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Use of Some Alternative Feeding Strategy to Reduce the Production Cost of the Cultivated Common Carp *Cyprinus carpio*

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ABSTRACT

This study evaluated alternative feeding strategies in the production of common carp in floating cages. A total of 600 common carp fish with an average weight of 103.2± 37.0g were distributed in the cages at a density of 50 fish/ cage. Three replications were used for each treatment for the period from 15/12/2021 to 1/12/2022, under three feeding strategies and control treatment. T1 consisted of continuous feeding with a 30% protein content, while T2 involved an alternative feeding, switching between a 30% protein feed and a 20% protein feed on consecutive days. T3 included two days of feeding with a 30% protein diet followed by a day of a 20% protein diet, and T4 involved three days of feeding with a 30% protein diet followed by a day of a 20% protein diet. The results showed that no significant difference (P> 0.05) in WG, DGR, RGR and SGR of the fish between continuous feeding and alternative feeding at the end of the experiment, and the feed conversion rate (FCR) was not affected by the different protein levels. T2 exhibited superiority (P≤ 0.05) in protein efficiency ratio (PER), recording a value of 1.10, whereas the control treatment had a lower value. There was no significant difference in the condition factor between the different treatments. T4 recorded the best economic benefit (1.2) among the different treatments. No significant difference was detected in the protein of the fish body between the treatments, while the value of the fat increased with the alternative feeding, and the treatment before the experiment recorded the best value of body fat with 6.32.

INTRODUCTION

Fish production is considered one of the important sectors in the agricultural field, and it has a large and important economic return for countries of the world due to its role in achieving high levels of self-sufficiency. It is also considered one of the basic pillars of the livestock production base due to its crucial role in global nutrition and food security. It represents an important source in diverse and healthy dietary patterns since it contains good levels of proteins and fats with a high percentage of unsaturated fatty acids (PUFA) in addition to essential amino acids and micronutrients, including iron, iodine, and vitamins A and D, as well as calcium and phosphorus, which are lacking in most animal food products **(Jie et *al.*, 2017)**. The contribution of capture fisheries as a source of food fish was estimated at less than 1 million tons per year in the early 1950s, and production peaked in 2006 at 51.7 million tons, representing an annual growth rate of about 7% **(FAO, 2008)**. The **FAO (2020)** reported that globally aquaculture provides approximately 17% of animal protein, reaching more than 50% in many countries in Asia and Africa. Aquaculture is one of the fastest growing sectors of animal food production and outpaces population growth with per capita farmed aquaculture increasing from 0.7kg in 1970 to 7.8kg in 2006, with an average annual growth rate of 6.9% **(FAO, 2006)**.

Feed contributes significantly to the costs of commercial fish production, and this cost can be the difference between profitable and unprofitable aquaculture businesses. This is the biggest challenge facing fish farmers **(Brown *et al.*, 2004)**. **Hatch and Kenokan (1993)** showed that some feed restriction protocols may reduce feed costs without a net reduction in productivity; however, it is not known whether these protocols result in more efficient feed consumption or better feed utilization (increased FCR) or both. Regular feeding of fish to the point of satiety also increases the risk of waste feed decomposition and poor fish health. There are some ways to control the quantity and quality of food and it seems that they have the ability to reduce the amount of food and thus reduce the cost of production, without negatively affecting the quantity of production **(Bolivar & Jimenez, 2006)**. These methods include employing efficient feeding techniques that minimize waste production, optimize food utilization, and reduce oxygen demand, particularly in warmer climates **(Hezron *et al.*, 2019)**.

MATERIALS AND METHODS

Study site

The study was conducted in the ponds of the aquaculture unit at the Agricultural Research Station in Al-Hartha (Fig. 1), which belongs to the College of Agriculture - University of Basrah. The trial period extended from 12/15/2021 to 12/1/2022, starting from the process of manufacturing the cages until marketing the fish. The station contains 18 ponds including 4 ponds with an area of 1 acers, an area among those the study was conducted and 14 ponds with an area of 600m^2/ pond. The ponds are fed with water from one of the branches of the Shatt al-Arab.

