Effect of replacing fishmeal by soybean meal in young Common Carp (Cyprinus carpio) diet on feed utilization and growth

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Abstract:
Among plant-based protein sources, soybean meal stands out as a highly nutritious option. However, its widespread use in aquafeed is hindered by the presence of anti-nutritional factors. Soy protein concentrate offers a solution by removing these undesirable components. Compared to fishmeal, soy protein concentrate boasts superior digestibility coefficients for protein and amino acids, along with consistent quality and availability. In a 50-day experiment conducted in plastic aquaria, the growth and feed utilization performance of common carp fry were evaluated using two different feed types: Control Ration and Treatment Ration. These feeds comprised various ingredients including fish meal, soybean, barley, corn, wheat flour, and premix, with a feeding rate of 3% of the fish's wet body weight. Although the crude protein content ranged from 28.92% to 30.04%, statistical analysis using the static t-test revealed no significant differences ($P<0.05$) between the two treatments across all parameters. However, it was noted that feeds with higher protein levels tended to promote better growth and feed utilization in the fish.

Keywords: Fish Meal, Common Carp, Soybean Meal, Carbohydrate utilization

INTRODUCTION

Aquaculture, as defined by [27], involves the cultivation of aquatic organisms under controlled or semi-controlled conditions. The demand for finfish and shellfish has surged due to factors like increasing population, wealth, and the recognition of seafood's health benefits, surpassing the estimated sustainable catch of wild fish by nearly 100 percent [28.[
Primarily driven by high local demand and favorable temperatures, aquaculture is predominantly practiced in developing countries. In 2010, this industry employed approximately 16 million people in the value chain, with half of them being women. Contributing significantly to the global seafood supply, aquaculture provided about 40 percent, equivalent to around 60 million metric tons, of the total supply in 2010 [8]. However, to meet the escalating demand, aquaculture needs to nearly double again in the next 15 years [20]. Sustainable growth

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requires the industry to respect ecological boundaries.

The common carp (Cyprinus carpio) stands out as one of the most extensively cultured fish species globally and one of the earliest domesticated for food [3]. Carps, being omnivorous, primarily consume benthic organisms such as water insects, larvae, worms, mollusks, and zooplankton, which can result in turbidity when they forage at the bottom of ponds [22]. Meeting the nutritional requirements for growth and reproduction in cyprinids entails a higher protein diet, highlighting the importance of efficient protein utilization [24.[

The aquafeed industry heavily relies on both animal and plant-derived components for nutrition. While animal-based feeds, particularly fish meal, offer superior nutritional value, their high cost and limited resources pose challenges [4]. The substitution of fish meal with plant proteins, notably soybean products, has been extensively studied [29]. Soy meal, being rich in biologically valuable proteins, serves as a significant plant-based alternative in aquafeed [32]. However, the presence of anti-nutritional factors and amino acid deficiencies in soy products necessitates additional investments in synthetic amino acids and heat treatment [32]. Nonetheless, many researchers believe that partial replacement of fish meal with soybean products is viable with the supplementation of synthetic amino acids.

The current research seeks to evaluate the impact of substituting animal protein found in fish meal with plant protein sourced from soybean meal in the diet of common carp. The study will specifically assess the following:

.1Feed utilization parameters, including Feed Conversion Ratio (FCR), Feed Conversion Efficiency (FCE), and Protein Efficiency Ratio (PER.(

.2Growth parameters, such as Weight Gain (WG), Specific Growth Rate (SGR), and Instantaneous Growth Rate (IGR.(

MATERIAL AND METHODS

Experimental Fish:

Experimental fish consisted of fingerling common carp (Cyprinus carpio L.) with weights ranging from 14.8g to 15g. These fish were sourced from Sharbazher Fish Farm near Sulaimani city on March 14, 2021. A total of 40 fish were utilized throughout the experiment. Upon arrival at the laboratory, the fish were sorted based on size, weighed, and then randomly distributed into oval plastic tanks. They were allowed a three-day acclimatization period without feeding to adjust to their new indoor environment. Subsequently, standard ration feeding (control pellets) resumed for another three days following the adaptation period. The experimental trial spanned 50 days for growth and feed utilization assessments.

