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Effect of Adding Leftover Bread to Iraqi Restaurant Waste on the Common carp (*Cyprinus carpio*) Diets and its Impact on Growth and Chemical Composition

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ABSTRACT

In this study, five diets were prepared using dry bread residues from popular Iraqi restaurants. The leftover bread (LB) was used at percentages of 0, 0.5, 2, and 3% for a period of 72 days in feeding the common carp (*Cyprinus carpio*) fish. The study was conducted to assess the effect of the leftover bread (LB) in fish diets and their impact on growth indicators, feed utilization, and fish body composition chemically. The experiment was designed with five treatments and three replicates, with 9 fish allocated to each treatment. Significantly superior results ($P \leq 0.05$) were observed for final weight (FW), weight gain (WG), and daily weight gain (WGD) for the treatment (LB 2%). The highest final weight was recorded in the LB 2% treatment (50.78±0.42 gram). The results of weight gain (WG) and daily weight gain (WGD) were significantly higher for the (LB 2%) treatment, recording 40.34±0.34 and 0.55±0.003gram, respectively. Treatments (LB 2%) and (LB 3%) outperformed significantly ($P \leq 0.05$) in the feed conversion ratio (FCR) efficiency, giving values of 2.36±0.12 and 2.35±0.05, respectively. The feed conversion efficiency percentage (FCE%) for the LB 2% treatment (44.48±0.00) was significantly higher than the other treatments. Both the specific growth ratio (SGR %) and relative growth ratio (RGR %) significantly outperformed ($P \leq 0.05$) in the (LB 2%) treatment compared to other treatments, recording 2.19±0.005 for SGR % and 386.70±0.01 for RGR %. The protein efficiency ratio (RER) was significantly higher ($P \leq 0.05$) in treatments (LB 2% and LB 3%), recording (1.62±0.000 and 1.64±0.02), respectively. The chemical analysis of fish bodies indicated that the protein content in fish bodies significantly surpassed ($P \leq 0.05$) in treatments LB 2% and LB 3% compared to the other treatments, recording (70.85±0.6) and (69.47±0.07), respectively. The results also showed that the fat content in fish bodies in the experimental groups significantly exceeded ($P \leq 0.05$) in treatments LB 0.5%, LB 1%, and LB 3% compared to the other treatments. The significance of this study lies in determining the optimal utilization of bread residues in fish diets and reduce the disposal of dry bread as waste, with reassuring results by adding 2% of dry bread to the diets.

INTRODUCTION

In recent times, Iraq has witnessed a development in the tourism sector that reflected in the proliferation of restaurants. This has led to an increase in the amount of waste, particularly bread crumbs, as Iraqi bread is known for its quality and delicious taste, which is enjoyed by the people. As a result, there has been a push to make the most of bread leftovers in restaurants and popular dishes.

Bread is a staple food in most countries and is made from wheat grains. It is produced by fermenting the dough after mixing the flour with some other secondary ingredients. The dough is then placed in ovens and, after a period of time, it is exposed to air to cool and dry, making it ready to eat **(Marić *et al*., 2009)**. Wheat covers 23.4% of the world's food needs, and is an important food source for around 40% of the world's population. It provides approximately 20% of the world's caloric and protein intake **(Bakke & Vickers, 2017)**. The amount of bread consumed per person daily in the developing countries ranges from 137 to 411 grams **(Sexena & Haridas, 2004)**. The issue of bread wastage due to the leftovers and disposal from restaurants is a significant economic problem in most countries. In Iraq, there are no recent studies on the amount of economic waste, and perhaps the latest studies were by **Carpet and Nazad Bashar (1982)**, who estimated the waste due to the phenomenon of flaking in the city of Baghdad alone at 3,499,837 dinars annually. There is also no accurate statistical data on restaurant bread wastage owing to the rapid increase in the number of Iraqi restaurants.