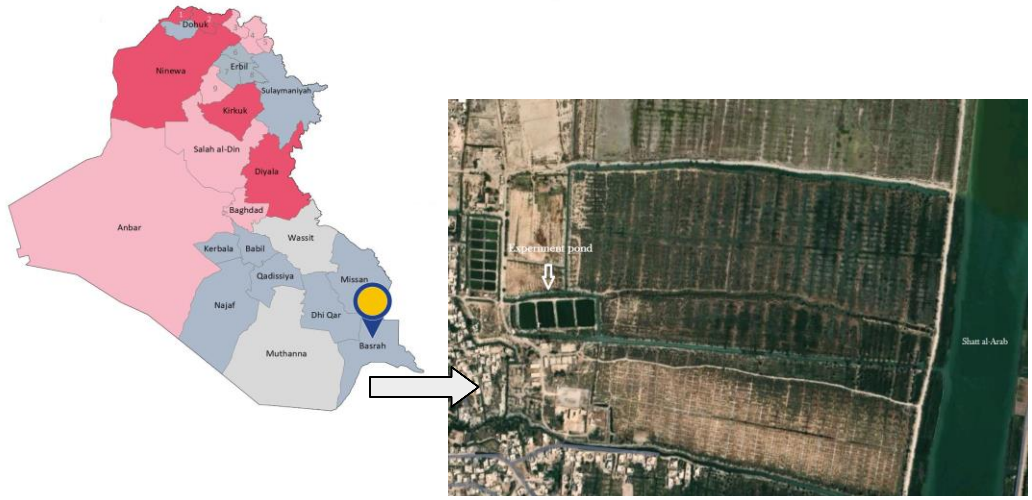

Fig. 1. The experimental site in the aquaculture unit in Basra Governorate

Fishes and experimental cages

Twelve cages are made of polyethylene with a diameter of 1.5 inches and dimensions of 2 x 2 x 2m surrounded by an external net. The length of the net opening is 10 x 10mm with four treatments (three replicates). However, these cages were placed inside the earthen ponds after preparing them; the pond was filled with water to a height of 1.5m, and ventilation fans were installed to maintain the oxygen level during high temperatures. 600 fish were selected; the average weight was 103.2± 37.0g, and the average length was 19.8± 3.0cm. These fish were distributed in cages at a rate of 50 fish per cage.

Feeding management

The proportions of primary materials used in the manufacture of fish feed were determined as outlined in Table (1). The primary materials were purchased from local markets in Basra Governorate, grounded thoroughly, and mixed homogeneously based on the calculated proportions. However, two different diets were formulated with different levels of protein, the first diet (A) which contained a protein percentage of 30%, and the second diet (B) which contained a protein percentage of 20%. The feed was packed in bags with marks placed to distinguish the diet and was transported to the store located at the work site.

Table 1. The percentages of ingredients used in manufacturing the feed

Ingredient	Feed (A)	Feed (B)
Fishmeal	35	18
Soybean	10	5
Barley	10	20
Flour	25	30
Bran	18	25
Vitamins and minerals	2	2
Total	100	100

Environmental measurements

Environmental factors of the ponds water in which the experiment was conducted were measured during the study period and periodic weighing of fish. All measurements were taken at approximately 10 a.m. The temperature was measured using a graduated mercury thermometer; salinity was measured using a WTW digital salinity meter (Cond 720), and pH was measured using a portable pH meter.

Growth performance

The length and weight of the fish were measured on 3/23/2022 by using a boat made of fiberglass. The fish were caught using a hand net tied to a long iron rod and placed in a plastic container. Fish were extracted, and their weight was measured using a Chinese digital scale to the nearest gram. The measurement was repeated every 24 days. Measurements were taken during the following dates: 4/17/2022, 5/12/2022, 6/6/2022, 7/1/2022, 7/26/2022, 8/20/2022, 9/14/2022, 9 10/2022, 11/3/2022. The amount of food provided to the fish was adjusted according to the weight gain. The diet was given in the amount of 4% of the weight of the live mass of the fish and for each cage, but only at the beginning of the experiment, 3% of the weight of the fish's live mass was provided due to the low temperature at the beginning. Feed was provided twice during the day (7 a.m. and 12 p.m.). The required quantities were weighed, placed in bags, and distributed to the ponds by boat. At the end of the experiment on 11/28/2022, all fish were removed from the cages; their lengths and weights were measured, and then they were isolated based on the size for marketing. The growth criteria were used to describe the growth performance of the fish:

Weight Gain (g): $WG = W_2 (g) - W_1 (g)$

Relative Growth Rate: $RGR = [(W_2 (g) - W_1 (g))/W_1] \times 100$

Specific Growth Rate: $SGR = (\ln W_2 (g) - \ln W_1 (g) /(t_2 - t_1)) \times 100$

Daily Growth Rate: $D.G.R. = (W_2 – W_1) /(t_2 - t_1)$

Feed Conversion Ratio: $FCR = R (g)/ WG (g)$

Protein Efficiency Ratio: $PER = WG (g)/ PI (g)$

Protein Productive Value: $PPV = (PG / PI) \times 100$

Condition factor

Condition factor values were calculated for fish at the beginning and the end of the experiment for each treatment. The following equation was used to calculate the length-weight relationship:

$W = aL^b$ **(Pauly, 1983)**.