Experimental system and design:

In this feeding experiment, eight plastic tanks were utilized, each holding approximately 100 liters of well water to accommodate five fish. Artificial aeration was provided continuously throughout the experiment using electric air pumps. Water temperature was monitored daily using standard thermometers. The experimental design comprised two treatments, each with four replicates, all randomly assigned to the plastic tanks. These tanks were situated on wooden platforms within the Fish Lab of the Animal Science Department at the College of Agricultural Engineering Sciences, University of Sulaimani. To maintain water quality, tanks were cleaned of fish waste and uneaten feed every two to three days using a manual pump and sponge. Lost water was replenished to maintain the original water level.

The experimental treatments are as follows:

The first treatment (Control Ration, CR) was used as a control treatment that contained (25%) of fishmeal; the second treatment (Treatment Ration, TR) contains (0%) of fishmeal.

3.3Diet formulation

Two different kinds of experimental diets were formulated using the following ingredients: Fish meal, Soybean meal, Wheat flour, Barley, Corn and Vitamin- Mineral Premix. Formulation of the experimental diets (CR and TR) was done depending on the proximate analysis of the feed ingredients. The ratios of each ingredient are shown in Table (1) for the three feeding rations.

Table (1): The formulation (%) of the experimental rations fed to common carp

Feedstuffs %	Control ration	Treatment ration
Fishmeal	25	0
Soybean meal	37	62
Corn	12	12
Wheat flour	12	12
Barley	12	12
Premix	2	2

The ingredients were mixed with water to obtain suitable dough then the dough passed through electrical mincer for making pellets. The pellets were dried at room temperature for a few days and then crushed to suitable pellets size. The proximate composition of the experimental rations is shown in (Table, 2 .(

Table (2): Proximate composition (%) of the experimental diets

Components	CR	TR
Crude Protein (CP)	30.04	28.92
Ether Extract (EE)	6.13	7.02
Total carbohydrates	32.97	37.14
Energy (Kcal/100g)	307.21	327.42

Feeding Method

The feeding regimen involved twice-daily feedings at 8:15 am and 2:15 pm. Initially, the feeding rate was set at 8% of the biomass during the adaptation period, gradually decreasing to a satiation level of 3% of the body weight based on observed feeding behavior. Feed rations were manually supplied to each tank, ensuring gradual delivery to allow individual consumption by the fish. Fish in all tanks were collectively weighed every ten days, and feed amounts were adjusted accordingly based on their new weights. To maintain tank cleanliness, fish waste and residual feed were removed via siphoning. Feeding trials were conducted over a 50-day period for growth and feed utilization assessment.

Studied Parameters

Growth parameters

Weight Gain

The weight gain (WG) for the whole biomass (g/10 fish) and for individual fish as (g/fish) was measured according to the following equation:

Body weight gain (WG) = Mean of weight (g) at the end of the experimental period – Mean weight (g) at the beginning of the experimental period

WG (g) = Wf – Wi Where: Wf is the final weight, and Wi is the initial weight in gram.

Relative Weight Gain

Relative weight gain (RWG %) was calculated from the following formula:

)RWG %) = Weight gain (WG) / Initial weight (Wi) x 100………[5[

Instantaneous Growth Rate

Instantaneous growth rate (IGR) was calculated according to the following equation:

IGR = (LnW2 – LnW1 / t2-t1) x 100……………… [30[

W2: final weight, W1: initial weight and T: time between W2 and W1

Specific growth rate

The rate of growth of an animal is a fairly sensitive index of protein quality; under controlled conditions weight gain being proportional to the supply of essential amino acids. Daily SGR can be calculated by using the formula:

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SGR = (Log final body weight – log initial body weight) / time period (day) X 100

Feed Utilization Parameters

Feed conversion ratio (FCR) and Feed conversion efficiency (FCE) were calculated according to [11] formula:

Feed conversion ratio (FCR) = Feed given (g) / Weight gain (g(

Feed conversion efficiency (FCE) =Weight gain (g) / Feed given (g) x 100

Protein efficiency ratio (PER(

Protein efficiency ratio was calculated using [14] equation:

Protein efficiency ratio (PER) = Live weight gain (g) / Protein fed (g(

Statistical analysis

The experimental was conducted using the (t-test paired) design and general linear models (GLM) procedure of XLSTAT. Pro. 7.5 was used to compare between means of the experiment treatments .

RESULTS AND DISCUSSION

Impact on Growth

Fingerlings common carp (C. carpio L.) fed on two different diet that CR with Fishmeal 25% and TR with Fishmeal 0% for 50 days grow in weight from average weights of 15g and 14.8g at the beginning of the experiment to final weights of 16.05 and 15.45 for CR and TR respectively as it shown in (Figure, 1

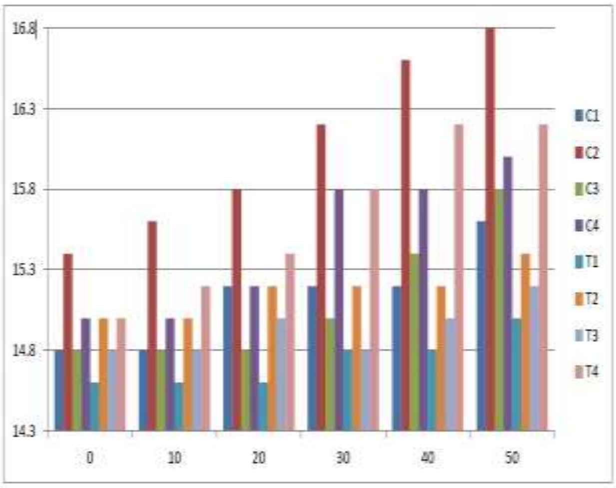

Figure: (1) Average of fish weight during whole experiment period

The growth of fingerling common carp, ranging from 14.6g to 16.8g in weight, observed in this study, was found to be similar to that reported in comparable feeding trials [19]. The results of our study indicated no significant impact on the growth of fingerling common carp in indoor feeding trials when replacing fishmeal with soybean meal in the diet. These findings align with those reported by previous study [12]. However, some studies have reported negative effects on the growth of common carp when fishmeal is replaced by soybean meal [34]. Fish species exhibit varying abilities to digest and metabolize alternative dietary components, particularly the protein in soybean meal [14]. Generally, herbivorous and omnivorous fish like carp and tilapia benefit from high levels of carbohydrates due to their efficient utilization, facilitated by specialized enzyme systems [21]. Conversely, carnivorous fish species such as salmonids exhibit poor utilization of carbohydrates due to the lack of specialized enzymes, resulting in reduced growth rates [15.[

Absolute and Relative Weight Gain (WG & RWG(

Weight gain of fingerlings common carp (C. carpio L.) fed on (CR) and (TR) are presented in Figure (2). We use the whole fishes weight static calculation in each parameter because of minimize fish weight in our feeding experiment as a result to make number more logical and appreciate discussion. Based on our data, the weight gain (WG) did not show significant increase initially; however, after the 50-day period, a noticeable improvement was observed. Lower WG ranging from 0 to 1g was recorded for both CR and TR. The highest WG were seen in CR treatments but contrary lowest were seen in TR treatments. There was a little superiority for CR over TR. However, differences were not significant (P>0.05) as appeared from the (Figure 2 .(

