well as Asia.[10] Catla catla is a surface feeder and it preferably feeds on zooplanktons. It shows maximum feed utilization and growth if it is provided with proper nourishment and optimum temperature.[11]

Lipids are an important group of organic compounds which are the derivatives of fatty acids. They are only soluble in organic solvents. They are considered as one of the most vital constituents of diet as energy rich compounds.[12] Dietary lipids play a significant role in improving the growth parameters, membrane fluidity, breeding, osmoregulation, vision and immunity of fish body. They also play a vital role in transportation, metabolism and absorption of carotenoids and vitamins. Supplementation of lipids in the diet of fish results in enhancing the growth and feed efficiency by increasing the sparing protein effect.[13] Plant oils are very important components in aquaculture feed formulations as it contains less amount of phosphorus than fish oil. They contain high levels of monounsaturated, omega 6 and polyunsaturated fatty acids. The plants by products are considered as a good source of vitamin E and proteins which are involved in the preparation of high-quality and cost-effective diets.[14]

Growth is one of the most important parameters of cultured fish species as it determines their economic value and effectiveness. It is affected not only by the diet

but also certain water quality parameters like PH, temperature and dissolved oxygen. They act as the most limiting factors for growth.[15] Lipid supplementation in the diet of fish is very important in maintaining the effective feed utilization and good growth rate. Antioxidants are usually supplemented to lipid enrich diet in order to prevent rancidity in feed. The growth and meat contents of the fish production in aquaculture are highly affected by the availability of necessary ingredients in diet and their digestibility.[16]

Body composition is usually measured in terms of the percentage of ash, moisture, protein and fat contents in aquatic organisms particularly fish. The physiological and functional state of fish can be determined by using this parameter. Omega 3 and omega 6 are the dietary fatty acids which plays an important role in enhancing the body composition of fish.[17] By increasing the level of fats in the diet, crude fat, total body fat and muscle lipid content also increases in fish which in turn contributes towards enhancing its nutritional value up to a certain limit.[18]

Now a day's aquaculture sector is focusing on the formulation of economical, low protein and high energy feeds for fish. However, the ratio between protein and non-protein energy should be balanced in order to enhance the growth and development of fish. One of the most important aspects of diet formulation is protein to energy ratio which has a direct impact on growth performance and body composition of fish which varies from specie to specie.[19] Therefore, the present was planned to evaluate the effect of dietary lipid levels (plant & animal origin) on the growth performance and body composition of major carps (Indian fishes, Catla catla, Cirhinus mirigla, Labeo rohitaa).

2. Methodology

2.1. Experimental Conditions:

Fingerlings of major carps were taken from the Government Fish Hatchery, Faisalabad. Fingerlings of carps (Labeo rohita, Cirrhinus mrigala and Catla catla) were put in tanks where they were acclimatized to new experimental conditions. Fishes were fed once a day on basal diets. Before conducting trial, these fingerlings were dipped in 5g/L NaCl solution. By using digital meter dissolved oxygen of water medium was checked and maintained (HANNA, model HI 9146). Water quality parameters i.e., temperature of water and pH was monitored by AMPROBE pH meter. Other water quality parameters like total ammonia, total dissolved solids (TDS), carbonates, bicarbonates, calcium, magnesium and total salinity were also measured periodically throughout the experimental trial. Aeration was given to experimental tanks by using aeration capillary system.

2.2. Experimental Diets and Ingredients:

Ingredients of experimental diets were taken from local market and before making diets these ingredients were chemically analyzed according to rules of AOAC (1995). Before making experimental fat-based diets, ingredients were ground and strained for getting specific particle size. The diets were formulated on the basis of plant origin (monounsaturated and polyunsaturated), animal origin (saturated and unsaturated) and combination of plant and animal origin dietary lipids. Each experimental diet formulated was made by supplementing different levels of lipids viz. 0%, 3%, 6% and 9% (El-Kasheif et al.2011).

Table 1: Composition of experimental diets with unsaturated animal-based lipid levels

Ingredients				% Animal-based saturated and unsaturated lipids in diet and % plant based mono and poly unsaturated			
Unsaturated animal-based lipid	**Saturated animal-based lipid**	**Monounsaturated plant-based lipid**	**Polyunsaturated plant-based lipid**	**Control**	**3%**	**6%**	**9%**
Fish Meal	Fish Meal	Fish Meal	Fish Meal	45.0g	45.0g	45.0g	45.0g
Fish oil	Beef Tallow	Canola oil	Sunflower oil	0.0g	1.5g	3.0g	4.5g
Cod liver oil	Poultry fat	Olive oil	Soybean oil	0.0g	1.5g	3.0g	4.5g
Wheat bran	Wheat bran	Wheat bran	Wheat bran	29.0g	26.0g	23.0g	20.0g
Vitamins and mineral mix	Vitamins and mineral mix	Vitamins and mineral mix	Vitamins and mineral mix	1.0g	1.0g	1.0g	1.0g
Rice bran	Rice bran	Rice bran	Rice bran	24.0g	24.0g	24.0g	24.0g
Ascorbic Acid (Antioxidant)	Ascorbic Acid (Antioxidant)	Ascorbic Acid (Antioxidant)	Ascorbic Acid (Antioxidant)	1g	1g	1g	1g
Total				100g	100g	100g	100g

Table 2: Composition of experimental diets with combination of (3%, 6% and 9%) plant and 3% animal-based lipid levels

Plant Based lipids	Parameters	Control	3% canola oil + soybean oil	6% canola oil + soybean oil	9% canola oil + soybean oil
(%) of diet	**3% animal-based lipid levels**	0.0g	1.5 + 1.5 = 3	3 + 3 = 6	4.5 + 4.5 = 9
Animal Based Fat (3%)		0.0g	3.0g	3.0g	3.0g
Fish oil		0.0g	1.5	1.5g	1.5g
Poultry lipids		0.0g	1.5g	1.5g	1.5g
Fish meal		27.0g	26.0g	26.0g	26.0g
Rice bran		30.0g	28.0g	28.0g	28.0g
Wheat Flour		40.0g	40.0g	40.0g	40.0g
Ascorbic-acid (antioxidant)		1.0g	1.0g	1.0g	1.0g
Vitamin Mineral complex		2g	2.0g	2.0g	2.0g
Total		100g	100g	100g	100g
(%) of diet	**6% animal-based lipid levels**	0.0g	1.5 + 1.5 = 3	3 + 3 = 6	4.5 + 4.5 = 9
Animal Based Fat (6%)		0.0g	6.0g	6.0g	6.0g
Fish oil		0.0g	3g	3.0g	3.0g
Poultry lipids		0g	3.0g	3.0g	3.0g
Fish meal		27.0g	26.0g	26.0g	26.0g
Rice bran		30.0g	25.0g	25.0g	25.0g
Wheat Flour		40g	40.0g	40.0g	40.0g
Ascorbic-acid (antioxidant)		1.0g	1.0g	1.0g	1.0g

Vitamin Mineral complex		2g	2.0g	2.0g	2.0g
Total		100g	100g	100g	100g
(%) of diet	**9% animal-based lipid levels**	0.0g	1.5 + 1.5 = 3	3 + 3 = 6	4.5 + 4.5 = 9
Animal Based Fat (6%)		0.0g	9.0g	9.0g	9.0g
Fish oil		0.0g	4.5g	4.5g	4.5g
Poultry lipids		0.0g	4.5g	4.5g	4.5g
Fish meal		27.0g	24.0g	24.0g	24.0g
Rice bran		28.0g	24.0g	24.0g	24.0g
Wheat Flour		40g	40.0g	40.0g	40.0g
Ascorbic-acid (antioxidant)		1.0g	1.0g	1.0g	1.0g
Vitamin Mineral complex		2g	2.0g	2.0g	2.0g
Total		100g	100g	100g	100g

2.3. Feeding Protocol:

The fingerling was fed according to 2% of their wet body weight. 17 fingerlings were stocked in each experimental tank and duplicate tanks were given for each experimental diet. The feeding session was lasted for 3-3.5 hours. After that un-consumed feed was collected from the tanks and tanks were washed and re-filled with fresh water.