Relative condition factor (Kn) **(Le Cren, 1951)** was estimated following the equation of **Sheikh *et al.* (2017)**: Kn = W/ ^w.

Economic benefit of the feed

The economic benefit of the feed was calculated according to the mechanism indicated by **Hekmatpour *et al.* (2019)** by applying the benefit guide as follows:

Benefit guide = Value of fish / Cost of feed

Chemical analysis of diet and fish

The experimental diets were analyzed according the guidelines of **A.O.A.C. (1990)**. Moisture was estimated by drying the samples at a temperature of 105°C. The proteins were estimated using the Micro Kjeldahl device, and lipids were estimated using a Soxhlet apparatus. Ash was estimated by burning the samples in a Muffle furnace at 550°C for four hours. The ash was estimated by placing 5g of the feed in an incineration furnace at a temperature of 550°C until a grayish-white color of ash was obtained. The carbohydrates of the diet were estimated according to the method indicated by **Wee and Shu (1989)** through the difference between the total components represented by the percentage of moisture, fat, protein, and ash, subtracted from the number 100.

Statistical analysis

A complete randomized design (CRD) was used to design the experiment with seven treatments and three replications for each treatment and it relied on the least significance differences (LSD) test. All statistical tests were conducted using the Statistical Package for Social Sciences program (SPSS) version 26.

RESULTS

Water quality

Table (2) shows the results of water quality measurements for the culture pond which included water temperature, pH, and salinity during the experiment period. Salinity changed the most and recorded the highest value (7.2PSU) in October and the lowest value (3.1PSU) in March. The highest temperature value (34°C) was recorded in June, and the lowest value (19°C) was recorded in March, while the change in pH values was slight, as the highest value (8.8) was recorded in June and the lowest value (7.6) was recorded in October.

Table 2. Water quality measurements for the culture pond during the experimental period

Sample date	Salinity (PSU)	PH	Temperature (°C)
23/03/2022	3.1	8.5	19
17/04/2022	3.3	8.6	22
12/05/2022	3.4	8.7	26
06/06/2022	3.7	8.8	34
01/07/2022	3.9	8.4	32
26/07/2022	3.9	8.4	32
20/08/2022	7.7	8.3	31
14/09/2022	7.1	7.8	27
09/10/2022	7.2	7.6	27
03/11/2022	4.8	7.8	25
28/11/2022	3.9	8.1	24

Chemical analysis of the diets

Table (3) indicates that a high level of protein was observed in diet (A) with a low level of moisture, fat, and crude fiber in it; while in diet (B), an increase in the level of moisture, fat, and fiber appeared. However, the raw material contained a level of protein that is within the limits that the experimental diet was designed for.

Table 3. Chemical analysis of the diets used in the experiment (Mean + SD)

Chemical composition	Diet (A)	Diet (B)
Moisture (%)	1.2± 7.1	0.91± 8.4
Ash (%)	0.55± 6.6	0.12± 7.8
Crude protein (%)	0.35± 29.9	0.76± 20.1
Fats (%)	0.94± 4.6	1.01± 5.8
Crude fiber (%)	0.37± 3.8	0.22± 4.7
Carbohydrates (%)	1.65± 48.0	1.91± 53.2

On the other hand, Table (4) exhibits the average weight of the common carp fish used in the treatments during the sampling period. The initial weight average ranged from

101.4g in cage 3 to 108.9g in cage 6, and the final weight average ranged from 683.7g in cage 8 to 1057.9g in cage 10.