Nutrition is extremely important, especially in fish farming, where it can account for 50-70% of the operational costs **(Cardia & Lovatelli, 2015)**. Fish farmers face significant challenges regarding the high cost of feed. In order to mitigate these costs, they have sought alternative feed sources for fish nutrition. Therefore, the nutritional components present in the feeds are crucial for the growth of fish **(Yan *et al*., 2017)**. One of the habits of restaurants in Iraq is to dispose of leftovers, with bread scraps being the largest portion. It is possible to use bread scraps as feed for fish production, as bread is high in carbohydrates at the expense of protein. Non-protein food sources such as carbohydrates and fats can be used to balance energy. This can reduce the consumption of protein and increase the energy production for the fish, potentially leading to an increased weight gain since these nutrients can be stored in the muscles **(Aminikhoei *et al*., 2015)** .

The common carp (*Cyprinus carpio*) is characterized by its diverse diet, rapid growth rate, and high reproductive capacity. It is considered one of the most economically important farmed fish species **(Nakajima *et al*., 2019)**. In Iraq, the common carp is the main type of fish farmed in floating cages, earthen ponds, and small tanks **(Ahmed *et al*., 2020 ;Mohammad *et al*., 2022)**. A study conducted by **Taher (2020)** on the use of dried bread in the diets of the farmed common carp in floating cages in the city of Basra, Iraq, showed no significant differences in growth rates. The researcher recommended not to use the dried bread alone in feeding the farmed carp in floating cages.

Baes on the aforementioned data, this study aimed to address the issue of leftover bread waste that constitutes the largest portion of the local restaurant waste in Iraq. It also targeted to highlight the importance of nutritional additives in fish diets filling the gap in literature concerning the use of mixed dried bread with waste. To attain the target, this study attempted to optimize the use of mixed bread leftovers with waste in fish diets and its impact on growth indicators, feed utilization, and body composition of the fish under investigation.

MATERIALS AND METHODS

Experimental tanks

The aquaculture system relied on designing tanks for fish farming in an open system. Five tanks were used for the experiment, each with volumetric dimensions of 70x30x30cm, and each tank had a capacity of 42 liters of water. The tanks were filled with dechlorinated tap water, and one of the tanks was filled as a reserve before filling the experimental tanks. The tanks were arranged in the same manner and sterilized using a solution of sodium hypochlorite, which is a highly oxidizing substance that could attack the microorganism cells from their internal components and result in cell lysis. Thus, its predominant application lies in water treatment, where it is widely utilized as disinfectant and bleach **Cheng *et al*., (2022)**, with a concentration of 200ppm before filling them with water. Ordinary sponge and some gravel were placed in the tank filters to create a water filtration system and establish a suitable environment for the completion of the tank's biological cycle before introducing the experimental fish. Additionally, the tanks were covered with netting to prevent the fish from jumping out of the tanks.

Experimental fish

In the study experiment, the common carp fish with an average weight of (10.36 ± MSE 0.03) grams were used. The total number of fish used during this study was 135 fish, with 27 fish per tank and three replicates per treatment. The fish were obtained from hatcheries in Wasit Governorate, Kut, Iraq. They were exposed to a 5% saline solution for 2- 4 minutes to sterilize fish. The fish specimens were then fed a commercial diet at a rate of 2% of their body weight, covering the acclimation period before starting the study experiment. The experiment was conducted from 20/1/2024 to 1/4/2024, spanning 72 days, The study and design experiment took place in the researcher's own home. During this time, the water temperature in the tanks ranged from 25 to 30°C in the study. Simple pumps were used to pump water from the basins used in Iraq with what is called natural ventilation coolers. The lighting was naturally gained via the sunlight .

Environmental measurements of water

The temperature was measured using a mercury thermometer with a range of 0- 50 degrees Celsius, locally sourced, after being submerged in water for one minute. The salinity of the water was measured using a portable EC meter from the Italian company, Hanna. Daily readings of oxygen concentration inside the basins were considered to determine the oxygen levels in each basin. A field device from the English company, Jenway, was used to measure the oxygen concentration after immersing the device's probe in water to a depth of 10cm until the reading was stabilized. The pH values were determined after taking water samples from each basin daily, using a portable EC meter from the Italian company, Hanna.