2.4. Proximate Composition Analysis:

Muscle samples of fishes (Labeo rohita, Catla catla, Cirrhinus mrigala) were analyzed by the standard method of AOAC (1995). Moisture content was determined by drying sample at 105^{o} C for 12 hours in oven. Crude protein (CP) (N X 6.25) was determined by micro kjeldahl method. Petroleum ether extraction method (Soxhlet method) was used for determination of crude fat (CF). Crude fiber was determined by loss in weight by igniting fat-free sample. This sample was made by digesting it with 1.25% H_2SO_4 and 1.25% NaOH. Carbohydrates were determined by subtracting the crude protein percentage, crude fat percentage and crude fiber percentage from the dry matter.

2.4.1. Moisture:

Sample of fish muscle (1 gram) was taken in petri dish (W1). This petri dish was placed in the oven at 105^{o} C for 12 hours. This dried sample was then shifted to desiccator for 5 minutes and weight again. This sample was shifted again to the oven for 1-2 hours until constant weight was observed (W2). The difference in weight was determined as moisture. Following formula was used for calculation of dry matter percentage.

$$\text{Moisture (\%)} = \frac{W1 - W2}{\text{Weight of sample}}$$

Where,

W1= Weight of petri dish + sample before drying

W2= Weight of petri dish + sample after drying

Dry matter (%) = 100 – moisture %

2.4.2. Kjeldahl's method for Crude Protein Determination:

Crude protein of muscle sample was analyzed by micro Kjeldahl's method. Digestion mixture was made by mixing K_2SO_4, $CuSO_4$ and $FeSO_4$ by the ratio of 90:7:3. Dried sample of fish muscle (1 gram) was taken in kjeldahl's flasks. 5 gram of digestion mixture and 30ml of concentrated sulphuric acid was added in flask. Then it was boiled at low temperature and later at high temperature until the color of solution become

transparent green (clear). This digested sample was cooled, filtered and volume was raised up to 250ml by using distilled water. 10ml of this digested, diluted sample was taken and 10ml of NaOH was added and distilled with steam. Ammonia was released by this process; it was collected in a beaker having 10ml of boric acid solution with a drop of indicator (methyl red). Ammonia was collected for 2 minutes until the colour of boric acid changes from pink to golden yellow. Then this was titrated against 0.1N H_2SO_4. The amount of H_2SO_4 used during titration was noted and percentage of nitrogen was determined by using it.

$$\text{Nitrogen (\%)} = \frac{\text{Vol. of } H_2SO_4 \text{ used X Normalit}}{\text{Weight of s}}$$

2.4.3. Crude Fat:

Crude fat was determined by Soxhlet apparatus using petroleum ether. 1-gram dried sample of muscles was placed in de-fatted paper and weighed. Then it was placed in thimble which was joined to adapter. Then this thimble was inserted into condenser. The extraction cup was weighed and 50-70ml petroleum ether was added in it. Extraction cup was placed on hot plate and hot plate was turned on. Supply of cold tap water was turned on. Ether was kept on boiling for about 20 minutes. The thimble was filled with solvent. Sample was immersed in solvent as it is also present in thimble. Condenser valve was kept open at that time. For 30 minutes knob of extraction mood was moved to 'rinsing'. Thimble was hung above the solvent surface. The condenser valve was kept quarter closed. Extraction cup was released after rinsing and for collection of ether condenser valves was kept opened. Water tap and electricity supply to hot plate was stopped at that time. The extraction cup was weighed, and fat was determined by following formula:

$$\text{Fat (\%)} = \frac{W2 - W1}{\text{Weight of sample}} X100$$

Where,

W1= Weight of empty extraction cup

W2= Weight of extraction cup having fat after evaporation of ether

2.4.4. Crude Ash:

Total ash content was calculated by taking 2 grams of dried sample in crucibles ad weight it. Then this sample was put in muffle furnace and ignited for 4-5 hours at 550-600°C. Then it was cooled by shifting into desiccator and weighed. Percentage ash was determined by using following formula.

$$\text{Total Ash} = \frac{\text{Weight of ash}}{\text{Weight of original sample}} X100$$

2.4.5. Preparation of Fatty Acid Methyl Esters (FAMEs) by esterification of fats:

The required reagents for the Preparation of Fatty Acid Methyl Esters (FAMEs) by esterification of fats are 1) KOH solution 0.5N, and 2) Ammonium chloride methanol H_2SO_4 mixture. For the Preparation of Ammonium chloride methanol H_2SO_4 mixture2g ammonium chloride was dissolved in 3ml H_2SO_4 and 60ml methanol was added in this mixture.A sample of fat which is 200 to 300 mg was added in the flask and reflux this solution with 15ml of KOH which is o.5N for 3-5 minutes. When the solution become hot then 15 ml Ammonium chloride methanol H_2SO_4 was added and refluxes it for 15 minutes. Swirled to mix and again reflux for 3 minutes. Cool this and add light petroleum ether and shake it. When ether layer was separated then evaporated the ether under the vacuum. For determination of fatty acid, the residue was dissolve in 3-10 ml of petroleum ether by gas chromatography, by gas chromatography the fatty acid methyl esters will analyze. They were identified by comparing their relatives and the absolute retention time with authentic known standards.

The fingerlings of Major carps were feed with the rate of 2% of the live wet weight with their daily prescribed diet. Three replicates were assigned for each test feed with stocking density

of 10 fish per tank. After 3 hours feeding session, the uneaten feed was drained out by opening the valves of tank. The tanks should be washed completely to remove diet particles and again fill with fresh water. After this the fishes were transformed to the tanks. From the fecal collection tube, feces were collected from each tank. After the interval of almost 2 hours first open the valve 1 and the valve 2. Care was taken to avoid breaking the strings of feces which are thin in order to less nutrient leaching. Fecal material of each treatment was dried in oven then ground and was store for chemical analysis. The experiment ends at 4-5g fecal material collection of each replicate.

Apparent nutrient digestibility coefficients (ADC) of each test diet were calculated by this formula reported in NRC in 1993

$$ADC\% = 100 - 100X\frac{\text{Percent maker in diet X Percent nutrient}}{\text{Percent maker in feces X Percent nutrie}}$$

Growth performance was determined by measuring monthly gross weights of fishes from each treatment. Growth performance can be determined in terms of absolute weight gain (WG), weight gain (%), specific growth rate (SGR), survival rate (%). Weight gain was determined by following formula:

$$\text{Weight gain \%} = \frac{\text{Final weight} - \text{Initial weigh}}{\text{Initial weight}}$$

Absolute weight gain was determined by subtracting the final weight from initial weight of fish.

Absolute weight gain (g) = Final weight (g) – Initial weight (g)

Total body length of fish was calculated as:

Total body length (cm) = Final total length (cm) – Initial total length (cm)

The total fork length of fish was determined as:

Total fork length (cm) = Final fork length (cm) – Initial fork length (cm)

2.4.6. Statistical analysis:

Statistical analysis of data was done by applying ANOVA (One-way analysis of variance). Tukey's Student Newman-Keul test was used for comparing means of data (Steel et al. 1997) and probability was taken as $p < 0.05$ (Snedecor and Cochran 1991).

Results

3.1. Body Growth

Table 3 demonstrates the effect of saturated and unsaturated animal origin fatty acid diets on bodyweight, fork length, and length of Labeo rohita, Catla catla and Cirrhinus mrigala. Our study results shows that the highest weight gain was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T3 9% (ABS), T6 9% (ABUS), T6 9% (ABUS). Lowest weight gain was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T1 3% (ABS). Where's maximum total length was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T6 9% (ABUS), T2 6% (ABS), T2 6% (ABS) respectively. Minimum total length was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T1 3% (ABS), T4 3% (ABUS), T3 9% (ABS). In comparison to that maximum fork length was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T5 6% (ABUS), T3 9% (ABS) T2 6% (ABS) respectively and minimum at T0 (control). In overall comparison shows that C. mrigala shows maximum fork length.