Table 4. Average weight of common carp during the sampling period with standard deviation

	Date / 2022										
Cage no.	23/3	17/4	12/5	6/6	1/7	26/7	20/8	14/9	9/10	3/11	28/11
1	102.9 ±49.4	132.7 ±55.8	190.9 ±77.2	212.5 ±86.7	307.1 ±155.6	343.1 ±187.1	387.8 ±220.6	482.0 ±267.0	669.3 ±387.9	700.0 ±311.2	776.3 ±439.5
2	103.6 ±50.2	133.3 ±77.6	177.7 ±98.0	226.0 ±123.7	310.5 ±188.5	346.7 ±175.6	404.1 ±200.6	532.5 ±250.7	626.3 ±312.4	721.0 ±345.7	939.0 ±467.1
3	101.4 ±25.6	144.2 ±45.6	187.0 ±67.0	245.6 ±112.0	322.5 ±123.8	358.9 ±177.8	452.0 ±198.0	531.2 ±223.7	647.6 ±255.4	675.0 ±278.6	856.9 ±319.7
4	102.9 ± 56.3	148.6 ±57.8	194.1 ±77.6	255.5 ±100.0	358.9 ±189.9	375.0 ±188.7	447.0 ±236.0	575.0 ±323.8	627.8 ±398.0	714.3 ±433.8	809.0 ±513.9
5	104.7 ±54.1	130.0 ±66.8	184.8 ±88.9	232.4 ±102.5	322.5 ±170.9	388.9 ±198.9	454.0 ±229.0	612.5 ±300.6	785.0 ±334.7	810.0 ±378.0	892.2 ±445.0
6	108.9 ± 27.2	143.7 ±55.8	200.0 ±77.9	233.3 ±99.0	267.3 ±123.5	361.4 ±145.0	422.4 ±188.9	535.7 ±230.7	743.0 ±290.0	716.7 ±299.4	886.0 ±342.0
7	102.1 ±26.7	134.3 ±44.6	194.5 ±66.7	239.5 ±66.0	297.9 ±110.8	350.0 ±133.3	410.2 ±124.9	462.5 ±188.9	627.8 ±245.9	700.2 ±289.9	883.9 ±326.4
8	104.0 ±29.1	121.2 ±28.5	138.8 ±33.9	214.6 ±66.9	321.1 ±102.0	381.7 ±143.0	370.0 ±188.9	466.7 ±230.9	578.9 ±280.9	590.9 ±311.2	683.7 ±381.0
9	102.3 ±22.3	138.3 ±33.7	150.6 ±45.8	236.4 ±78.8	323.5 ±100.9	314.3 ±122.7	378.0 ±180.9	573.3 ±222.2	537.5 ±223.7	521.0 ±245.6	751.7 ±294.5
10	104.4 ±46.3	160.4 ±66.9	192.2 ±88.9	256.4 ±100.8	364.2 ±180.9	415.0 ±220.0	493.5 ±287.9	646.4 ±387.9	779.4 ±422.4	781.0 ±498.0	1057.9 ±561.1
11	102.9 ±38.7	132.7 ±36.8	190.9 ±44.9	212.5 ±89.9	307.1 ±120.5	343.1 ±187.9	387.7 ±185.7	482.0 ±233.4	669.3 ±328.7	700.0 ±400.0	776.3 ±439.5
12	103.6 ±40.8	133.3 ±45.6	177.7 ±66.8	226.1 ±88.9	310.5 ±120.0	346.7 ±158.9	404.1 ±145.8	532.5 ±222.3	626.3 ±330.9	721.0 ±380.9	939.0 ±467.1

Table (5) shows the rates of final weight, weight gain, daily growth rates, relative growth rate, and specific growth rate of fish in different treatments. The final weight values of the experimental fish ranged from 912.3g in T4 to 773.1g in T3. The results of the statistical analysis showed that there were no significant differences (*P*> 0.05) between the treatments. Furthermore, weight gain rates ranged between 808.0g for T4 and 754.7g for T1, with no significant (*P*> 0.05) difference in all treatments. Additionally, the SGR of the fish ranged from the highest value of 0.90%/ day in T4 to the lowest value of 0.84%/ day in T3, with no significant differences (*P*> 0.05) between treatments.

Table 5. Growth criteria for common carp used in different protein ratio treatments

Treatment	T1	T2	T3	T4
Final weight (g)	857.3 ±81.35 a	862.4±46.35 a	773.1±101.7 a	912.3±126.0 a
WG	754.7±81.01 a	756.9±44.31 a	670.3±102.6 a	808.0±125.9 a
DGR	3.14±0.33 a	3.24±0.27 a	2.79 ±.420 a	3.37±.520 a
SGR	0.88±.0.40 a	0.89±.020 a	0.84±.060 a	0.90±.050 a
RGR	24.13± 0.87a	24.28±.630 a	23.16±1.35 a	24.68±1.18 a

*Different letters in the same row show significant differences (*P*≥ 0.05).

