

## PLANT DERIVED OILS AS SUBSTITUTE FOR FISH OIL IN DIETS FOR ROHU (*LABEO ROHITA*): EFFECTS ON GROWTH PARAMETERS, NUTRIENT DIGESTIBILITY AND WHOLE-BODY COMPOSITION

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### ABSTRACT

A study was carried out on *Labeo rohita* fingerlings to assess the effects of various plant oils as a substitute for fish oil (FO) for 70 days. A total of 270 fingerlings (15 fish/tank) were distributed in V-shaped tanks each with three replicates. Total six experimental diets were formed. Test diet-I (control) consisted of FO, whereas test diets-II, III, IV, and V comprised of sunflower, corn, canola and palm oils, respectively, and test diet-VI composed of mixture of all four plant oils. Results of this study showed that plant oil mixture based test diet-VI fed fingerlings showed maximum specific growth rate ( $1.92 \pm 0.001$ ), weight gain ( $19.16 \pm 0.01$  g) and lowest feed conversion ratio ( $1.32 \pm 0.02$ ). While test diet-IV (canola oil) showed least growth performance. The fingerlings fed with test diet-VI had maximum digestibility i.e., crude fat (CF) ( $82.20 \pm 0.30\%$ ), crude protein (CP) ( $74.79 \pm 0.14\%$ ) and gross energy (GE) ( $73.51 \pm 0.21\%$ ). The lowest nutrient digestibility values for CP, CF, and GE were noticed in fingerlings fed with test diet-IV. In the case of body composition, test diet-VI showed maximum CP and ash values while having the least moisture and fat values. The outcomes of this research revealed that using plant oil mixture as a substitute for FO improved all growth parameters, carcass composition, and digestibility of *L. rohita*.

**Keywords:** Plant oils, Fish oil, Crude protein, Feed conversion ratio, Body composition.

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### INTRODUCTION

Aquaculture is a food industry that is flourishing at a rapid pace and is supplying around fifty percent of the fish consumed by humans. Many health organizations declare fish as a significant omega-3 fatty acid and protein source that provide consumers with great health benefits (Ansari *et al.*, 2021). The World Bank (2013) predicted that aquaculture output will rise from 93.2 to 101.2 million tons by 2030. On the other hand, it is estimated that by 2050, the population of world will be 8-9 billion (Yarnold *et al.*, 2019). A fundamental challenge is the requirement for higher aquaculture productivity without putting stress on wild caught fish used as aqua-feed. The demand of fish has increased significantly and this can only be solved by escalating aquaculture but there remains the challenge of providing highly nutritious fish (FAO, 2018; Selamoglu, 2021). In order to expand the aquaculture sector globally and fulfill rising food

demand, sustainable and novel solutions must be successfully implemented (Dineshbabu *et al.*, 2019).

Fish oil (FO) is one of the significantly utilized source of fats in aqua-feeds, since it has high concentrations of n-3 polyunsaturated fatty acids (n-3 PUFAs), that are particularly crucial for growth of fish and have major impact on reproduction (Yang *et al.*, 2020). Lipids have a key physiological role as a source of essential fatty acids, metabolic energy and vitamin D, K and A (Jiménez-Martínez *et al.*, 2020). However, the use of FO in aquatic feeds has been constrained, particularly for freshwater fish, due to its high price, quick oxidation, limited availability and unsaturated fatty acids (HUFAs) rancidity (Li *et al.*, 2015; Monteiro *et al.*, 2018). Therefore, appropriate substitutes to FO are essential for sustainability of aquaculture, hence there is a growing research interest in other lipid sources (Zhou *et al.*, 2016).