Table 3: Effect of saturated and unsaturated animal origin fatty acid diets on bodyweight, fork length, and length of Labeo rohita, Catla catla and Cirrhinus mrigala

Major Carps	Parameters	T0 (control)		T1 3% (ABS)		T2 6% (ABS)		T3 9% (ABS)		T4 3% (ABUS)		T5 6% (ABUS)		T6 9% (ABUS)	
		Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain
L.rohita	Weight (g)	39.21	5.08	40.8	5.40	44.63	5.9	46.53	6.2	42.13	5.5	45.88	6.15	43.25	5.71
C. catla		35.15	3.16	38.65	3.6	47.36	4.76	42.56	4.11	41.23	3.93	44.85	4.41	48.58	4.88
C.mrigala		31.79	2.43	34.535	2.78	48.60	4.635	35.49	2.9	34.85	2.87	37.65	3.11	49.195	4.77
L. rohita	Length (cm)	6.86	0.7	7.38	0.73	7.38	0.71	7.58	0.76	7.05	0.71	7.46	0.75	7.56	0.73
C. Catla		6.63	0.48	8.35	0.7	9.76	0.88	9.05	0.73	8.01	0.65	8.76	0.73	9.4	0.83
C.mrigala		6.96	0.43	8.46	0.63	10.65	0.88	7.78	0.53	8.28	0.56	8.26	0.6	10.11	0.8
L. rohita	Fork Length (cm)	5.86	0.7	6.9	0.73	6.85	0.71	7.18	0.76	6.7	0.71	7.5	0.8	6.8	0.6
C.catla		8.55	0.78	9.11	0.83	9.63	0.91	9.86	0.91	9.41	0.88	9.61	0.883	9.633	0.916
C.mrigala		6.58	0.43	8.06	0.63	9.96	0.86	7.51	0.55	7.88	0.56	8.1	0.63	9.94	0.85

Table 4 results show the Effect of monounsaturated and polyunsaturated plant origin fats supplementations on body weight (g) fork length, and length of Labeo rohita, Catla catla and Cirrhinus mrigala. Our study shows that highest weight gain was observed in Labeo rohita, Catlacatla and Cirrhinus mrigala at T9 (9%PBMU) and lowest weight was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T7 (3%PBMU), T10 (3%PBPU), T10(3%PBPU) Where's maximum total length was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T9 (9%PBMU) and minimum total length of Labeo rohita, Catla catla and Cirrhinus mrigala at T10 (3%PBPU). In

overall comparison shows that C. mrigala shows maximum total length. In comparison to that maximum fork length of Labeo rohita, Catla catla and Cirrhinus mrigala is observed at T2 6% (ABS), T6 9% (ABUS), T2 6%(ABS) respectively and minimum at T0 (control). In overall comparison shows that Cirrhinus mrigala shows maximum fork length.

Table 4: Effect of monounsaturated and polyunsaturated plant origin fats supplementations on body weight (g) fork length, and length of of Labeo rohita, Catla catla and Cirrhinus mrigala

Major Carps	Parameters	T7 (3%PBMU)		T8 (6% PBMU)		T9 (9%PBMU)		T10 (3%PBPU)		T11 (6%PBPU)		T12 (9%PBPU)	
		Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain
L.rohita	Weight (g)	41.63	5.46	44.6	6.01	50.53	6.81	41.8	5.43	46.98	6.31	44.16	5.86
C. catla		42.25	4.23	46.08	4.76	49.3	5.25	38.15	3.65	48.96	5.033	43.65	4.41
C.mrigala		37.90	3.19	37.695	3.1483	51.105	5.06	35.295	2.8	45.496	4.37	36.233	2.935
L.rohita	Length (cm)	7.25	0.73	7.53	0.78	8.21	0.85	7.16	0.71	7.93	0.8	7.21	0.68
C. catla		7.41	0.53	8.31	0.65	8.91	0.8	7.08	0.53	8.4	0.66	7.43	0.58
C.mrigala		8.48	0.583	9.05	0.666	10.58	0.81	9.18	0.66	8.9	0.6	8.73	0.583
L.rohita	Fork Length (cm)	6.85	0.73	7.10	0.78	7.80	0.85	6.76	0.71	7.5	0.8	7.36	0.68
C. catla		6.93	0.56	7.68	0.63	8.31	0.78	8.35	0.7	9.76	0.88	9.05	0.733
C.mrigala		8.03	0.56	8.6	0.65	10.1	0.81	8.45	0.61	9.45	0.75	8.56	0.63

Table 5 results show the Effect of animal and plant origin combination dietary lipid supplementation on body weight (g) of Labeo rohita, Catla catla and Cirrhinus mrigala. Our study results shows that maximum weight was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T19 (A9p3), T14 (A3p6), T20 (A9p6) respectively. Minimum weight was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T18 (A6p9), T21 (A9p9), T21 (A9p9) respectively. Where's maximum total length of Labeo rohita, Catla catla andCirrhinus mrigala was observed at T17 (A6p6) and minimum at T21 (A9p9). In overall comparison shows that C. mrigala shows maximum total length. In comparison to that maximum fork length (cm) of Labeo rohita, Catla catla and Cirrhinus mrigala at T19 (A9p3), T19 (A9p3), T20 (A9p6) respectively and minimum fork length (cm) of Labeo rohita, Catla catla and Cirrhinus mrigala at at T17 (A6p6), T20 (A9p6), T21 (A9p9) respectively. In overall, comparison shows that C. mrigala shows maximum fork length.

Table 5: Effect of animal and plant origin combination dietary lipid supplementations on body weight (g) of Labeo rohita, Catla catla and Cirrhinus mrigala

Major Carps	Parameters	T13 (A3p3)		T14 (A3p6)		T15 (A3p9)		T16 (A6p3)		T17 (A6p6)		T18 (A6p9)		T19 (A9p3)		T20 (A9p6)		T21 (A9p9)	
		Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain	Avg	Gain
L. rohita	Weight (g)	41.33	5.2	42.2	4.3	43.4	5.53	40.1	4.66	40.4	4.66	39.4	4.63	43.8	5.16	42.2	4.75	40.7	4.93
C. Catla		41.48	3.783	43.46	4.133	42.20	3.69	42.15	3.82	46.6	4.41	40.37	3.7	47.5	4.26	49.96	4.48	37.15	3.08
C. mrigala		49.58	4.25	50.08	4.2	45.66	3.8	48.33	4.1	50.4	4.40	48.01	4.08	53.2	4.76	56.38	5.05	47.21	3.98
L. rohita	Length (cm)	8.0	0.7	8.5	0.75	7.6	0.7	7.45	0.71	7.6	0.73	8.65	0.76	8.6	0.76	8.0	0.73	7.45	0.71
C. Catla		9.45	0.73	9.15	0.61	7.66	0.45	8.13	0.46	9.26	0.6	8.33	0.51	8.65	0.51	9.13	0.58	8	0.48
C. mrigala		9.16	0.96	10.21	1.05	9.03	0.9	9.26	0.98	10.47	1.16	9.07	0.9	11.45	1.28	12.83	1.56	8.33	0.88
L. rohita	Fork Length (cm)	8.01	0.85	8.21	0.8	7.55	0.76	0.13	0.71	6.96	0.63	7.6	0.7	8.31	0.8	7.75	0.73	7.15	0.7
C. Catla		14.05	1.4	8.33	0.53	7.26	0.45	7.61	0.43	8.5	0.53	7.6	0.5	8.18	0.5	8.88	0.68	7.66	0.55
C. mrigala		8.16	0.8	9.01	0.91	8.15	0.76	7.88	0.76	9.46	0.98	8.266	0.8	10.95	1.03	11.35	1.21	8.133	0.75

3.2. Body Growth

Table **6** demonstrates the Effect of saturated and unsaturated animal origin fatty acid diets on the moisture, crude protein, crude fat, and crude ash of major carps. Our study results shows that maximum moisture contents were observed in Labeo rohita at T4 (3% ABUS) and T2 (6% ABS) while minimum moisture contents were observed in Catla catla at T2 (6% ABS) and T6 (9% ABUS).