The present results are depicted in Fig. (2), illustrating the cumulative final weight average for the different treatments during the different sampling periods which shows that the final average weight for all treatments was approximately equal in the first and second months, and then differences began to appear in the third month of the experiment. On the other hand, the daily growth rate of common carp fish was the highest at 3.37g/ day in , and the lowest was at 3.14g/ day in T1. The statistical analysis of the results did not record any significant difference (*P*> 0.05) between the treatments. However, Fig. (3) indicates the cumulative weight gain of the fish during the experimental periods. Weight gain gradually increased during the first four months then this increase fluctuated during the fifth and sixth months. The highest cumulative weight gain value was recorded during the seventh and eighth months of the experiment, and then it began to decrease during the last two months.

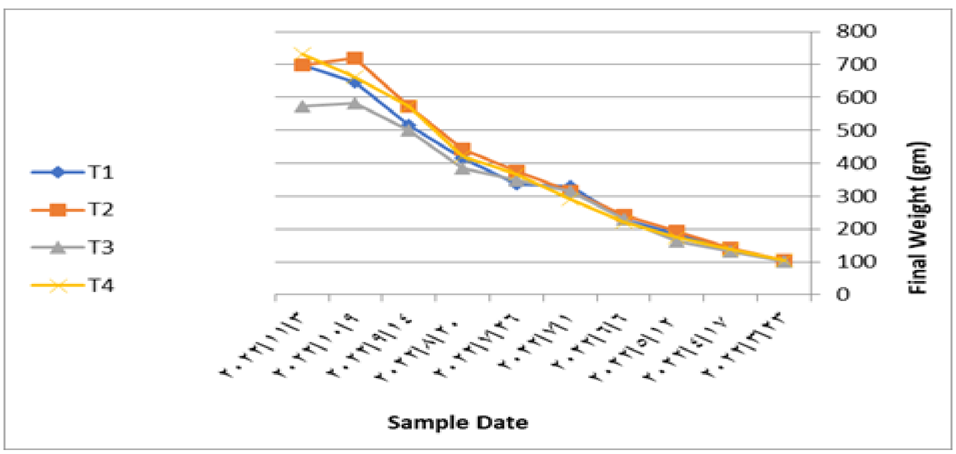

Fig. 2. Cumulative final weight rates for treatments during the trial period

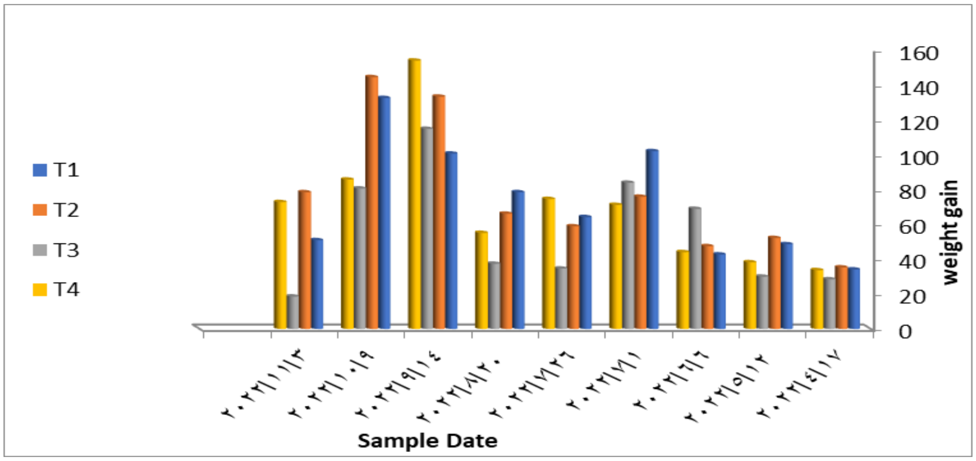

Fig. 3. Cumulative weight gain rate of fish in different experimental periods

Table (6) displays the feed conversion rate, protein efficiency ratio, and protein production value for the different treatments. The FCR was 5.22 and 6.47 for T3 and T4, respectively, and did not show any significant difference ($P> 0.05$) between the treatments. While considering PER, the highest value (1.10%) was registered in T2, whereas the lowest value (0.90%) was recorded in T1. The results of the statistical analysis showed that the T2 was significantly superior to the rest of the treatments ($P\leq 0.05$). The PPV recorded its highest value (35.74%) in T2, while the lowest value (29.79%) was recorded in T1, with no significant difference ($P> 0.05$) between all treatments.