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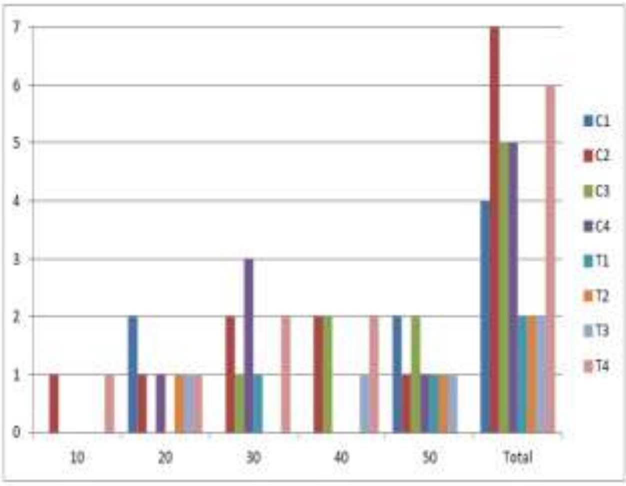

Figure (2): Absolute weight gain (WG) of fingerlings common carp fed on CR and TR for 50 days in plastic tanks

To mitigate the impact of initial weight discrepancies, relative weight gain (RWG) was computed. Detailed RWG data over the 50-day rearing period are depicted in Figure .(3)The outcomes exhibited a parallel trend to absolute weight gain. RWG values ranged from a peak of 9.09% in the CR treatment to 2.6% in the TR treatment. Statistical analysis revealed no significant differences in RWG between the treatments (P>0.05), indicating that the absence of fishmeal in the diet did not influence weight gain regardless of the initial weight

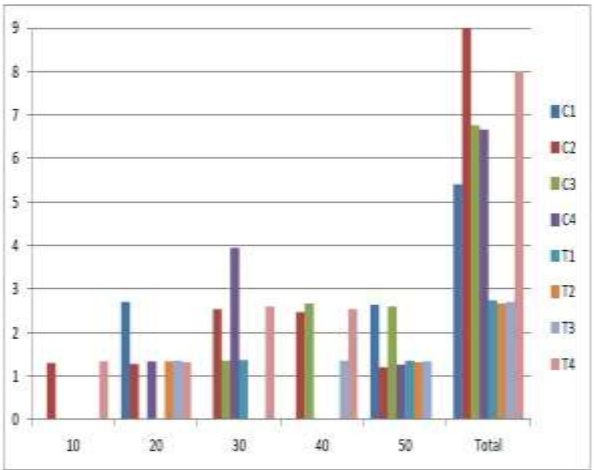

Figure (3): Relative weight gain (RWG) of fingerlings common carp fed on CR and TR for 50 days in plastic tanks

Weight gain and instantaneous growth rate are critical parameters to monitor in indoor feeding experiments, as emphasized by various authors [23]. Our findings align with those of [1], who observed that replacing fishmeal with plant protein sources such as soybean meal in Nile tilapia fingerlings did not adversely affect weight gain (WG) and relative weight gain (RWG). Conversely, [31] noted that soybean meal with high levels of trypsin inhibitor activity led to a reduced growth rate in fish fingerlings, resulting in lower WG and RWG compared to control diets. The authors attributed this reduction to inadequate lysine rather than residual antitrypsin in properly processed commercial soybean meals. Furthermore, [31] demonstrated a linear decrease in relative weight gain of carp with increasing soybean meal inclusion levels, consistent with our study's findings. Supplementation of diets containing soy flour with essential amino acids significantly enhanced carp growth [18]. However, the authors reported that treating soy flour with methanol did not significantly impact fish performance. They speculated that carp might be less susceptible to appetite-suppressing factors in soybean products compared to other fish species.