Where our study illustrates that in Labeo rohita maximum crude protein was observed in T5 6% (ABUS) and minimum in T6 9% (ABUS). For Catla catla maximum crude protein was observed in T6 9% (ABUS) and minimum in T0 (control) while maximum crude protein was observed in T2 6% (ABS) and minimum in T0 (control) in case of Cirrhinus mrigala. Overall comparison showed that maximum crude protein was observed in Cirrhinus mrigala.

In comparison to that in L. rohita maximum crude fat was observed in T2 6% (ABS) and minimum in T0 (control). For C. catla maximum crude fat was observed in T6 9% (ABUS) and minimum in T0 (control) while for C. mrigala maximum crude fat was observed in T2

6% (ABS) and minimum in T6 9% (ABUS). Overall comparison showed that maximum crude fat was observed in C. catla.

Table 6: Effect of saturated and unsaturated animal origin fatty acid diets on the moisture, crude protein, crude fat, and crude ash of major carps

Major Carps	Parameters	TO Control	T1 (3% ABS)	T2 (6% ABS)	T3 (9%ABS)	T4 (3% ABUS)	T5 6% ABUS)	T6 (9% ABUS)
L.rohita	**Moisture**	75.05±0.838	74.12± .09	76.15±1.734	72.02±1.177	77.24± .06	71.9±0.02	73.04±0.793
C. catla		71.66±0.40	71.28±0.16	68.66±0.27	70.88±0.19	71.1±0.20	69.76±0.14	68.66±0.27
C. marigala		71.71±0.07	71.08±0.12	71.78±0.14	70.39±0.01	71.80±0.08	70.88±0.08	70.21±0.15
L. rohita	**Crude protein**	15.60 ± 0.26	16.69 ± 0.02	17.42 ± 0.09	18.04 ± 0.02	20.19 ± 0.26	19.90 ± 0.06	16.52 ± 0.54
C. catla		12.66±0.19	13.88±0.24	13.72±0.15	14.02±0.015	13.66±0.01	13.24±0.29	14.76±0.10
C. mrigala		16.72 ± 0.1	18.55 ± 0.09	20.32 ± 0.1	17.29 ± 0.1	18.47 ± 0.1	19.01 ± 0.01	19.97 ± 0.02
L. rohita	**Crude Fat**	4.60 ± 0.07	5.89 ± 0.09	7.18 ± 0.04	7.12 ± 0.02	6.14 ± 0.03	6.99 ± 2.82	5.54 ± 0.12
C. catla		6.31±0.12	5.89±0.04	6.82±0.11	6.45±0.17	5.95±0.06	5.98±0.02	7.54±0.16
C. mrigala		3.44 ± 0.09	3.88 ± 0.09	4.26 ± 0.21	3.66 ± 0.20	3.77 ± 0.19	3.83 ± 0.10	4.33 ± 0.21
L. rohita	**Crude Ash**	2.70 ± 0.23	3.11 ± 0.01	2.89 ± 0.09	2.21 ± 0.13	2.77 ± 0.19	1.90 ± 0.08	2.76 ± 0.20
C. catla		8.11±0.53	7.02±0.53	6.12±0.54	7.08±0.54	5.05±0.015	6.13±0.54	6.09±0.04
C. mrigala		5.59 ± 0.07	7.41 ± 0.08	6.41 ± 0.08	5.88 ± 0.09	7.46 ± 0.13	6.71 ± 0.18	6.86 ± 0.08

Table **7** illustrates the Effect of monounsaturated and polyunsaturated plant origin fatty acid diets on the moisture, crude protein, crude fat, and crude ash of major carps. Our study shows that maximum moisture contents was observed in Labeo rohita at T7 (3%PBMU) and T12 (9%PBPU) while minimum moisture contents was observed in Catla catla at T7 (3%PBMU) and T10 (3%PBPU).Where our study showed that in Labeo rohita maximum crude protein was observed in T11 (6%PBPU) and minimum in T7 (3%PBMU). For Catla catla maximum crude protein was observed in T9 (9%PBMU) and minimum in T10 (3%PBPU) while maximum crude protein was observed in T10 (3%PBPU) and minimum in T7 (3%PBMU) in case of Cirrhinus mrigala. Overall comparison showed that maximum crude protein was observed in Cirrhinus mrigala.

In comparison to that in L. rohita maximum crude fat was observed in T12 (9%PBPU) and minimum in T8 (6% PBMU). For C. catla maximum crude fat was observed in T7 (3%PBMU) and T10 (3%PBMU) and minimum in T9 (9%PBMU) while for C. mrigala maximum crude fat was observed in T9 (9%PBMU) and minimum in T7 (3%PBMU). Overall comparison showed that maximum crude fat was observed in C. catla.

Table 7: Effect of monounsaturated and polyunsaturated plant origin fatty acid diets on the moisture, crude protein, crude fat, and crude ash of major carps

Body composition		Monounsaturated fat			Polyunsaturated fats		
Major Carps	Parameters	T7 (3%PBMU)	T8 (6% PBMU)	T9 (9%PBMU	T10 (3%PBPU)	T11 (6%PBPU)	T12 (9%PBPU)
L. rohita	Moisture	73.21±0.82	72.26±0.072	71.15±0.135	71.5 ±0.04	72.09 ±.75	74.14±0.11
C. catla		67.67±0.06	69.88±0.06	69.57±0.10	67.58±0.10	69.22±0.19	68.87±0.08
C. marigala		70.60±0.09	70.81± 0.30	70.35±0.13	70.68±0.13	70.44±0.11	70.59±0.09
L. rohita	Crude protein	16.52 ± 0.1	17.55 ± 0.06	18.64 ± 0.05	16.57 ± 0.1	19.52 ± 0.1	18.59 ± 0.10
C. catla		14.34 ± 0.22	15.73 ± 0.21	16.99 ± 0.37	14.98 ± 0.66	15.91 ± 0.47	16.81 ± 0.63
C. mrigala		15.54 ± 0.528	16.82 ± 0.17	19.06 ± 0.06	15.69 ± 0.19	18.01 ± 0.01	17.84 ± 0.10
L. rohita	Crude Fat	5.20 ± 0.11	4.22 ± 0.07	5.10 ± 0.005	5.28 ± 0.03	4.26 ± 0.05	5.22 ± 0.07
C. catla		6.10 ± 0.005	5.78 ± 0.02	5.28 ± 0.17	6.10 ± 0.005	5.43 ± 0.14	5.02 ± 0.01
C. mrigala		3.55 ± 0.09	4.22 ± 0.03	4.28 ± 0.14	3.64 ± 0.30	4.25 ± 0.13	4.20 ± 0.01
L. rohita	Crude Ash	2.23 ± 0.112	2.21 ± 0.085	1.23 ± 0.112	1.56 ± 0.121	1.49 ± 0.247	1.76 ± 0.121
C. catla		7.8 ± 0.05	6.02 ± 0.01	6.64 ± 0.30	7.08 ± 0.01	6.72 ± 0.07	6.97 ± 0.02
C. mrigala		6.48 ± 0.23	6.55 ± 0.13	6.15 ± 0.05	6.60 ± 0.28	6.19 ± 0.08	6.66 ± 0.24

Table **8** stated the Comparison of animal and plant origin fats on the moisture, crude protein, crude fat, and crude ash of major carps. Our study shows that maximum moisture content was observed in Labeo rohita, Catla catla and Cirrhinus mrigala at T20 (P. Fats: 6%, A. Lipids: 9%) and minimum moisture content was observed at T21 (P. Fats: 9%, A. Lipids: 9%). Overall comparison of three major carps showed maximum moisture content in L. rohita at T20 (P. Fats: 6%, A. Lipids: 9%) while minimum in C. catla at T21 (P. Fats: 9%, A. Lipids: 9%).