Table 6. Feed efficiency for fish in different treatments

Treatment	T1	T2	T3	T4
FCR	5.57 ±1.18 a	6.12±0.59 a	6.47±1.69 a	5.22±1.24 a
PER	0.90±0.03 a	1.10±0.01 a	0.94±0.08 b	0.97±0.03 b
PPV	29.79±4.26 a	35.74±1.77 a	34.94±6.58 a	33.71±9.99 a

*Different letters in the same row show significant differences ($P\geq 0.05$).

Table (7) shows the values of three types of condition factor that were calculated for fish in the different treatments. The value of the relative condition factor (Kn) was 1.00 ($P> 0.05$). While, the values of the modified condition factor (Kb) recorded the highest value (1.66) in T3, and the lowest value (0.61) was recorded in T2. The results of the statistical analysis showed that there was a significant difference ($P\leq 0.05$) between the treatments; T3 was significantly superior to the rest of the treatments. In terms of Fulton's condition factor (K3), T4 recorded the highest value of 1.57, and the lowest value of 1.43 in T1. The results of the statistical analysis also showed that there was a significant difference ($P\leq 0.05$) in K3. T4 was significantly superior ($P\leq 0.05$) over the rest of the treatments, while there was no significant difference ($P> 0.05$) between T1, T2, and T3.

Table 7. Condition factor for fish in different treatments

Treatment	Relative condition factor (KN)	Modified condition factor (Kb)	Fulton's condition factor (K3)
T1	0.11± 1.00 a	0.01± 0.51 b	0.17± 1.43 d
T2	0.11± 1.00 a	0.05± 0.43 d	0.18± 1.49 cd
T3	0.14± 1.01 a	0.61± 1.67 a	0.23± 1.50 bc
T4	0.12± 1.00 a	0.08± 0.43 cd	0.21±1.57 a

*Different letters in the same column show a significant difference ($P \geq 0.05$).

Table (8) displays the economic benefit of the diets used in all experimental treatments. T4 recorded the best value (1.2) for the benefit index compared to the rest of the treatments, while T1 recorded the lowest value (0.8).

Table 8. The economic benefit of the diets used in feeding the experimental fish for all treatments

Criteria	Treatment			
benefit Index	T1	T2	T3	T4
	0.8	1.1	1.1	1.2

Chemical composition of fish before and after the experiment

Table (9) shows the chemical composition of the fish body in the different treatments before and after the experiment. The humidity value ranged from 71.04 in the treatment before the experiment to 70.11% in T1, and there was no significant difference ($P > 0.05$) between the treatments. In the same case, the highest protein value (19.62%) was recorded in T1 and the lowest value (17.36%) was recorded before the experiment. T1 was statistically superior ($P \leq 0.05$) to the rest of the treatments, and there was no significant difference ($P > 0.05$) between it and T2. The best fat value (6.32%) was recorded before the experiment, and the worst value (7.47%) was detected in T4. The results of the statistical analysis showed a significant ($P \leq 0.05$) superiority before the experiment over the rest of the treatments. The percentage of ash (3.06%) in T1 was superior to the rest of the treatments, with no significant differences between it and T2, T3, and T4 ($P > 0.05$), while a significant difference was recorded ($P \leq 0.05$) before the experiment.

Table 9. Chemical composition of the fish body before and after the experiment

Chemical composition	Before	T1	T2	T3	T4
Moisture (%)	71.04±1.07 a	70.11±0.08 a	70.40±0.82 a	70.57±1.09 a	70.98±1.59 a
Ash (%)	5.17±0.72 b	3.06±0.08 a	3.36±0.36 a	3.38±0.54 a	3.40±0.26 a
Crude protein (%)	17.36±0.12 b	19.62±0.49 a	19.11±2.06 a	18.74±1.77 ab	18.13±1.54 ab
Fats (%)	6.32±1.02 a	7.33±0.46 b	7.10±0.70 ab	7.22±0.58 ab	7.47±0.46 b

*Different letters in the same row show significant differences ($P \geq 0.05$).

DISCUSSION

Water quality

The present results showed that there were no significant differences (P>0.05) between treatments, and these results are similar to the results of **Abo Zaid and Ali (2015)** who recorded that, there were no significant differences in the final weight of the Nile tilapia (*Oreochromis niloticus*) upon using different protein levels on alternate days and the best final growth was obtained when the protein level was 20%. While, **Abo-Taleb *et al.* (2014)** obtained the best final growth in the Nile tilapia raised under continuous feeding treatment which was significantly superior ($P \leq 0.05$) compared to the alternative feeding system. However, the present findings show no significant difference (P> 0.05) between the treatments of WG, and that the highest weight gain was obtained from feeding the fish an alternative feed for two days with a diet containing a protein content of 30%, followed by one day of 20% protein content. These results are consistent with the results of **Hossain *et al.* (2006)**, who did not record any significant difference in weight gain between the treatment, in which the sutchi catfish were fed with silver carp (*Hypophthalmichthys molitrix*) fish on a high protein day, followed by a low protein day and the treatment in which the fish were fed high protein daily and also the results of **Udo and William (2018)** who elucidated that there was no significant difference weight gain between different treatments upon using three days of high protein, followed by one day of low protein in feeding *Clarias Gariepinus* fish. However, they differ from the findings of **Sardar *et al.* (2011)**, who recorded the highest weight gain in feeding common carp fish when treated with a day of high protein followed by a day of low protein.