Instantaneous Growth Rate & Specific Growth Rate

The values of instantaneous growth rate (IGR) depicted in Figure (4) suggest that fish fed on the control ration (CR) exhibited better growth compared to those fed on the treatment ration (TR). IGR values ranged from 0.174% per day in the CR treatment to 0.052% per day in the TR treatment. It is noteworthy that IGR values in the CR treatment were highest in the last ten days of the experiment, whereas in the TR treatment, lower IGR values were observed during the same period. However, statistical analysis revealed that these differences were no significant (P>0.05.(

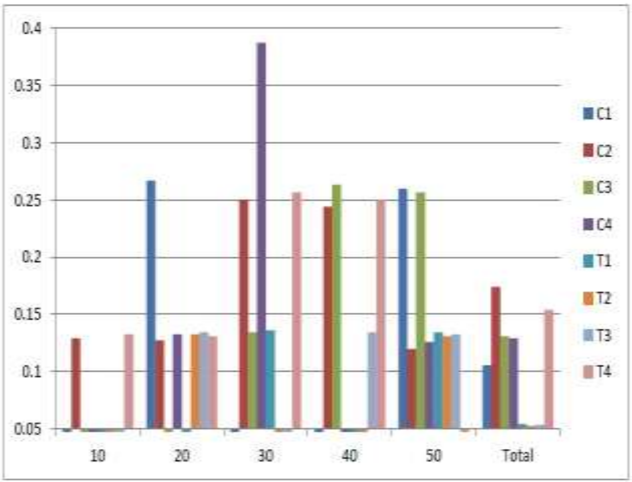

Figure (4): Each ten days and final values of IGR in fingerlings common carp fed on CR and TR

The values of specific growth rate (SGR) illustrated in Figure (5) mirror the trend observed in IGR, with fish fed on the control ration (CR) displaying better growth compared to those fed on the treatment ration (TR). SGR values ranged from 0.04% per day in the CR treatment to 0.02% per day in the TR treatment. Notably, the lowest SGR was observed in both CR and TR during the first and second ten days of the experiment, while the highest SGR value of 0.16% was recorded in the CR treatment during the third ten days of the experiment. However, statistical analysis indicated that these differences were not significant (P>0.05.(

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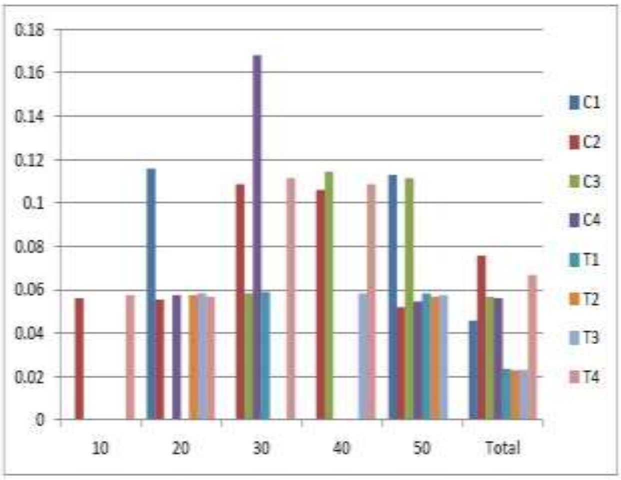

Figure (5): Each ten days and final values of SGR in fingerlings common carp fed on CR and TR

In fish diets, soybean meal (SBM) is often utilized to partially substitute fish meal. However, when SBM inclusion levels exceed 30%, it can lead to intestinal damage and generally reduce growth performance across different fish species, which may explain the low SGR and IGR observed in the present study [7]. It seems that carnivorous fish species like salmon and trout are more susceptible to the anti-nutritional components present in SBM compared to herbivorous or omnivorous species such as carp [10]. Despite this, numerous studies have demonstrated significant success in partially or completely replacing fish meal with SBM and other soybean products in diets for various fish species [2]. Soybeans contain several antinutritional factors, including protease inhibitors, non-digestible carbohydrates, lectins, saponins, phytates, and potentially allergenic storage proteins [16.[

Impact on Feed Utilization

Feed Conversion Ratio (FCR) and Feed Conversion Efficiency (FCE(

The food conversion ratio (FCR), which represents the amount of food required to produce 1g of weight gain, is a crucial parameter for assessing feed utilization in fish feeding trials. It helps elucidate growth responses to changes in feed ingredients [13]. In the present study, FCR can be used to evaluate the effect of replacing fishmeal with soybean meal, as discussed by [17], who examined the utilization of different levels of soybean meal by common carp.