Where our study demonstrated that in L. rohita maximum crude protein was observed in T20: P. Fats: 6%, A. Lipids: 9% and minimum in T16: P. Fats: 3%, A. Lipids: 6%. For C. catla maximum crude protein was observed in T20: P. Fats: 6%, A. Lipids: 9% and minimum in T18: P. Fats: 9%, A. Lipids: 6%T10 while for C. mrigala maximum crude protein was observed in T20: P. Fats: 6%, A. Lipids: 9% and minimum in T18: P. Fats: 9%, A. Lipids: 6%. Overall comparison showed that maximum crude protein was observed in C. mrigala.

In comparison to that in L. rohita maximum crude fat was observed in T20: P. Fats: 6%, A. Lipids: 9% and minimum in T13: P. Fats: 3%, A. Lipids: 3%. For C. catla maximum crude fat was observed in T19: P. Fats: 3%, A. Lipids: 9% and minimum in T18: P. Fats: 9%, A. Lipids: 6% while for C. mrigala maximum crude fat was observed in T20: P. Fats: 6%, A. Lipids: 9% T21 (9%PBMU) and minimum in T13: P. Fats: 3%, A. Lipids: 3%. Overall comparison showed that maximum crude fat was observed in C. mrigala.

Table 8: Comparision of animal and plant origin fats on the moisture, crude protein, crude fat, and crude ash of major carps

Major Carps	Parameters	T13: P. Fats: 3%, A. Lipids: 3%	T14: P. Fats: 6%, A. Lipids: 3%	T15: P. Fats: 9%, A. Lipids :3%	T16: P. Fats: 3%, A. Lipids: 6%	T17: P. Fats: 6%, A. Lipids: 6%	T18: P. Fats: 9%, A. Lipids: 6%	T19: P. Fats: 3%, A. Lipids: 9%	T20: P. Fats: 6%, A. Lipids: 9%	T21: P. Fats: 9%, A. Lipids: 9%
Labeo rohita	**Moisture**	72.28±0.15	73.26±0.05	74.23±0.08	75.33±0.02	76.37±0.04	77.16±0.08	77.39±0.06	76.41±0.03	71.08±0.01
Catla catla		71.28±0.10	71.35±0.04	71.43±0.02	71.23±0.05	71.37±0.02	71.26±0.04	71.49±0.12	71.51±0.14	71.18±0.01
C.marigala		71.78±0.11	71.99±0.08	71.86±0.07	71.82±0.08	72.03±0.05	72.65±0.18	72.65±0.18	72.96±0.12	71.76±0.10
L. rohita	**Crude protein**	17.95±0.02	18.25±0.07	19.14±0.08	17.29±0.16	17.98±0.01	18.16±0.03	19.15±0.09	19.61±0.24	18.19±0.06
C. catla		16.85± 0.05	17.15±0.05	17.04±0.03	17.11±0.01	17.55±0.13	16.83±0.06	18.05±0.02	18.51±0.36	17.09±0.05
C. mrigala		17.96±0.01	18.20±0.15	18.08±0.01	18.12±0.02	18.74±0.21	17.94±0.04	19.54±0.19	19.94±0.04	17.96±0.02
L. rohita	**Crude Fat**	2.81±0.06	3.95± 0.04	2.80±0.05	2.99±1	2.95±0.04	3.78±0.02	4.25 ± 0.13	4.63 ± 0.29	2.89 ± 0.08
C. catla		2.71±0.20	2.85± 0.05	2.69±0.20	2.76±0.04	2.88±0.08	2.68±0.22	3.15 ± 0.05	3.53 ± 0.31	2.69 ± 0.19
C. mrigala		3.42±0.15	3.65± 0.31	3.37±0.12	3.81±0.06	3.81±0.06	3.51±0.36	4.02± 0.01	4.17 ± 0.04	3.46 ± 0.27
L. rohita	**Crude Ash**	6.42±0.13	7.58±0.10	7.66±0.24	7.62±0.25	7.89±0.08	7.68±0.24	8.27±0.15	9.48± .005	1.2±0.17
C. catla		7.32±0.06	7.58±0.23	7.38±0.07	7.41±0.20	7.81±0.09	7.46±0.27	8.05±0.01	8.38 0.24	1.02±0.01
C. mrigala		6.65±0.35	6.83±0.06	6.53± 0.14	6.85±0.05	6.85±0.05	6.64±0.36	7.46±0.90	7.21 0.08	6.51±0.18

4. Discussion

Balanced fatty acid profile is the basic requirement for the growth of fish. By combining the animal and vegetable oils for the fish diet, or replacement of animal oils with vegetable oils, some fish showed increase in growth and other showed retardation in their growth.[20] Growth performance in the three fish species were recorded in terms of average weight gain, total body length and fork length. Among the three species of Indian major carps, Cirrhinus mrigala showed significantly highest growth in terms of weight gain in combination in T20 with 9% animal and 6% plant dietary lipids (A9P6) and individual animal andplant origin dietary lipids intreatment T9 (9% PBMU) with mean values of 56.38±17.26 and 51.10±18.45 followed by Labeo rohita and Catla catla with the mean values of 50.53±24.72 and 49.38±19.48 respectively in T9 (9% PBMU) Cirrhinus mrigala also showed highest growth in terms of total length and fork length in T9 (9% PBMU) with mean values of 10.58±3.35 and 10.16±3.35 followed by Catla catla and Labeo rohita in T2 6% animal based saturated (6% ABS) and T3 (9% ABS) with values of 9.76 and 9.86 followed by Labeo rohita in T18 (A_6P_9) and T19 (A_6P_9) with values of 8.65 and 8.31 respectively. Such specific species variations in growth have also been reported by Sahzadi et al[21] and Pradhan et al.[22] Growth is mainly influenced by the concentration of feed having all the

essential nutrients and energy when fed up to satiation Kaushik.[23] Significant higher growth in terms of weight gain, total length and fork length of Cirrhinus mrigala towards 9% animal and 6% plant origin combination dietary lipids as compared to the other two species and the highest total length and fork length in Catla catla towards 3% animal and 3% plant origin combination dietary lipids followed by Labeo rohita with 9% animal and 6% plant origin combination dietary lipids may be attributed to the optimum utilization of the both plant and animal origin feed nutrients more efficiently by the optimization of the digestion process by fish (Zoccarato et al.[24] The significant difference in weight gain, total length and fork length of Cirrhinus mrigala , Labeo rohita and Catla catla towards 9% plant based monounsaturated , 9% animal based saturated and 9% plant based monounsaturated dietary lipids may be attributed to the herbivore and omnivore nature of the fish as the monounsaturated plant and saturated animal ingredients can be considered nutrient content wise adequate for fish growth Ahmed[25] and Hixson.[26] Among animal origin saturated and unsaturated dietary lipids, Cirrhinus mrigala showed significant higher growth in treatment T6 (9% ABUS) with mean values of 48.78±18.89 followed by Catla catla and Labeo rohita in T6 (9% ABUS) and T3 (9% ABS) with the mean values of 48.58±17.44 and 46.53±22.46 respectively. The results showed the non-significant difference in weight gain of the two species Cirrhinus

mrigala and catla catla in T6 with 9% animal basedunsaturated dietary lipids whereas significant difference in Labeo rohita in T3 with 9% animal based saturated dietary lipids.

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The significant difference in the weight gain of two fish species from Labeo rohita may be attributed to the inherent ability of Labeo rohita to vary its weight gain in response to certain feed ingredients with varying digestibility. Only animal based unsaturated fatty acids with high concentration can't be used for the enhanced growth as lipid peroxidation reactions caused the damage of liver cells. Similarly, only plant based high concentration of lipid levels can disturb the n−3/n−6 fatty acids that can disturb the eicosanoid synthesis, Fracalossi et al.[27] and Sargent et al.[28]

The comparative results of the three fish species showed that by increasing the level of dietary lipids up to a certain percentage (9%) increases the values of weight gain than in case of using diets containing 3% and 6% supplemented lipid. Labib et al[29] showed that the Oreochromis niloticus fed on diets containing 28% protein and three levels of fat (3, 6 and 9 %) showed increase in weight from 12.6 to 169.3g, from 10.6 to 154.39 and from 10.0 to 164.1g. Similarly, Hassanen[30] reported that the dietary fat when increased from 3 to 6% of the diet appeared to spare protein as reflected in greater protein deposition with higher fat level. Williams and Robinson[31] described the importance of lipid as one of the essential food ingredients is due to the fact that it provides a source of concentrated energy and essential fatty acids that can be used to spare dietary protein for growth. Lipids also can be used as a source of protein-sparing energy (Mai et al[32].