Animal lipids and plant oils are considered suitable alternatives to FO due to their abundant supply

and accessibility. Numerous studies have demonstrated that animal derived lipids i.e., lard oil and plant derived oils i.e., corn, soybean, linseed oils and rapeseed, can partially or totally replace FO in aqua-feed without having a negative impact on the body functioning of animals (Liu *et al.*, 2018; Abbasi *et al.*, 2020). As a feasible lipid source for diverse aquatic species, several terrestrial oil sources made from palm, olive, sunflower, and mixtures of two or more oils have also been demonstrated (Hassankiadeh *et al.*, 2013; Chen *et al.*, 2015; Sankian *et al.*, 2019). Rohu (*L. rohita*) is a popular fish among consumers, with a global production of roughly 16.8,000 tonnes in 2018 (FAO, 2020). It is the most significant specie among cultivable Indian major carps. It is chosen due to its higher growth rate, increased market value, improved resistance against diseases, and delectable quality of fish meat (Anand *et al.*, 2018; Asghar *et al.*, 2024). About 87% of India's entire freshwater aquaculture production is comprised up of Indian major carps, with *L. rohita* being the most prominent species within this group, contributing a significant 35% to the overall IMCs production (ICLARM, 2001; Mir *et al.*, 2017). The demand for commercially feasible and nutritionally balanced pelleted feed is growing, as carp farming becomes more commercialized (Musharraf and Khan, 2022). This research investigates the efficacy of plant oils as a substitute for FO in the diet of *L. rohita*, focusing on its impact on growth, digestibility, and carcass composition.

## MATERIALS AND METHODS

**Conditions for fish rearing and acclimatization:** *L. rohita* fingerlings (n=270; 15 fish/tank) were taken from local Fish Seed Hatchery. These were placed in V-shaped tanks (designed specifically to collect feces) with water holding capacity of 50 L. Then fish were subjected to acclimatization for 2 weeks. To prevent any parasite or fungal infection from fish skin, fish were bathed with salt solution at the start of trial (Rowland, 1991). They were given basal diet (control diet) one time a day to apparent satiety (Hussain *et al.*, 2018). PH, temperature, and dissolved oxygen were checked daily by using a meter (pH meter) (Jenway 3510), thermometer and DO meter (Jenway 970). For 24-hour aeration, capillary system was supplied to each experimental tank.

**Experimental design:** Table 1 shows the test diets composition. Control diet (Test diet I) was formed using FO while four test diets (II, III, IV and V) were formed by using canola oil, sunflower oil, corn oil and palm oil, and the sixth one (VI) was formed by mixing all these oils. Three replicate tanks were used for each test diet (18 tanks). The feeding rate was 5% of the fish's live wet body weight per day and the age of fingerlings was about

2 months at that time. The total trial duration was 70 days.

**Pellet formation:** Ingredients for feed formation were taken from local feed mill and chemical composition of diet was tested. Then all feed ingredients were grounded and mixed completely using a mixer. During mixing process, different oils were gradually added. Chromic oxide worked as an inert indicator. Moreover, water was also added gradually (10-15%) used to make perfect dough (Lovell, 1989). The dough was transferred to a pelletizer for formulation of feed pellets. Then the feed was dried in the shade. All the six oil-based experimental diets were formed following this process and were placed at 4°C till they are being used.

**Feeding protocol and sample collection:** Fingerlings were given six plant oil-based diets. After feeding practices, the valves of tanks were opened for the removal of any uneaten feed. The tanks were than cleaned properly and water being refilled. Following 2 hours of feeding, the fecal matter was taken carefully through fecal collecting tube, so that thin fecal fibers did not break. After collection, the fecal material was dried, ground and then preserved for further analysis (Hussain *et al.*, 2018).

**Biochemical assay of feces, feed, and fish muscle samples:** Feces, Feed and muscle samples of fingerlings were ground in a pestle and mortar. Standard protocols (AOAC, 2005) were used to perform chemical analysis. All samples were placed in oven at 105°C to dry for 12 hours to find moisture amount. Crude fat (CF) extraction was done through petroleum ether extraction technique by Soxtec HT2 1045 apparatus. Moreover, Micro Kjeldahl equipment was utilized to calculate crude protein (CP, N6.25). For ash, sample was heated for 12 hours (650°C) in an electric furnace to a uniform weight. The gross energy (GE) determination (Rodrigues *et al.*, 2022) was done by using oxygen bomb calorimeter (C200, IKA, Staufen, German).