Growth performance

The daily growth rate of the experimental fish is shown in Table (5). The statistical analysis of the results did not record a significant difference (P> 0.05) between the treatments. The highest daily growth rate was recorded in T4 in which the fish were fed an alternative diet for two days with a diet containing 30% protein followed by alternating days with a diet containing 20% protein. The results agree with the results of **El-Saidy and Gaber (2005)**, who did not notice an increase in the daily growth rate with increasing levels of dietary protein in feeding the Nile tilapia. Moreover, the findings agree with the study of ***Nandesha et al.*** **(2002)** on common carp, **Arun and Yakupitiyage (2003)** on the Nile tilapia fish, and **Ali *et al.* (2005)** on *Pangasius hypophthalmu*; these researches indicated that alternative feeding with a diet with a high protein content followed by a diet with a low protein content gave better or almost similar growth to fish that were fed a diet with a high protein content continuously. However, the result does not agree with those of **Adewolu and Adoti (2010)**, who indicated that fish that were constantly fed a diet with a high protein content showed a better growth rate than fish fed an alternative feed on a high-protein day and a low-protein day and that fish that were constantly fed a diet with a high protein content followed by low protein content had the lowest growth rate.

Regarding DGR, the results coincide with the results of **El-Saidy and Gaber (2005)**, who did not notice an increase in the daily growth rate with increasing levels of dietary protein in feeding the Nile tilapia fish. It agrees with some studies of common carp **(Nandesha *et al.*, 2002)**, the Nile tilapia **(Arun & Yakupitiyage, 2003)**, and striped catfish (*Pangasius hypophthalmu*) **(Ali *et al.*, 2005)**, that these researches indicated that alternative feeding with a diet with a high protein content followed by a diet with a low protein content gave better or almost similar growth to fish that were fed a diet with high protein content. The SGR results shown in Table (5) did not display a significant difference ($P > 0.05$) between the treatments, and the highest SGR was recorded in T4. These results do not agree with **Al-Jader and Sulevany (2012)**, who obtained the highest SGR in the treatment in which the common carp fish were fed continuously with a diet containing a protein content of 30%, and it was better than when using a diet with a protein content of 30%, 25% and 35%. Similarly, **Pradhan *et al.* (2014)** reported superior SGR with continuous feeding of *Catla catla* with a diet containing 30% protein. Furthermore, the present findings showed there was no significant difference ($P > 0.05$) between the treatments, and the highest RGR found in T4, and the results are almost similar to the results of **Muhammad *et al.* (2017)** in their study on common carp. However, **Assal (2023)** obtained the highest RGR in the treatment in which continuous feeding of a diet containing 35% protein was used in feeding grass carp (*Ctenopharyngodon idella*).

Feed efficiency

The highest FCR was obtained in T4 in which the fish were fed an alternative feed for three days with a diet containing 30% protein, followed by a day of a diet containing 20% protein. The results of the study agree with the results of the study by **Nandesha *et al.* (2002)** and **Sardar *et al.* (2011)** who found that, the best value for FCR was obtained when feeding common carp an alternative feed with a day of 30% protein followed by a day of 20% protein, as fish that are constantly fed with a diet with a protein content of 20% showed a significantly lower FCR, and in general when fish fed constantly on a low-protein diet this leads to poor growth and feed utilization. On the other hand, the highest value

(1.10%) was recorded in T2 which was significantly superior to the rest of the treatments. These results agree with **Ali *et al.* (2005)**, **Hüseyin Sevgili *et al.* (2006)**, **Hossain *et al.* (2010)** and **Sardar *et al.* (2011)**, who also recorded the best PER in feeding a diet with a protein content of 30% followed by low protein. In the same case, the highest value of PPV was recorded in T2 with a value of 35.74%. The results of the statistical analysis did not show any significant difference ($P > 0.05$) between the treatments; the PPV improved with the treatment of alternative feeding featuring a lower protein content than continuous feeding. These results are similar to the results of **Ahmed *et al.* (2004)**, **Yong Liu *et al.* (2009)**, **Abdel-Tawwab *et al.* (2010)** and **Muhammad *et al.* (2017)**.