As depicted in Figure (6), FCR ranged from 0.8 in the CR treatment to 2.7 in the TR treatment over the entire experimental period. This suggests slightly better utilization of feed in the CR group (with 25% fishmeal) compared to the TR group (with 0% fishmeal). The lowest FCR values were observed for the CR group during the first and fourth ten days of the feeding experiment, indicating better feed utilization by the fish during these periods. Conversely, the TR group exhibited high FCR values during the first and second ten days of the feeding experiment, suggesting poor feed utilization by the fish during these periods. However, the results of paired t-test analysis indicated that the differences in FCR between fish fed CR and TR were not significant (P>0.05

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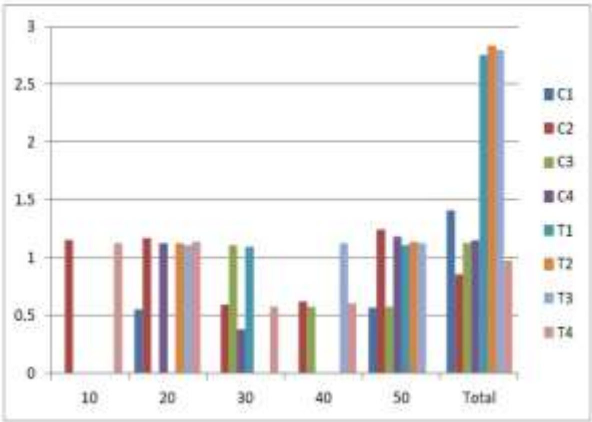

Figure (6): Variations in FCR in fingerlings common carp fed on CR and TR rations during 50 days feeding trial

Another nutritional parameter used to assess the impact of replacing fishmeal with soybean meal is feed conversion efficiency (FCE), which represents the percentage of weight gain resulting from a certain amount of feed. It facilitates easy comparison between treatments. In our results, FCE ranged from 1.16% in fish fed on CR to 1.02% for TR (Figure, 7). The higher FCE values observed in the CR group suggest better utilization of the ration by the fish compared to the TR group. However, there were no significant differences between the two treatments (P>0.05). This lack of significant difference between the dietary treatments indicates similar utilization of the diets by the fish

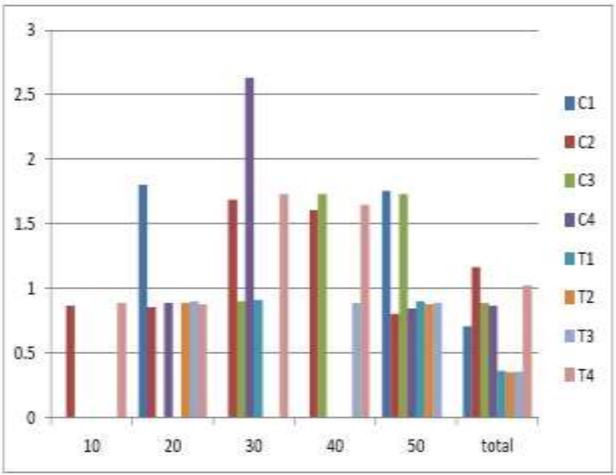

Figure (7): Variations in FCE in fingerlings common carp fed on CR and TR rations during 50 days feeding trial

The values of FCR and FCE obtained in the present study are generally comparable to those reported by other authors in various fish species [19]. Specifically, in our study, fish fed the TR diet exhibited a higher feed conversion ratio. Similar findings have been reported previously in carnivorous fish species such as Bloch's catfish [25]. The utilization of dietary protein by fish varies and seems to be linked to the complexity and quantity of protein in the fish's diet [26]. In

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theory, feeding on standard protein diet growth. This could influence FCR and FCE values if fish are fed to satiation. However, in our study, restricted feeding levels were provided, so the impact on FCR and FCE was negligible. The superiority of the CR level could therefore be attributed to the higher weight gain rather than reduced feed intake. However, [33] observed that incorporating 58.3% soybean meal (SBM) into the diets of tilapia (Oreochromis niloticus) improves FCR. However, such a level of SBM is lower than the SBM level used in the present study.