**Growth studies:** Fingerlings from every tank were weighed at the start and end of the study period to measure growth. Then their growth parameters as specific growth rate (SGR), weight gain% (WG%) and feed conversion ratio (FCR) were measured with the help of these formulae:

$$FCR = \frac{\text{Total dry feed intake (g)}}{\text{Wet weight gain}}$$

$$\text{Weight gain \%} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

$$SGR (\%) = \left[ \frac{\ln(\text{final weight}) - \ln(\text{initial weight})}{\text{Trial duration}} \right] \times 100$$

**Digestibility determination:** Apparent digestibility (ADC) for the test diets were determined by following formula:

$$\text{ADC (\%)} = \left[ 100 - \left( 100 \times \frac{\text{Percent chromic in diet} \times \text{Percent nutrient in feces}}{\text{Percent chromic in feces} \times \text{Percent nutrient in diet}} \right) \right]$$

**Estimation of chromic oxide:** Oxidation was done by molybdate solution and then the quantity of chromic oxide in samples was evaluated by a Spectrophotometer at 370 nm (UV-VIS 2001) absorbance (Divakaran *et al.*, 2002).

**Data analysis:** Tukey's Honest Significant Difference Test (HSD) was utilized to assess differences among means (Snedecor and Cochran, 1989). The data on body composition, growth performance and nutrient digestibility were analyzed by one-way ANOVA under completely randomized design (Steel *et al.*, 1996). For statistical assay, Co-Stat computer program was used.

## RESULTS

**Growth parameters:** Results for growth of fish are given in Table 2. Prior to the experiment, weight of fish

was nearly same, but at the end of experiment, final weights were significantly different. Highest weight gain (WG; 19.16±0.01 g) and WG% (283.80±0.77%) were noted in fingerlings fed test diet-VI (plant mixture oil). Following test diet-VI, test diet-V (palm oil) showed second best WG (16.99±0.05 g) and WG% (251.16±1.63%) results. Minimum WG (12.54±0.01 g) and WG% (185.73±0.75%) were noted in fingerlings fed test diet-IV (canola oil). FCR values of fingerlings also showed significant increase. Highest FCR (1.72±0.03) was shown by fingerlings fed test diet-IV (canola oil) and lowest FCR (1.32±0.02) was shown by test diet-VI (plant mixture oil). For SGR values, test diet-VI gave best result (1.92±0.001) while test diet-IV fed fingerlings showed minimum SGR value (1.50±0.001). As a whole, test diet-VI (plant mixture oil) had best impact on growth in terms of WG, WG (%), FCR and SGR (%).

**Table 1: Nutritional composition and ingredient of experimental diets.**

| Diets Ingredients (%)                | TD-I*(Control) | TD-II* | TD-III* | TD-IV* | TD-V* | TD-VI* |
|--------------------------------------|----------------|--------|---------|--------|-------|--------|
| Canola meal                          | 32             | 32     | 32      | 32     | 32    | 32     |
| Fish meal                            | 20             | 20     | 20      | 20     | 20    | 20     |
| Corn gluten meal 60%                 | 15             | 15     | 15      | 15     | 15    | 15     |
| Wheat flour                          | 16             | 16     | 16      | 16     | 16    | 16     |
| Rice polish                          | 7              | 7      | 7       | 7      | 7     | 7      |
| Fish oil                             | 6              | 0      | 0       | 0      | 0     | 0      |
| Sunflower oil                        | 0              | 6      | 0       | 0      | 0     | 0      |
| Corn oil                             | 0              | 0      | 6       | 0      | 0     | 0      |
| Canola oil                           | 0              | 0      | 0       | 6      | 0     | 0      |
| Palm oil                             | 0              | 0      | 0       | 0      | 6     | 0      |
| Oil mixture                          | 0              | 0      | 0       | 0      | 0     | 6      |
| Vitamin premix**                     | 1              | 1      | 1       | 1      | 1     | 1      |
| Mineral premix***                    | 1              | 1      | 1       | 1      | 1     | 1      |
| Ascorbic acid                        | 1              | 1      | 1       | 1      | 1     | 1      |
| Chromic oxide                        | 1              | 1      | 1       | 1      | 1     | 1      |
| Nutrient composition                 |                |        |         |        |       |        |
| Crude protein                        | 30.79          | 30.82  | 30.73   | 30.74  | 30.62 | 30.58  |
| Crude fat                            | 7.31           | 7.27   | 7.28    | 7.31   | 7.29  | 7.30   |
| Gross energy (kcal g <sup>-1</sup> ) | 3.44           | 3.43   | 3.42    | 3.41   | 3.45  | 3.46   |