Diets of the experiment

Five homogeneous experimental feeds were prepared in the laboratory with a protein content of 27.59±SME 0.61. Each feed was processed using a meat grinder machine of the national brand with 5.1mm openings. After the diets were extruded in the form of threads of different lengths, the diets were naturally dried using sunlight, with a continuous turning of threads to remove moisture. Once dried, these threads were cut into small-sized threads (small pellets), then placed in nylon bags labeled with the treatment number (diets type) and stored until used. The first diet was the control diet, with no additives. The second feed contained 0.5% ground bread crumbs, while the third, fourth, and fifth contained 1, 2, and 3%, respectively (Table 1).

Table 1. Formulations(g per 1000gm) and chemical composition (%) of the experimental diets, LB (Leftover bread)

Ingredients	control	0.5 % LB	1 % LB	2 % LB	3% LB
Soybean	350	350	350	350	340
yellow corn	300	300	300	295	295
Barley	120	120	120	115	115
wheat bran	100	100	95	95	95
Fish powder	100	95	95	95	95
***vit mineral mixture**	8	8	8	8	8
corn oil	20	20	20	20	20
****Antioxidant**	2	2	2	2	2
Leftover bread	0	5	10	20	30
		chemical composition			
Moisture	6.64	5.74	6.84	5.81	5.31
Protein	29.2	28.8	27.1	27.33	25.53
Fat	6.2	5.8	6.3	6.2	6.2
Fiber	6.1	6.8	6.5	6.8	7.1
Carbohydrate	45.76	46.76	47.06	47.76	48.76
Ash	6.1	6.8	6.2	6.1	7.1
*****Energy Kilocal/100g**	423.024	421.57	418.053	421.5268	415.9688

*Each gram contains vitamins A (800 IU), vitamin D3 (1500 IU), vitamin E (1 mg), vitamin B1 (0.5 mg), B2 (0.5 mg), B6 (0.2 mg), B12 (0.008 mg), folic acid (0.05 mg), K3 (2 mg), nicotinic acid (6 mg), iron sulphate (0.5 mg), manganese sulphate (0.4 mg), cobalt chlorides (0.01 mg), zinc sulphate (0.15 mg) .

** Butyrate Hydroxyl Anisole (BHA) type antioxidant .

***The represented energy was calculated based on the equation mentioned by **Alhassan *et al.* (2012)**, which is as follows: Total energy = % of protein x 5.56 + % of carbohydrates x 4.45 + % of fat x 9.2.

Assessment of somatic growth parameters

- Daily weight gain (DWG) = Weight gain(WG)/ time duration (days) **(Allama *et al*., 2012)**
- Feed conversion ratio(FCR) = Feed intake (g)/ weight gain (g) **(Guo *et al*., 2012)**
- Feed conversion efficiency(FCE%) = Biomass(g) / Total feed intake(g) **(Guo *et al*., 2012)**
- Protein Intake(PI) = Feed Intake (g) × protein in diet % /100 **(Guo *et al*., 2012)**
- Protein efficiency ratio(PER) = Weight gain(g)/ protein intake(g) **(Guo *et al*., 2012)**

- Specific growth rate (SGR %/) = 100 × [(ln final fish weight) - (ln initial fish weight)] / time duration (days) **(Dhawan & Kaur, 2002)**
- Relative growth ratio (RGR %/) = 100 × [(ln final fish weight) - (ln initial fish weight)] / ln initial fish weight **(Keremah & Ockiya-Alfred, 2013)**

Statistical analysis

All experiments were conducted in a fully randomized manner with three replications. The treatments were evaluated. ANOVA was used to determine the significance of the treatments using Origin Pro 2023 software. The means of the treatments were compared, and the significance was observed using the Duncan test at a $P < 0.05$ level and descriptive statistics (±SE).