Protein Efficiency Ratio (PER(

The protein efficiency ratios (PER) presented in Figure (8) illustrate the weight gain per unit of protein fed. It is evident that fish fed the CR sources can contribute to cell diet, which contains a higher level of protein (30.04%), exhibit the highest PER. Conversely, the TR diet, which contains lower protein levels (28.92%), shows lower PER. This suggests that the reduced protein levels in the diet affect protein utilization by the fish, resulting in poorer utilization of protein for weight gain. The highest PER was recorded for the CR group during the last ten days of the experiment, reaching 5.8, whereas the lowest PER was observed for the TR group during the first and second ten days of the feeding trial. However, these differences were not significant (P>0.05), indicating that weight gain per unit of protein intake is nearly similar across all treatments.

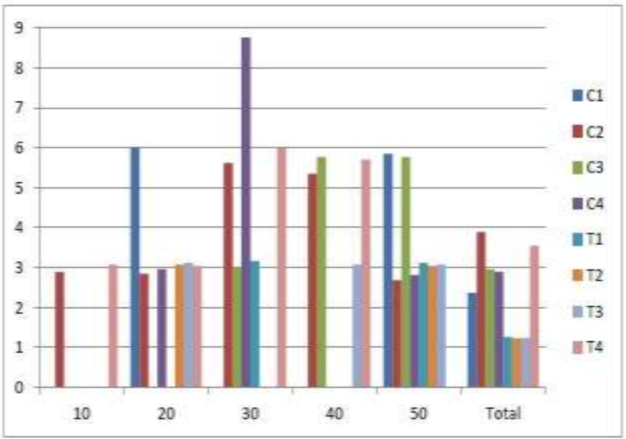

Figure (8): Variations in PER in fingerlings common carp fed on CR and TR rations during 50 days feeding trial

To contextualize the results of this research with previous findings, [9], who investigated the utilization of plant proteins in fish diets, reported significant differences in protein efficiency ratios (PER) between different dietary treatments. Additionally, [6], in their study on the effect of saponin extract from soybean meal on feed intake and growth of chinook salmon and rainbow trout, observed that the lowest PER were associated with increasing levels of soybean meal. The PER values reported in their study are comparable to the results of the present study.

Conclusions:

.1Increasing the inclusion of soybean meal in the diet of common carp up to 62% does not result in significant (P>0.05) effects on growth parameters and feed utilization.

.2The values of feed utilization remain largely unchanged when fish are fed a diet that entirely replaces fishmeal with soybean meal.

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.3Weight gain per unit of protein intake is similar in both the control ration (CR) and the treatment ration (TR.(

.4Growth parameters such as weight gain (WG), relative weight gain (RWG), instantaneous growth rate (IGR), and specific growth rate (SGR) analyzed in this study demonstrate no significant ($P>0.05$) effects of replacing fishmeal with soybean meal in fingerling common carp.

Recommendations

.1Increasing the level of soybean meal in fingerling common carp diets up to 62% appears to have no adverse effects on growth and feed utilization. Therefore, this level of inclusion can be considered safe and beneficial.

.2By reducing the expensive protein source such as fishmeal in fingerling common carp diets, it is possible to lower the overall cost of diet composition while maintaining satisfactory growth and feed utilization.

.3Further studies should be conducted to explore the potential of replacing fishmeal with other inexpensive protein sources in diets for various farmed fish species .

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