\*TD-I = Test diet-I (6% Fish oil), TD-II (6% Sunflower oil), TD-III (6% Corn oil), TD-IV (6% Canola oil), TD-V (6% Palm oil) and TD-VI (6% Plant oil mixture)

\*\*Vitamin (Vit.) premix kg<sup>-1</sup>: Vit. A: 15,000,000 IU, Vit. E: 30000 IU, Vit. B<sub>12</sub>: 40 mg, Vit. C: 15,000 mg, Vit. K<sub>3</sub>: 8000 mg, Folic acid: 1500 mg, Vit. D<sub>3</sub>: 3,000,000 IU, Nicotinic acid: 60,000 mg, B<sub>2</sub>: 7000 mg, Vit. B<sub>6</sub>: 4000 mg, Vit. Ca pantothenate: 12,000 mg.

\*\*\*Mineral premix kg<sup>-1</sup>: Mg: 55 g, Ca: 155 g, Zn:3000 mg, Se: 3 mg, I: 40 mg, Na: 45 g, Mn: 2000 mg, Co: 40 mg, Fe: 1000 mg, Cu: 600 mg, P: 135 g.

**Nutrient digestibility:** Values for analyzed composition of feces and digestibility with respect to CF, GE and CP are given in Table 4. Nutrient digestibility of *L. rohita* for CP were substantially different ( $P < 0.05$ ) and maximum in test diet-VI (plant oil mixture) than control and all

other test diets. Findings of nutrient digestibility showed that best results for CP (74.79±0.14%), CF (82.20±0.30%) and GE (73.51±0.21%) were shown by plant oil mixture-based test diet-VI. While the minimum values for CP (57.58±0.66%), CF (74.65±0.73%) and GE

(68.19±0.66%) were given by test diet-IV (canola oil). Thus, overall plant oil mixture-based test diet-VI caused least amount of nutrients to be discharged into environment by improving nutrient digestibility in fingerlings.

**Whole body composition:** Findings for carcass in terms of CF, CP, moisture and ash for *L. rohita* are shown in Table 4. As a result, maximum and significantly different

values for CP (18.24±0.09%) and ash (2.21±0.07%) were observed in test diet-VI. However, least values for CP (16.13±0.10%) and highest value of ash (1.72±0.09%) were seen in the case of test diet-IV. The values of fat and moisture were maximum as; 6.13±0.10% and 76.19±0.06%, respectively, in test diet -VI. While test diet-VI showed least values for moisture and fat as 74.82±0.07% and 4.74±0.12%, respectively.