RESULTS AND DISCUSSION

The chemical and physical properties of water

Table (2) shows the environmental results for the water of the basins at temperatures ranging from 25.2- 27.1°C for various experimental basins, which were measured during the experiment period. In terms of temperatures, they were within the suitable range for the fish breeding, as indicated by **Liu *et al*. (2013)**, who elucidated that the temperature plays an important role in the overall biological activities of the fish, such as the feeding and growth in different environments. Feeding and growth rates are correlated with the water temperature, as mentioned by **Assiah *et al*., (2004)**, reporting that suitable temperatures for the growth of the common carp fall between 20 & 30°C. Regarding the dissolved oxygen value in the water, **Bhatnagar and Devi (2013)** stated that the oxygen value should not be less than 5mg/ L of water to achieve an optimal growth. Furthermore, **Arya *et al*. (2023)** noted that the oxygen concentrations exceeding 7mg/ L are quite suitable for fish growth in rivers, with recorded values ranging between 6.8- 8.1mg/ L, which are considered suitable for fish breeding and growth in this study. The pH value was within the optimal ranges in the study experiment, recorded with a range from 8.2- 7.3. **Kohlmann *et al*. (2003)** assessed that the appropriate pH value for living organisms ranges between 7- 9. **Iffat *et al*. (2022)** stated that a pH level between 6.5 & 9 is suitable for the growth of the common carp. On the other hand, for the salinity percentage in the experimental basin waters, it was within suitable ranges for the growth of the carp, with salinity recorded in the range of 2.1- 2.3mg/ L. In this respect, **Syawal *et al*. (2023)** demonstrated that the common carp can tolerate up to 11ppt salinity. These results are in line with the findings of **Sreekala *et al*. (2013)**, who found that a salinity percentage of 2mg/ L is suitable.

Table 2. Temperature rates, acidity function values, dissolved oxygen concentrations, and salinity levels for the waters of the experimental treatments

Treatment	Water temperatur (°C)	Oxygen (mg/l)	pH	Salinity (mg/l)
Control	26.8	7.7	8.1	2.1
LB 0.5%	25.2	8.1	7.7	1.8
LB 1%	26.6	7.5	7.9	2.2
LB 2%	27.1	6.8	8.2	2.3
LB 3%	26.8	7.6	7.3	1.9

Growth in fish

Table (3) depicts significant increases ($P\leq$ 0.05) in the final weight (FW), weight gain (WG), and daily weight gain (WGD) for the treatment LB 2%, followed by the treatment LB 3%. There were significant differences ($P\leq$ 0.05) among the treatments in the final weight (FW), with the highest final weight (50.78±0.42 gram) observed in treatment LB 2%, followed by treatment LB 3% with 46.85±0.67 gram. The results also indicated significant superiority ($P\leq$ 0.05) in the weight gain (WG) and daily weight gain (WGD) for treatment LB 2%, recording (40.34±0.34gram and 0.55±0.003 gram, respectively. Treatment LB 4% ranked the second. During the study period, the results for the daily weight gain over 72 days showed positive and significant effects of the dried bread residues on the weight gain, as shown in Fig. (1) .

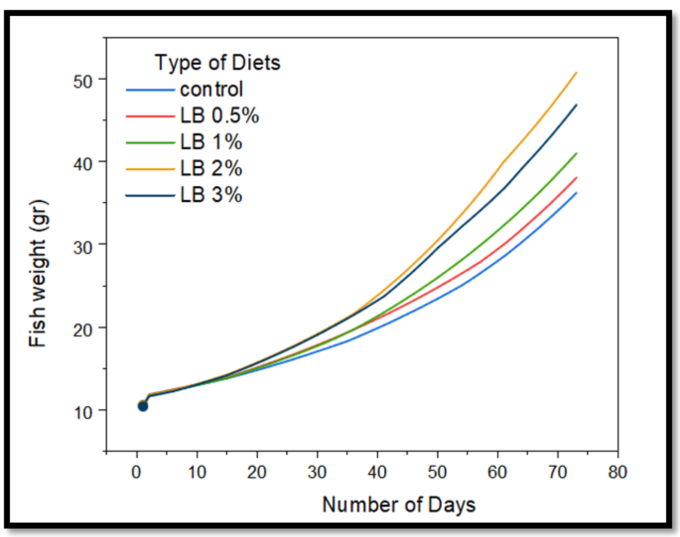

Fig. 1. Weight gain rates of the replicates in the treatments over the course of the experimental days

To our knowledge, the current study is the first to document the use of restaurant bread residues as dietary additives in fish feeds. In order to reduce the cost of common carp feeds, dried bread residues extracted from the leftovers of the Iraqi restaurants were used at different proportions in the experimental diets for the common carp cultivated in laboratory basins. The growth results indicated that the use of the bread residues had a significant impact ($P \leq 0.05$) on fish fed different diets. The findings of the current study differ from those of **Taher (2020)**, who cultivated the carp in floating cages and fed diets containing 75% of dried bread and 25% of dry fish at different densities, without detecting any significant differences, except for a slight increase in the daily weight. In addition, the present outcomes differ from those of **Al-Ruqaie (2007)** in feeding the *Oreochromis niloticus* fish on diets containing food residues, which showed no significant differences ($P \leq 0.05$) compared to the control diet in terms of the average weight.