The results of different percentages of combination animal and plant origin dietary lipids of the three major carp species showed that by combining the animal and vegetable oils for the fish diet, or replacement of animal oils with vegetable oils, some of the fish showed increase growth and other showed retardation in their growth. In the present studies, highest significant increase in the growth of Cirrhinus mrigala towards treatment T20 (9% animal based and 6% plant based dietary lipids) with mean value of 56.38±17.26 was observed as compared to other two fish species which showed the decreasing trend with the increase in plant origin dietary lipids in T21 (9% animal and 9% plant based dietary lipids) in Catla catla with minimum mean value of 37.15±11.64 respectively. The lower performance of Catla catla fed on 9% plant-based diets with 9% animal origin dietary lipids may be due to the specie specific inherent response towards higher percentages of plants and presence of anti-nutritional factors present within the different plants. Plant evolves these substances to protect them and to prevent them from being eaten (Inuwa et al[33]).

In general, the increasing levels of dietary lipid level improve the certain growth parameters of fish because of protein sparing effect due to the use of lipid (Lee et al[34]; Skalli et al[35] and Torstensen et al[36]. However, no sparing effect of protein was observed by the two scientists due to the use of dietary lipids but in other different species (McGoogan and Gatlin[37], Thoman et al[38]. Every species of fish have an optimum level of dietary lipids over which that quantity of lipid can cause growth retardation Du et al[39]. The higher lipid contents in fish diet results in excessive energy can cause reduced growth and feed consumption which can also reduce the ability of a fish to digest and absorb higher levels of lipids Wang et al.[40]

The present results showed that the increasing levels of dietary lipids increased the growth performance of fish. For example, condition factor and protein efficiency ratio increase with the increasing levels of dietary

lipids of all type of treatment diets but these dietary lipids improve the feed utilization of fish up to certain limits by Peres and Teles.[41] An experiment on three dietary lipids levels, 13, 17 and 21%, was conducted where the diet with 17% lipid levels (intermediate slevel of lipids among all three diets) had significantly improved the body weight, length and growth rate of fish Argyrosomus regius, Chatzifotis et al.[42]. Similarly Asian sea sbass and the white sea bass (Atractoscion nobilis), also showed the higher growth rates on 17% lipid level as compared to 13% or 23%, and 19.5% or 21.5%, respectively (Lopez et al.[43]). Furthermore, there is also a disadvantage to the pelleting quality of food with the higher use of dietary lipids in the diet. Hence it was also concluded from the present study that adequate quantity must be evaluated for specific type of fish species.

During present investigation, the overall comparative results showed that four diets, two from animal-based (ABUS and ABS) and two from plant-based (PBMU and PBPU) origins as dietary lipids sources have different types of growth trends in the three fish species in terms of weight gain in the order: Cirrhinus mrigala>Labeo rohita>Catla catla with mean values of 51.10±18.45, 50.53±24.72 and 49.38±19.48 whereas for total length and fork length the pattern followed the order : Cirrhinus mrigala>Catla catla>Labeo rohita. The order for the growth in combination of animal and plant origin dietary lipids was Cirrhinus mrigala>Catla catla>Labeo rohita with the mean values of 56.38±17.26, 47.5±16.34 and 43.8±18.76. The diet having soybean and sunflower oil as replacer for the fish and cod liver oils showed the significantly ($p < 0.05$) higher values of growth in T9, 9% (PBMU).

Kim and Lee[44]., also reported that sub-adult olive flounderwhen fed with soybean oil mix diet showed significantly higher values of final mean weight, protein efficiency ratio and hepatosomatic index. The present study showed that the fishes fed on animal and plant-based diets showed highest growth at 9% dietary lipid level than 0, 3% and 6% levels, However the retarded growth in fish fed on plant-based diets at higher level of dietary lipids showed that the lipid may limit the protein consumption, higher fat accretion and impaired the growth of C. catla (Wang et al[40].).

The 6% dietary lipid level may improve the digestion as well as absorption of nutrients as compared to 9% dietary lipid level (El-Kasheif et al[45].) Similarly Kheir[46] reported the highest growth at 6% lipids that subsequently decreases with the increasing level of lipid up to 8%. The overall results showed the significant higher growth in terms of weight gain, total length and fork length of Cirrhinus mrigala as compared to the other two fish species. T9 (9% PBMU) showed the significant growth in all the three fish species of Indian major carps and 9% dietary lipids showed better growth than 0%, 3% and 6%. Hence a trend in increase in growth of Cirrhinus mrigala, Labeo rohita and Catla catla was measured with an increase in the percentage of animal, plant and combination dietary lipids.

Body composition is used as an indicator of the whole flesh quality of the fish. Growth, feeding rate and diet are the most important factors which effect the body composition of the fish (Cho et al[47]). During present studies, Cirrhinus mrigala showed significantly higher crude protein in T2 (6% ABS) with the value 20.32±0.15 followed by Labeo rohita and Catla catla with the mean values of 20.19±0.57and 18.51±0.36 respectively in T4 (3% ABUS) and T20 (A9P6).

The lowest value of crude protein followed the pattern of Catla catla<Labeo rohita<Cirrhinus mrigala in TO, T7(3% PBMU) and T10(3% PBPU) with the mean values of 12.66±0.19, 15.54±0.528 and 15.69±0.14. The significant higher moisture content was recorded in Labeo rohita in T4 (3% ABUS) with the value 77.24±1.06 followed by Cirrhinus mrigala and

Catla catla in T20 (A9P6) with the values of 72.96±0.34 and 71.51±0.14 respectively. The minimum values of moisture were recorded in Catla catla in T10 (3% PBPU) with mean values of 67.58±0.10 in comparison with Labeo rohitaand Cirrhinus mrigala in T9(9% PBMU) and T21(A9P9) with mean values of 70.35±0.13 and 71.76±0.14.

Catla catla showed the significant higher crude fat content in T6 (9% ABUS) dietary lipids with mean value of 7.54±0.16 as compared to Labeo rohita and Cirrhinus mrigala in T2 (6% ABS) and T6 (9% ABUS) with the values 7.18 and 4.33.The minimum values of crude fat were shown by Catla catla followed by Labeo rohita and Cirrhinus mrigala in T15 (A3P9) with mean values of 2.68±0.20 2.80±0.01 and 3.37±0.20 The higher significant value of crude ash was showed by Labeo rohita in T20 (A9P6) with the value. 9.48±0.005 followed by Catla catla and Cirrhinus mrigala in T0 and T19 (A9p3) with the values of 8.11±0.53 and 7.46±0.09 and the minimum values were recorded in Labeo rohita, Catla catla and Cirrhinus mrigala in T9(9% PBMU), T4 (3% ABUS) and T0 with the mean values of 1.23±0.02, 5.05±0.015 and 5.59±0.13.

The whole-body composition of the three fish species fed with different plant and animal origin dietary lipids in this study varied substantially. Body moisture content decreased significantly from Labeo rohita>Cirrhinus mrigala>catla catla with increasing lipid content up to 6% plant based and 9% animal-based combination dietary lipids. Further increasing the animal and plant origin dietary lipids did not result in any significant difference in moisture content. Body protein content increased with increasing animal origin dietary lipid levels up to 6% in Cirrhinus mrigala; thereafter a significant fall of body protein was noticed in 9% dietary lipid levels, However the combination of 9% animal and 6% plant dietary lipids showed significant growth in Catla catla. This may be attributed to the protein spare effect of dietary lipids up to a certain level. The elevated growth rate of silver barb fingerlings with enhanced dietary lipid percentages could be due to protein sparing effect of lipids. In fish feed, dietary protein utilization is enhanced by enhancing the adequate lipid percentages without lowering the fish growth (Han et al[48]).