**Table 2: Growth indices of *L. rohita* having different plant oil-based diets.**

| Growth parameters                                       | TD-I*                   | TD-II*                   | TD-III*                 | TD-IV*                 | TD-V*                  | TD-VI*                 |
|---|-------------------------|--------------------------|-------------------------|------------------------|------------------------|------------------------|
|   | (Control)               | Different Oil Sources    |                         |                        |                        |                        |
|   | Fish oil                | Sunflower oil            | Corn oil                | Canola oil             | Palm oil               | Plant mixture oil      |
| Initial Weight (g)                                      | 6.7±0.03 <sup>a</sup>   | 6.7±0.02 <sup>a</sup>    | 6.7±0.02 <sup>a</sup>   | 6.7±0.03 <sup>a</sup>  | 6.7±0.03 <sup>a</sup>  | 6.7±0.02 <sup>a</sup>  |
| Final Weight (g)  | 22.3±0.04 <sup>c</sup>  | 21.9±0.03 <sup>d</sup>   | 19.8±0.04 <sup>c</sup>  | 19.2±0.04 <sup>f</sup> | 23.7±0.04 <sup>b</sup> | 25.9±0.03 <sup>a</sup> |
| Daily Weight Gain (g)                                   | 0.2±0.001 <sup>c</sup>  | 0.2±0.001 <sup>d</sup>   | 0.1±0.002 <sup>c</sup>  | 0.1±0.002 <sup>f</sup> | 0.2±0.001 <sup>b</sup> | 0.2±0.001 <sup>a</sup> |
| Feed Conversion Ratio                                   | 1.4±0.01 <sup>c</sup>   | 1.4±0.02 <sup>c</sup>    | 1.6±0.001 <sup>b</sup>  | 1.7±0.03 <sup>a</sup>  | 1.4±0.01 <sup>c</sup>  | 1.3±0.02 <sup>d</sup>  |
| Weight Gain (g)   | 15.6±0.02 <sup>c</sup>  | 15.2±0.04 <sup>d</sup>   | 13.08±0.03 <sup>c</sup> | 12.5±0.01 <sup>f</sup> | 16.9±0.05 <sup>b</sup> | 19.1±0.01 <sup>a</sup> |
| Feed Intake (fish <sup>-1</sup> day <sup>-1</sup> ) (g) | 0.2±0.0002 <sup>d</sup> | 0.2±0.0002 <sup>dd</sup> | 0.2±0.001 <sup>a</sup>  | 0.2±0.001 <sup>a</sup> | 0.2±0.002 <sup>b</sup> | 0.2±0.003 <sup>c</sup> |
| Weight Gain (%)   | 231.9±0.9 <sup>c</sup>  | 226.04±1.01 <sup>d</sup> | 194.07±0.6 <sup>c</sup> | 185.7±0.7 <sup>f</sup> | 251.1±1.6 <sup>b</sup> | 283.8±0.8 <sup>a</sup> |
| Specific Growth Rate                                    | 1.7±0.002 <sup>c</sup>  | 1.6±0.001 <sup>d</sup>   | 1.5±0.002 <sup>c</sup>  | 1.5±0.001 <sup>f</sup> | 1.7±0.01 <sup>b</sup>  | 1.9±0.003 <sup>a</sup> |

\*TD-I = Test diet-I (6% Fish oil), TD-II (6% Sunflower oil), TD-III (6% Corn oil), TD-IV (6% Canola oil), TD-V (6% Palm oil) and TD-VI (6% Plant oil mixture)

<sup>a-f</sup> means having distinct superscripts differ statistically ( $P<0.05$ ). Data are averages of three replicas

**Table 3: Analyzed compositions (%) of CP, CF and GE in the feces and nutrient digestibility of *L. rohita* having different oil-based diets.**

| Parameters                     | TD-I*                  | TD-II*                  | TD-III*                | TD-IV*                  | TD-V*                  | TD-VI*                 |
|--------------------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|------------------------|
|                                | (Control)              | Different Oil Sources   |                        |                         |                        |                        |
|                                | Fish oil               | Sunflower oil           | Corn oil               | Canola oil              | Palm oil               | Plant mixture oil      |
| Fecal composition analysis (%) |                        |                         |                        |                         |                        |                        |
| CP**                           | 10.7±0.4 <sup>d</sup>  | 11.09±0.06 <sup>c</sup> | 12.6±0.06 <sup>b</sup> | 13.04±0.03 <sup>a</sup> | 9.8±0.04 <sup>c</sup>  | 8.6±0.06 <sup>f</sup>  |
| CF**                           | 1.7±0.02 <sup>c</sup>  | 1.8±0.03 <sup>bc</sup>  | 1.8±0.03 <sup>b</sup>  | 1.9±0.02 <sup>a</sup>   | 1.6±0.01 <sup>d</sup>  | 1.5±0.02 <sup>c</sup>  |
| GE** (kcal g <sup>-1</sup> )   | 1.06±0.02 <sup>b</sup> | 1.07±0.01 <sup>ab</sup> | 1.08±0.01 <sup>a</sup> | 1.08±0.005 <sup>a</sup> | 1.05±1.02 <sup>c</sup> | 1.02±0.01 <sup>d</sup> |
| Nutrient Digestibility (%)     |                        |                         |                        |                         |                        |                        |
| CP*                            | 66.6±0.9 <sup>ab</sup> | 59.8±8.9 <sup>b</sup>   | 59.8±1.2 <sup>b</sup>  | 57.5±0.6 <sup>b</sup>   | 70.2±0.06 <sup>a</sup> | 74.7±0.1 <sup>a</sup>  |
| CF**                           | 78.2±0.3 <sup>c</sup>  | 76.9±0.05 <sup>cd</sup> | 76.5±0.9 <sup>d</sup>  | 74.6±0.7 <sup>c</sup>   | 80.1±0.07 <sup>b</sup> | 82.2±0.3 <sup>a</sup>  |
| GE*** (kcal g <sup>-1</sup> )  | 70.5±1.1 <sup>c</sup>  | 69.5±0.2 <sup>cd</sup>  | 69.1±0.6 <sup>d</sup>  | 68.1±0.6 <sup>c</sup>   | 71.8±0.3 <sup>b</sup>  | 73.5±0.2 <sup>a</sup>  |