Table 3. The growth performance of the common carp fed with diets containing different levels of leftover bread (LB) from local Iraqi restaurants

	control	LB 0.5%	LB 1%	LB 2%	LB 3%
IW gr	10.46^{a} ±0.03	10.56^{a} ±0.12	10.50^{a} ±0.05	10.43^{a} ±0.08	10.36^{a} ±0.03
FW gr	36.07^{e} ±0.34	38.05^{d} ±0.27	40.99^{c} ±0.23	50.78^{a} ±0.42	46.85^{b} ±0.67
WG gr	25.60^{e} ±0.31	27.48^{d} ±0.15	30.49^{c} ±0.20	40.34^{a} ±0.34	36.49^{b} ±0.65
WGD gr	0.35^{e} ±0.005	0.37^{d} ±0.003	0.41^{c} ±0.003	0.55^{a} ±0.003	0.50^{b} ±0.008
FCR	2.87^{a} ±0.01	2.79^{a} ±0.01	2.64^{ab} ±0.06	2.36^{b} ±0.12	2.35^{b} ±0.05
FCE %	35.05^{d} ±0.25	36.04^{d} ±0.17	38.59^{c} ±0.11	44.48^{a} ±0.00	41.95^{b} ±0.48
SGR %	1.71^{e} ±0.008	1.77^{d} ±0.006	1.89^{c} ±0.005	2.19^{a} ±0.005	2.08^{b} ±0.166
RGR %	244.63^{e} ±2.28	260.15^{d} ±1.56	290.45^{c} ±1.87	386.70^{a} ±0.01	346.33^{b} ±0.01
RER	1.19^{d} ±0.008	1.24^{c} ±0.006	1.42^{b} ±0.005	1.62^{a} ±0.000	1.64^{a} ±0.020

Values are mean ± SEM (n = 3). Different letters in the same row indicate significant differences among treatments ($P \leq 0.05$).

IW- The initial weight; FW- The final weight; WG - weight gain; WGD- daily weight gain; FCR- food conversion ratio; FCE- food efficiency ratio; SGR- specific growth rate; RGR- relative growth rate; RER- protein efficiency ratio.

Table 4. Correlation analysis of the growth performance for the common carp fed on diets containing leftover bread

	IW	FW	WG	WGD	FCR	FCE	SGR	RGR
FW	r= - 0.28 *P*= 0.29							
WG	r= - 0.31 *P*= 0.26	**r= 0.99** *P*= 0.1>						
WGD	r=- 0.31 *P*= 0.25	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>					
FCR	r= 0.36 *P*= 0.18	r= -0.99 *P*= 0.1>	r= -0.99 *P*= 0.1>	r= -0.99 *P*= 0.1>				
FCE	r= -0.36 *P*= 0.18	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	r= -0.99 *P*= 0.1>			
SGR	r= -0.36 *P*= 0.18	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	r= -0.99 *P*= 0.1>	**r=0.99** *P*= 0.1>		
RGR	r= -0.36 *P*= 0.18	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	r= -0.99 *P*= 0.1>	**r=0.99** *P*= 0.1>	**r=0.99** *P*= 0.1>	
RER	r= -0.40 *P*= 0.13	**r=0.95** *P*= 0.1>	**r=0.95** *P*= 0.1>	**r=0.95** *P*= 0.1>	r= -0.97 *P*= 0.1>	**r=0.96** *P*= 0.1>	**r=0.97** *P*= 0.1>	**r=0.95** ***P*= 0.1>**

Statistically significant results are in bold. R: Pearson correlation coefficient, *P*: *P*-value.
IW: The initial weight; FW: The final weight; WG: weight gain; WGD: daily weight gain; FCR: food conversion ratio; FCE: food efficiency ratio; SGR: specific growth rate; RGR: relative growth rate; RER: protein efficiency ratio.