Condition factor

The value of the relative condition factor was recorded as 1.00 for the different treatments as exhibited in Table (7). The results of the statistical analysis did not show significant differences ($P > 0.05$) between the treatments and the results of the current study match the results of **El-Saidy and Gaber (2005)**. Similarly, the results of **Daudpota *et al.* (2014)** showed that the condition factor was not affected by the level of dietary protein, as they did not record any significant differences in the condition factor when using different protein levels in feeding the Nile tilapia fish. Moreover, the results concur with those of **Guroy *et al.* (2017)**, who did not record a significant difference in condition factor when feeding meagre fish diets with different protein levels. However, the present study results contrast with the results of **Du *et al.* (2009)**, who showed that the condition factor was significantly affected by an increase of the protein content in the diet, and it also showed an increasing trend with the increase in the protein level in grass carp feed. Similarly, the results differ from those of **Yong liu *et al.* (2009)**, who observed a decrease in condition factor with lower levels of dietary protein when feeding fish.

Economic feasibility of the feed

Generally, when comparing the economic benefit of the diets in the different treatments as shown in Table (8), it is evident that T4, where the fish were fed an alternative feeding for three days with a diet containing a high protein content followed by a day with a diet containg a low protein content gave the highest economic benefit from continuous feeding, as well as the rest treatment. This outcome may be attributed to the optimal protein content in the diet, meeting the fish's growth requirments, as well as the absence of excessive feeding that would lead to economic loss. The results of the study are similar to those of **Abou-Zied and Ali (2015)**, who postulated that the profitability calculation showed that the fish fed alternative feeding were more profitable than fish fed continuous feeding. **Bolivar *et al.* (2006)** reported that, although the cost of feed was halved by feeding on alternate days, it did not reduce the growth or production performance of the Nile tilapia, and yields were not significantly different, and profit margins were higher for the alternate day feeding strategy compared to regular continuous feeding.

Chemical composition of the fish body before and after the experiment

The present findings show that moisture was not affected by the difference in the protein level in the diet. For instance, **Sardar *et al*. (2011)** observed similar results in common carp, while **Abo-Taleb *et al.* (2014)** noticed that feeding strategies did not have a significant effect on the moisture in the fish body with differences in the protein level in the diet of the Nile tilapia. The protein value recorded the highest value (19.62%) in T1, meaning that the highest protein in the fish's body was recorded in the treatment, in which the fish were fed continuously with a diet with a protein content of 30%. The present results are congruent with those concerning the Nile tilapia **(Daudpota *et al.*, 2014; Cadorin *et al.*, 2021)** and *Labeo rohita* **(Xavier *et al.*, 2017)**. In a similar vein, the lipid content in the fish's body increased with the with higher protein levels in the diet, consistent with the findings of **Ali *et al.* (2005)** with respect to catfish **(Daudpota *et al.*, 2016)** and the outcomes of **Cadorin *et al.* (2021)** on the Nile tilapia. These studies observed an increase in fat content with an increase in the level of dietary protein in the diet. In contrast, **Hossain *et al.* (2006)** on grass carp and **Xavier *et al.* (2017)** on *Labeo rohita* fish recorded a decrease in fat content in body fish with an increase in the level of protein in the diet. However, the ash value of the fish body in the different treatments did not record any significant difference between the different treatments, meaning that the difference in protein level in the diet did not affect the ash value in the fish body. These results agree with the results of **Ahmad *et al.* (2012)** for common carp, **Yong Liu *et al.* (2009)** for Jian carp (*Cyprinus carpio* var. Jian), and **Abdel-Tawwab *et al.* (2010)** for the Nile tilapia, who did not notice any significant differences in the ash value in the fish body, with the use of different protein levels in the diet.

CONCLUSION

This study investigated the alternative feeding strategy by feeding a diet with a high protein content alternating with a diet with a low protein content, achieving almost similar growth with continuous feeding. A decrease in protein level in the diet did not lead to a decline in fish growth, also the feed conversion factor was not affected by a decrease in protein level despite the decrease in feed cost in alternative feeding. Therefore, the alternative feeding is considered promising in raising common carp fish. The results open up a new avenue in the development of more efficient feeding schedules; nevertheless, further research is needed to develop this new strategy.

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