\*TD-I = Test diet-I (6% Fish oil), TD-II (6% Sunflower oil), TD-III (6% Corn oil), TD-IV (6% Canola oil), TD-V (6% Palm oil) and TD-VI (6% Plant oil mixture)

\*\*CP= crude protein, CF= crude fat, GE= gross energy

<sup>a-f</sup> means having distinct superscripts differ statistically ( $P<0.05$ ). Data are averages of three replicas

**Table 4: Whole body composition of *L. rohita* having different oil-based diets.**

| Parameters   | TD-I*                    | TD-II*                 | TD-III*                | TD-IV*                 | TD-V*                   | TD-VI*                 |
|--------------|--------------------------|------------------------|------------------------|------------------------|-------------------------|------------------------|
|              | (Control)                |                        |                        |                        |                         |                        |
|              | Different Oil Sources    |                        |                        |                        |                         |                        |
|              | Fish oil                 | Sunflower oil          | Corn oil               | Canola oil             | Palm oil                | Plant mixture oil      |
| Ash (%)      | 2.02±0.10 <sup>abc</sup> | 1.9±0.05 <sup>bc</sup> | 1.8±0.06 <sup>cd</sup> | 1.7±0.09 <sup>d</sup>  | 2.1±0.01 <sup>ab</sup>  | 2.2±0.07 <sup>a</sup>  |
| Moisture (%) | 75.1±0.03 <sup>d</sup>   | 75.5±0.1 <sup>c</sup>  | 75.9±0.09 <sup>b</sup> | 76.1±0.06 <sup>a</sup> | 74.9±0.08 <sup>dc</sup> | 74.8±0.07 <sup>c</sup> |
| Fat (%)      | 17.4±0.1 <sup>abc</sup>  | 16.8±0.1 <sup>bc</sup> | 16.4±0.1 <sup>c</sup>  | 16.1±0.1 <sup>d</sup>  | 17.7±0.1 <sup>ab</sup>  | 18.2±0.09 <sup>a</sup> |
| Protein (%)  | 5.3±0.1 <sup>d</sup>     | 5.6±0.1 <sup>c</sup>   | 5.7±0.1 <sup>b</sup>   | 6.1±0.1 <sup>a</sup>   | 5.1±0.1 <sup>c</sup>    | 4.7±0.1 <sup>f</sup>   |

\*TD-I = Test diet-I (6% Fish oil), TD-II (6% Sunflower oil), TD-III (6% Corn oil), TD-IV (6% Canola oil), TD-V (6% Palm oil) and TD-VI (6% Plant oil mixture)

<sup>a-f</sup> means having distinct superscripts differ statistically ( $P<0.05$ ). Data are averages of three replicas