This sparing effect of lipids which can significantly enhance the use of protein for growth and improved protein efficiency ratio has been studied in other fish species (Chatzifotis et al[42]). The fat content of fish fed with different types of dietary lipids gradually increased with increasing the percentage of animal based saturated and unsaturated lipids from 6% to 9% and was found to be significantly higher for Catla catla with a decreasing trend in Labeo rohita to Cirrhinus mrigala. Cirrhinus mrigala showed the highest value of crude protein and lowest value of Crude fat among other two carp species. This corresponds with the findings for Oncorhynchus mykiss (Storebakken et al[49]) and African catfish, Clarias gariepinus (Adebayo and Fagbenro[50]).

When the percentages of dietary lipids were lower the amount of fat was slightly lower, although at the same time the fish maintain relatively higher and constant amounts of protein in their body tissues in comparison to the initial value, suggesting that in fish body fat is preferred to protein as an energy source. Similar findings for body fat were also reported by Khan et al[10].

On the basis of the results from the present study, it is concluded that provision of dietary lipids in the range 7.0–9.0% is optimum for growth and for efficient feed utilization. The whole-body lipid content was enhanced and the moisture content was decreased with increasing dietary lipid levels. This relationship of whole body moisture to lipid content was also seen in a different fish species, Argyrosomus regius (Chatzifotis et al[42]).

The whole-body lipid content of the major carps was increased as the percentage of dietary lipids were increased from 3-9% which

also showed the optimum values of lipid content in terms of whole-body composition in Catla catla in T6 with 9% ABUS dietary lipids. This is in line with the previous studies in Dicentrarchus labrax Peres[41.] The whole-body protein content of silver barb was enhanced by increasing the fish oil supplementation in fish feed as reported in Oreochromis auraus and Oreochromis niloticus (Kheir[29] and El-Kasheif et al[45]).

Conclusion

Among three fish species, Cirrhinus mrigala showed significantly highest growth in terms of weight gain in treatment T20 with combination of 9% animal and 6% plant dietary lipids (A9P6) and T9 plant based monounsaturated (9% PBMU) with mean values of 56.38 ± 17.26 and 51.10 ± 18.45 followed by Labeo rohita and Catla catla with the mean values of 50.53 ± 24.72 and 49.38 ± 19.48 in T9 plant based monounsaturated (9% PBMU).The total and fork length gain also showed the similar trend as weight gain in Cirrhinus mrigala in T9 with 9% plant based monounsaturated (9% PBMU) with mean values of 10.58 $\pm$ 3.35 and 10.16 $\pm$ 3.35 followed by Catla catla and Labeo rohita in T3 9% animal based saturated (9% ABS) and T9 9% plant based monounsaturated (9% PBMU) with mean values of 9.76 $\pm$ 3.34, 9.70 ± 3.25 and 8.21 ± 3.12, 7.81 ± 3.12 respectively. Significant higher growth in terms of weight gain, total length and fork length of Cirrhinus mrigala towards 9% animal and 6% plant origin combination dietary lipids as compared to the other two species may be attributed to the optimum utilization of the both plant and animal origin feed nutrients more efficiently by optimizing the digestion process. The comparative results of growth of the three fish species showed that by increasing the level of dietary lipids up to a certain percentage (9%) increases the values of weight gain than in case of using diets containing 3% and 6% supplemented lipid may be due to the fact that it provides a source of concentrated energy and essential fatty acids and can be used to spare dietary protein for growth. Lipids also can be used as a source of protein- sparing energy. The results of different percentages of combination animal and plant origin dietary lipids among three fish species showed the significant increase in the growth of Cirrhinus mrigala as compare to other two fish species which showed the decreasing trend with the increase in plant origin dietary lipids may be attributed to the presence of anti-nutritional factors present within the different plants. Plant evolves these substances to protect them and to prevent them from being eaten. The present results showed that the increasing levels of dietary lipids increase the growth performance of fish. The overall results showed the significant higher growth in terms weight gain, total length and fork length of Cirrhinus mrigala as compared to the other two fish species. T9 (9% PBMU) showed the significant growth in all the three fish species and 9% dietary lipids showed better growth than 0%, 3% and 6%. Hence a trend in increase in growth of Cirrhinus mrigala, Labeo rohita and Catla catla was measured with an increase in the percentage of animal, plant and combination dietary lipids.

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Supplemental material

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Ethical approval

Fishes were managed according to the principles and specific guidelines of Institute of Animal and

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References

1. Maulu S, Nawanzi K, Tawwab MA, Khalil HS (2021) Fish Nutritional Value as an Approach to Children's Nutrition. Frontiers in Nutrition 8:780-844
2. Che J, Su B, Tang B, Bu X, Li J, Lin Y, Yang Y, Ge. X (2017) Apparent digestibility coefficients of animal and plant feed ingredients for juvenile Pseudobagrus ussuriensis. Aquaculture Nutrition 23:1128-1135
3. Paul BN, Chanda S, Bhowmick S, Sridhar N, Saha G , Giri S (2017) Nutrient profile of Indian climbing perch, Anabas testudineus. SAARC Journal of Agricultural Research 15:99-109
4. Abbas S, Ashraf M, Ahmed I (2014) Effect of fertilization and supplementary feeding on growth performance of Labeo rohita, Catla catla and Cyprinus carpio. Journal of Animal & Plant Science 24:42-148
5. Subasinghe R, Soto D, Jia J (2009) Global aquaculture and its role in sustainable development. Reviews in Aquaculture 1:2-9.
6. FAO (Food and Agriculture Organization of the United Nation) (2016) The State of World Fisheries and Aquaculture, Rome.
7. Ebrahim Z (2014) Report on Inside Pakistan's Untapped Fishing Industry. net/(2014/11/inside-pakistans-untapped-fishing industry.
8. Nazir K, Yongtong M, Hussain K, Kalhoro MA, Kartika S (2014) A study on exports of fish and fish products and their role in economic growth of Pakistan. Journal of Biological Sciences 4:1-4
9. Paul BN, Chanda S, Sridhar N, Saha GS, GiriSS (2015) Fatty acid profile of Indian major carp. Indian Journal of Animal Nutrition 32:221– 226
10. Khan MA, Jafri AK, Chadha NK, Usmani N (2003) Growth and body composition of rohu (Labeo rohita) fed diets containing oilseed meals partial or total replacement of fish meal with soybean meal. Aquaculture Nutrition 9:391-396
11. Mokolensang JF, Yamasaki S, Onoue Y (2003) Utilization of Shochu distillery by products for culturing the common carp Cyprinus carpio. Journal of Biological Sciences 3:502-507
12. Appleton K. M,Rogers PJ, NessAR (2010) Updated systematic review and meta-analysis of the effects on n-3 long chain polyunsaturated fatty acids on depressed mood. The American Journal of Clinical Nutrition 91:757– 770
13. Abasubong KP, Li XF, Zhang DD, Jia ET, Xiang-Yang Y, Xu C, Liu WB (2018) Dietary supplementation of xylo-oligosaccharides benefits the growth performance and lipid metabolism of common carp (Cyprinus carpio) fed high-fat diets. Aquaculture Nutrition1:1-9
14. Ghosh K, Mandal S (2015) Nutritional evaluation of groundnut oil cake in formulated diets for rohu, Labeo rohita (Hamilton) fingerlings after solid state fermentation with a tannase producing yeast, isolated from fish gut. Aquaculture Reports 2:82-90