The results of the current study presented in Table (3) show the significant superiority ($P\leq$ 0.05) of treatments LB2% and LB3% in FCR, with values of 2.36 and 2.35, respectively. The FCE of treatment LB2% was significantly higher than the other treatments, recording 44.48±0.00. There was no significant difference between the control and the LB 0.5% treatments, with values of 35.05±0.25 and 36.04±0.17, respectively. Both SGR % and RGR % showed a significant increase ($P\leq$ 0.05) in treatment LB2% compared to the other treatments, recording 2.19±0.005 for SGR and 386.70±0.01 for RGR. The PER also showed a significant superiority ($P\leq$ 0.05) in treatments LB2% and LB3% compared to the other treatments, with values of 1.62±0.00 and 1.64±0.02, respectively. The results of the current study demonstrated the superiority of treatment LB2%, possibly because the remaining dried bread mixed with food wastes may contain additional nutrients and flavors mixed with the bread residue used in the experimental diets. These mixed flavors may contribute to improving the nutritional value. Increasing the level of dry bread in the diet led to an improvement in the productivity of the fish, indicating that dry bread is rich in essential carbohydrates for energy, as noted by **El-Shear (2003)**. It was observed that fish in treatment LB3% showed a decreased productivity compared to treatment LB2% despite the higher proportion of dry bread. This decrease in productivity may be due to the excessive increase of dry bread, which could contain harmful substances affecting the digestion, such as yeasts used in bread fermentation and the gluten protein in wheat bread, which in excess can cause bloating and digestive issues **(Frits Koning, 2015)**.

Fig. (2) exhibits the feed intake of the experimental treatments by the fish in the study. The results showed a significant superiority ($P\leq0.05$) of treatment LB2% over the other treatments, recording 90.71±0.76gr. This was followed by treatment LB3%, which recorded 86.98±0.59gr. It was noticed that, treatment LB0.5% did not differ significantly ($P\leq0.05$) from treatment LB1%, with values of 77.72±0.21 and 79.01±0.41gr, respectively. This confirms that the remaining dry bread used in the experimental diets has a significant impact ($P \leq 0.05$) on the amount of feed intake. Additionally, bread is appetizing and has a significant effect on regulating the digestion process, which helps in consuming larger amounts of food **(Gonzalez-Anton, 2015)**.

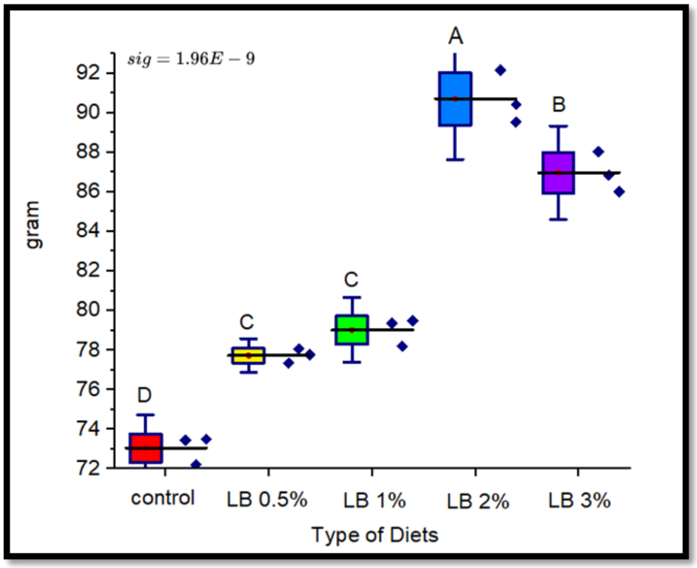

Fig. 2. Food offered for the experimental treatments to the studied fish, with significant differences between the experimental treatments (Mean ± SEM).