## DISCUSSION

The aquaculture industry places a high focus on the quest to substitute lipid sources because of the constrained supply and rising prices of FO. Dietary lipids' efficacy in boosting growth depends more on the type and quantity of fatty acids they contain than on the total amount of lipid in diet. Freshwater fish, whether herbivorous or omnivorous, can convert LA (Linoleic acid) and ALA (Alpha-linolenic acid) into EPA (Eicosapentaenoic acid), ARA (Arachidonic acid) and DHA (Docosahexaenoic acid) (Sargent *et al.*, 2002; Hixson *et al.*, 2015); however, the potential to de-saturate and elongate the fatty acid chains varies between fish species. The effect of nutrients of diet is usually determined by growth performances (NRC, 2011). According to present study, plant oils in diet of *L. rohita* can replace FO, as no lethal effects on growth performance of fingerlings is noticed. According to some studies conducted on other cyprinid species, such as black carp (Sun *et al.*, 2011) with rapeseed oil, and the minnow (*Onchystoma macrolepidota*) (Gou *et al.*, 2021) and common carp with grapeseed oil (Zorlu and Gümüş, 2022), sunflower oil (Sonu *et al.*, 2014) and unrefined peanut oil (Yıldırım *et al.*, 2013), total FO replacement did not affect growth adversely. In the present study, test diet-VI comprising blend of plant oil showed best growth performance results among control and all other test diets, indicating that requirement for essential fatty acid (EFA) was fully fulfilled.

Similar to our findings, Wabike *et al.* (2020) observed higher SGR, FER (feed efficiency ratio), WG in yellow drum when fed on blend of plant oils than FO. Loum *et al.* (2013) also noted an improvement in growth parameters of Nile tilapia (*O. niloticus*), including SGR, weight gain, fed on blend of vegetable oils. Our study suggests that a blend of vegetable oils is the best option because canola and corn oil have high PUFA content, particularly linoleic (18:2 n6) and oleic acid (18:1 n9), palm oil contains a balanced mix of saturated (40%) and unsaturated (60%) fatty acids, whereas FO is

predominantly polyunsaturated (60-70%), and sunflower oil is rich source of vitamin E, and mono-unsaturated fatty acids. Hence, the blend of these oils (canola, corn, palm and sunflower) are rich in energy, thus sparing PUFAs for biological purposes (Nasopoulou and Zabetakis, 2012; Corrêa *et al.*, 2018). While Sáez-Royuela *et al.* (2022) observed that when FO was totally substituted by a blend of plant oils, there was no substantial change in survival rate and growth of juvenile tench, similar to our findings, there was a considerable drop in total body lipid contents. Contrary to what we found in our results, An *et al.* (2020) found highest weight gain, SGR and lowest FCR in hybrid grouper fed on FO than plant oil. The possible reason can be that most of marine fish are not able to de-saturate ALA to DHA and EPA (Castro *et al.*, 2012).

Diet influences the final composition of fish, which can alter its nutritional value and quality as a human food source (Ayisi *et al.*, 2019). Regarding proximate composition of body, *L. rohita* fed a combination of plant oils exhibited a considerable decrease in lipid content in contrast to control and other experimental diets. Contrary to what has been documented in other freshwater species, such as mandarin fish (Sankian *et al.*, 2019), beluga sturgeon (Falihatkar *et al.*, 2018), rainbow trout (Güler, and Yıldız, 2011) and Nile tilapia (Erondu *et al.*, 2021), whole body or other tissues lipids does not increase by addition of vegetable oils in the diet. Guo *et al.* (2021) found a significant ( $P<0.05$ ) correlation between dietary ALA/LA and body lipid content in research on juvenile golden pompano (*Trachinotus ovatus*), finding that the low body lipid amount is linked with high ALA/LA ratio. Similar relationship is seen in our study, where fingerlings fed with control diet had high lipid (5.32±0.14%) deposition whereas low lipid deposition (4.74±0.12%) corresponded to fish fed blend of plant oils. In our research, blend of canola, corn, palm and sunflower oils showed low lipid deposition because these oils plant oils have a different fatty acid composition compared to FO. FO is high in N-3 fatty acids,

particularly EPA and DHA, which are readily absorbed and deposited in fish tissues. In contrast, plant oils are generally higher in omega-6 fatty acids and oleic acid, which are metabolized differently and tend to have lower deposition rates in fish bodies (Corrêa *et al.*, 2018).

**Conclusion:** This study determined that usage of plant oils as substitute of FO is a cost effective as well as environmentally friendly strategy. Also, the use of blend of different plant oils rather than individual plant oil is more suitable. Plant oil mixture successfully improved growth parameters and nutrient digestibility with positive effect on carcass composition of *L. rohita*.

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