15. Bhatnagar A, Devi P (2013) Water quality guidelines for the management of pond fish culture. International Journal of Environmental Science 36:1980–2009
16. Ashfauq FA, Dhawan A, Ansal MD (2016) Efficacy of feeding frequency, feeding rates and formulated diets on growth and survival of rohu Labeo rohita brood stock under intensive rearing. International
Journal of Fisheries and Aquatic Studies 5:85-89
17. Chatzifotis S, Panagiotidon M, Papaioannou N, Pavlidis M, Nengas I, Mylonas CC (2010) Effect of dietary lipid levels on growth, feed utilization, body composition and serum metabolites of meagre (Argyroso musregius) juveniles. Aquaculture 307:65-70
18. Goldstein, L. E., Fisher, A. M., Tagge, C. A., Zhang, X. L., Velisek, L., Sullivan, J. A., ... & McKee, A. C. (2012). Chronic traumatic encephalopathy in blast-exposed military veterans and a blast neurotrauma mouse model. Science translational medicine, 4(134), 134ra60-134ra60.
19. ChiSY, Zhou QC, Tan BP, Dong XH, Yang QH, Zhou JB (2010) Effect of dietary protein and lipid levels on growth performance, carcass composition, and digestive enzyme of the juvenile spotted Babylon, Babylonia areolata.Journal of the World Aquaculture Society 41:903-911
20. Peng S, Chen L, Qin JG, Hou J, Yu N, Long Z, Ye J, Sun X (2008) Effects of replacement of dietary fish oil by soybean oil on growth performance and liver biochemical composition in juvenile black seabream, Acanthopagrus schlegeli. Aquaculture 276:154-161
21. Sahzadi T, Salim M, Um-e-Kalsoom, Shahzad K (2006) Growth performance and feed conversion ratio (FCR) of hybrid fingerlings (Catla catla × Labeo rohita) fed on cottonseed meal, sunflower meal and bone meal. Pakistan Veterinary Journal 26:163-166
22. Pradhan C, Giri SS, Mohanty TK, Mohanty SN (2020) Influence of a diet containing plant ingredients at different levels on growth performance, carcass biochemical composition, and blood parameters in Indian major carps grown in polyculture earthen ponds. Tropical Animal Health and Production 3:1-9
23. Kaushik SJ (2013) Feed management and on-farm feeding practices of temperate fish with special reference to salmonids. FAO Fish. Tech 583:519-551
24. Zoccarato I, Benatti G, Bianchini ML, Boccignone M, Conti A, Napolitano R, Palmegiano GB (2009) Differences in performance, flesh composition and water output quality in relation to density and feeding levels in rainbow trout, Oncorhynchus mykiss (Walbaum), and farming. Fish Aquaculture 25:639-647
25. Ahmed I, (2007) Effect of ration size on growth, body composition, and energy and protein maintenance requirement of fingerling Indian major carp, Labeo rohita (Hamilton).Fish Physiology and Biochemistry 33:203-212
26. Hixson SM (2014) Fish nutrition and current issues in aquaculture the balance in providing safe and nutritious seafood, in an environmentally sustainable manner. Journal of Aquaculture Research and Development 5:1-10
27. Fracalossi DM, Craig-Schmidt MC, Lovell RT (2006) Effect of dietary lipid sources on production of leukotriene B by head kidney of channel catfish held at different water temperatures.

Journal of Aquatic Animal Health6:242-250
28. Sargent JR, Tocher DR, Bell JG, Halver JE, Hardy RW (2002) Fish nutrition. Lipids 182-257
29. Labib W, Shahat T, kheir MT, Sobhy AS (2011) Growth of tilapia nilotica (Oreochromis niloticus) fed with feed of different levels of lipids. Bulletin of the Faculty of Science 17:166-180
30. Hussain SM, Rana SA, Afzal M, Shahid M (2011) Efficacy of phytase supplementation on mineral digestibility in Labeo rohita fingerlings fed on corn gluten meal (30%) based diets. Pakistan Journal of Agricultural Sciences 48:237-241
31. Williams CD, Robinson EH (2011) Response of red drum to various dietary levels of menhaden oil. Aquaculture70:107-120
32. Mai K, Mercer JP, Donlon J (2001) Comparative studies on the nutrition of two species of abalone, Haliotis tuberculata L, Haliotis discus hannai Ino Optimum dietary protein level for growth. Aquaculture 136:165-180
33. Inuwa HM, Aina VO, Ja L (2011) Determination of nephrotoxicity and hepatoxicity of monosodium glutamate (MSG) consumption. Brazilian Journal of Pharmacology Toxicology 2:148-153
34. Lee SM, Jeon IG, Lee JY (2002) Effects of digestible protein and lipid levels in practical diets on growth, protein utilization and body composition of juvenile rockfish (Sebastes schlegeli) Aquaculture 211:227-239
35. Skalli A, Hidalgo M.C, Abellan E, Arizcun M, Cardenete G (2004) Effects of the dietary protein/lipid ratio on growth and nutrient utilization in common dentex (Dentex dentex L.) at different growth stages. Aquaculture 235:1-11
36. Torstensen B, Espe M, Sanden M, Stubhaug I, Waagbo R, Hemre GI (2008) Novel production of Atlantic salmon (Salmo salar) protein based on combined replacement of fish meal and fish oil with plant meal and vegetable oil blends. Aquaculture 285:193-200
37. McGoogan BB, Gatlin DM (2005) Dietary manipulations affecting growth and nitrogenous waste production of red drum, Sciaenops ocellatus I. Effects of dietary protein and energy levels. Aquaculture 178:333-348
38. Thoman ES, Davis DA, Arnold CR (2006) Evaluation of grow out diets with varying protein and energy levels for red drum (Sciaenops ocellatus) Aquaculture 176:343-353
39. Du ZY, Liu YJ, Tian LX, Wang JT, Wang Y, Liang GY (2005) Effect of dietary lipid level on growth, feed utilization and body composition by juvenile grass carp (Ctenopharyngodon idella) Aquaculture Nutrition 11:139-146
40. Wang JT, Liu YJ, Tian LX, Mai KS, Du ZY, Wang Y, Yang HJ (2005) Effect of dietary lipid level on growth performance, lipid deposition, and hepatic lipogenesis in juvenile cobia (Rachycentron canadum) Aquaculture 249:439-447
41. Peres H, Teles AO (2005) Effect of dietary lipid level on growth performance and feed utilization by European sea bass juveniles (Dicentrarchus labrax). Aquaculture 179:325-334
42. Chatzifotis S, Panagiotidon M, Papaioannou N, Pavlidis M, Nengas I, Mylonas CC (2010) Effect of dietary lipid levels on growth, feed utilization, body composition and serum metabolites

of meagre (Argyroso musregius) juveniles. Aquaculture 307:65-70
43. Lopez LM, Torres AL, Durazo E, Drawbridge M, Bureau DP (2006) Effects of lipid on growth and feed utilization of white seabass (Atractoscion nobilis) fingerlings. Aquaculture 253:557-563
44. Kim D, Kim K, Seo J, Lee H (2012) Effects of dietary lipid source and level on growth performance, blood parameters and flesh quality of sub-adult olive flounder (Paralichthys olivaceus) Journal of Animal Science 25:869-879
45. El–Kasheif M, Saad A, Ibrahim S (2011) Effects of varying levels of fish oil on growth performance, body composition and haematological characteristics of Nile tilapia Oreochromis niloticus. Egyptian Journal of Aquatic Biology and Fisheries15:125-141
46. Kheir MT (2011) Growth of Oreochromis niloticus raised on feeds with different protein levels. Egyptian Journal of Zoology 28:65-76
47. Cho CY, Slinger SJ, Bayley HS (2017) Influence of level and type of dietary protein, and of level of feeding on feed utilization by rainbow trout.Journal of Nutrition 106:1547-1556
48. Han T, Li X, Wang J, Hu S, Jiang Y, Zhong X (2014) Effect of dietary lipid level on growth, feed utilization and body composition of juvenile giant croaker Nibea japonica. Aquaculture 434:145-150
49. Storebakken T, Foss P, Schiedt K, Austreng E, Liaaen-Jensen S, Manz U (2001) Carotenoids in diets for salmonids:IV. Pigmentation of Atlantic salmon with astaxanthin, astaxanthin dipalmitate and canthaxanthin. Aquaculture65:279-292
50. Adebayo OT, Fagbenro OA (2000) Induced ovulation and spawning of pond raised African giant catfish, Heterobranchus bidorsalis by exogenous hormones. Aquaculture242:229-236