Fig (3) shows the protein intake of the experimental fish in the treatments. The results showed a statistically significant superiority ($P \leq 0.05$) for treatment LB2%, recording 24.78±0.36gr. This may indicate the appropriate amount for the remaining bread used in the experimental diets. Treatments LB0.5% and LB3% did not differ significantly ($P \leq 0.05$), and neither did the control and the LB1%. Additionally, there was a slight difference in treatment LB3% compared to the other treatments in terms of the crude protein percentage (25.53%) in the chemical analysis as shown in the Table (1). However, this did not affect the experimental fish's food intake for the other experimental treatments.

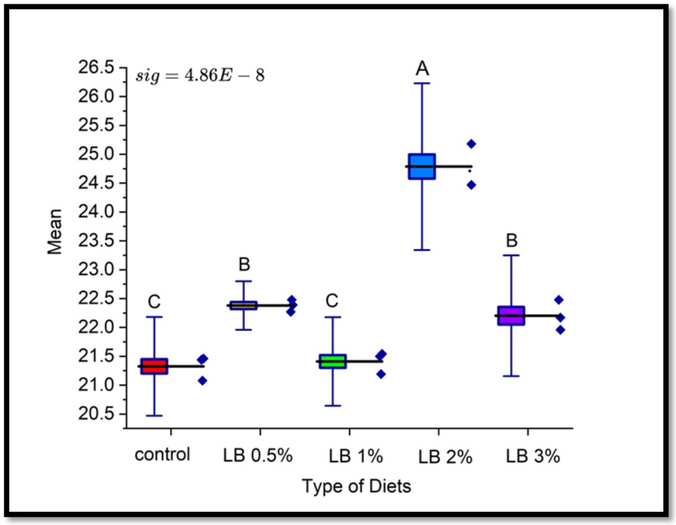

Fig. 3. The protein intake of the test fish for the experimental treatments showing significant differences between the experimental treatments (Mean ± SEM)

The chemical composition of the body

Table (5) displays the results of the chemical analysis of fish bodies for the different experimental fish fed on experimental diets compared to the control diets. The results indicate that the protein percentage in the fish bodies significantly exceeded $P \leq 0.05$ in treatments LB2% and LB3% compared to the other treatments, recording 70.85±0.6 and 69.47±0.07, respectively. This explains that the experimental fish-fed diets containing 2% of dried bread residues had a significant effect on the chemical composition of the fish bodies despite the low protein content in bread due to the lack of the essential amino acids, as outlined in the study of **Sluimer (2005)**. The increase in the protein percentage in fish bodies may suggest that the fish benefited optimally from the protein content in the diets due to the important benefits added by bread viz. carbohydrates and vitamins. This played a key role in creating a suitable environment for utilizing the protein in the experimental diets effectively. Additionally, the results showed that the fat percentage in the experimental fish bodies significantly exceeded $P \leq 0.05$ in treatments LB0.5%, LB1%, and LB3% compared to the other treatments, while treatment LB 2% exhibited the lowest value owing to the low-fat content in the dried bread added to the experimental diets. This indicates that we should not rely on this fat ratio to increase the fat percentage in the experimental fish bodies, but rather focus on the experimental diets and how to benefit from them efficiently **(Xu *et al.*, 2020)**.

Table 5. The chemical composition of the common carp fish bodies before and after the experiment for protein and fat (%, dry weight)

Parameter (%)	Control	LB 0.5%	LB 1%	LB 2%	LB 3%
protein	67.62 ^{c} ±0.20	68.51 ^{bc}±0.15	68.72 ^{b} ±0.21	70.85 ^{a} ±0.60	69.47 ^{ab}±0.07
lipid	9.90 ^{ab} ±0.50	10.63 ^{a} ±0.08	10.66 ^{a}±0.22	8.60 ^{b}±0.28	10.48 ^{a} ±0.26
Ash	14.4±0.32	16.10±0.22	14.62±0.64	13.85±0.77	16.23±0.18

Values (mean ± SE) with different superscripts in the same row differ significantly ($P \leq 0.05$).

CONCLUSION

From this study, we can conclude the effectiveness of dry bread crumbs in the diet of the common carp in terms of the growth and chemical composition of the fish bodies. The optimal level for adding dry bread crumbs is 2%. In addition, it will address the problem of high fish-fed prices, so we recommend that farmers use dry bread in fish feed because of its important role in growth.

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