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THE EFFECT OF PARTIAL REPLACEMENT OF ANIMAL PROTEIN WITH DUCKWEED GROWN IN THE TREATMENT UNIT OF THE NINEVEH PHARMACEUTICAL FACTORY WATER ON THE GROWTH PERFORMANCE OF COMMON CARP *Cyprinus carpio* L. FISH

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ABSTRACT

Duckweed grown in the water treatment unit of the Nineveh Pharmaceutical Factory contribute to reducing the level of pollution, and are used as a partial substitute for animal protein in common carp fingerling diets, in a growth experiment that lasted for 56 days, where the replacement rates reached 16.67, 33.33, and 50%, that is, a replacement rate, 0%, 2.6%, 5.2%, and 7.8% for treatments T1, T2, T3, and T4 of the total diet, respectively. The results of the statistical analysis showed that the fishes that fed the third diet were significantly superior ($P \leq 0.05$) to the other experimental diets in terms of criteria, final weight, total growth, daily gain, relative and specific growth rate, feed intake, feed conversion ratio, feed efficiency ratio, and protein efficiency ratio compared to the control treatment. The results showed that the highest percentage of pollutant removal from the water cleared from the treatment unit was in the spring season, which was represented by both total solids and phosphate compared to the winter and autumn seasons, while the highest percentage of nitrates was in the autumn season. It is clear from what was mentioned above that it is possible to partially replace duckweed with animal protein and that it is effective in reducing pollution of the water discharged from the process unit of the pharmaceutical factory.

INTRODUCTION

Fish supplies in natural bodies of water are small compared to the increase in the per capita share of fish from 9 kg/year during the 1960s of the last centuries to 20.5 kg in 2018. Therefore, attention has turned to fish farming (aquaculture) to meet these high consumption requirements by adopting intensive farming (FAO, 2020).

This caused the oxygen content in the fish habitat to decrease and the water's quality to decline. As a result, the fish suffered stress, lost their capacity to deal with these unusual environmental conditions, and increased the development of infections that inhibited the fish's ability to grow (Gaunt *et al*., 2010), exposing the fish to oxidative stress (Dawood *et al*., 2020), which led to the use of antibiotics to control diseases and increased growth in aquaculture projects (Defoirdt *et al*., 2011). Then, the use and circulation of antibiotics were banned due to their negative impacts on the health of fish and consumers by the European Union (EU) in January 2006 (Luckstadt, 2008). Attention has turned towards the use of safe food additives and plants to improve growth (Mustafa *et al*., 2022; Abdullah *et al*., 2022; Rahawi *et al*., 2022), as well as their positive impacts on the health of the aquatic environment and fish or use unconventional food (Hidayet *et al*., 2023). Duckweed has been used as a source of protein and included in the manufacture of fish feed for its advantages in availability and development. Sustainably and at low production costs (Dorothy *et al*., 2018).

Duckweed is one of the most miniature flowering plants and grows in floating colonies on the surface of calm waters year-round. The plant belongs to the Lemnaceae family, and the Arles order is a monocot. The duckweed plant contains 15–43% crude protein, 5–10% fiber, and 5% fat on a dry matter basis. It is often used in the manufacture of animal feed, in addition to its high production and growth, with a product period of up to 2–3 days (Al-Taee, 2012). It is included as fodder to feed fish because it is high in protein and rich in xanthophyll, carotene, and minerals (calcium and phosphorus) (Dorothy *et al*., 2018). The duckweed is one of the fastest-growing and most productive plants, known for its constant yearly harvest. They also have a high nutritional value because they contain a significant protein and the amino acids methionine and lysine, which are lacking in terrestrial plants. Finally, they can be fed to fish and farm animals in both fresh and dry form (Leng *et al*., 1995; Moyo *et al*., 2003).

The economic importance of the duckweed

The duckweed plant is an economic plant and national treasure, and production is invested as a fodder source. It is rich in protein and can be used as an alternative to traditional fodder sources that are expensive and increase the cost of production. This is distinguished by its production not requiring high costs, as this depends on experience and follow-up. In addition to its influential role in improving water properties and recycling waste in a vital way in the aquatic environment, water processes become productive as well as service-based and can be invested for this purpose (Yılmaz *et al*., 2004; Tavares *et al*., 2008).

Objectives of the study

1. To replace partial animal protein with duckweed and its effect on the growth of common carp (*Cyprinus carpio* L) and the extent to which these fish benefit from these diets .
2. To know the extent to which carp fish benefit from experimental diets by studying the growth standards and chemical composition of the edible part of the fish body.
3. To examine the ability of duckweed to remove pollutants from the water in the treatment unit—Nineveh Pharmaceuticals Laboratory.

MATERIALS AND METHODS

Ethical Approve

The Scientific Ethical Committee approved the research at the College of Veterinary Medicine at the University of Mosul, with its letter numbered UM.VET. 2023.032.1/2/2023.

Duckweed culturing

The duckweed plant was grown in the water treatment unit of the Nineveh Pharmaceutical Factory, and the plant was harvested for later use in a fish feeding experiment.

Experience location

This experiment was conducted at Department of Animal Production in the fish laboratory of the College of Agriculture and Forestry, University of Mosul, the study lasted 56 days, using 21 measuring glass aquarium (40 x 60 x 40) cm. It equipped an air pump, of Chinese origin, with all aquarium supply air tubes from an AUTOSAN air compressor of Chinese origin.

Experience fish

96 common carp *Cyprinus carpio* L. fingerlings were brought from Erbil Governorate. In the growth experiment, it was used and treated with a saline solution at a concentration of 3 g/L until signs of stress appeared on the fish to get rid of bacteria and external parasites, distributed in 12 glass aquariums, with eight fish per replicate and three replicates per each treatment. Before the feeding experiment started, the fish were kept in the aquarium for two weeks to acclimate to the glass tank's environment.

Chemical and physical properties of water

The water's temperature was controlled by air conditioners by a thermometer, which ranges between 25 and 28 degrees Celsius, measured with a mercury thermometer. Measurement of chemical characteristics included the percentage of dissolved oxygen at a rate of 5–5.5 mg/L using an Extech oxygen measuring device, model D0600. The pH values ranged between 7 and 7.3 using pH measuring device (digital meter). These standards are within acceptable limits for rearing of carp fish (FAO, 1981).

Trace elements

The iron element in the water was tested using an atomic absorption device in the central laboratory/College of Agriculture and Forestry/University of Mosul.

Estimating the percentage of pollutants removed

The percentage of pollutants removed by the duckweed plant is estimated by adopting the following equation based on Al-Taee (2012).

$$\text{Removal ratio} = (x - y / x) \times 100$$

Where:

X= represents the concentration of the substance at the beginning of the experiment.

Y= concentration of the substance in the duckweed development basin after ten days.

Diet preparation

The fish were fed a balanced diet of energy and crude protein. Duckweed was used to partially replace animal protein meal in four experimental meals, (which obtained from our laboratory and was grown in the processing unit of the Nineveh Pharmaceutical Factory), with varying proportions (0, 2.6, 5.2, and 7.8% for treatments 1, 2, 3, and 4, respectively) according to the study of Kamil and Taha (2022). Meat grinders were used to turn the diets into feed pellets Table (1) and (2).

Table (1): Dietary ingredient and proximate (DM%) of the experimental diets containing different levels of duckweed

Ingredients \ Treatment Diets	T1 (0%) control	T2 (21.67%)	T3 (43.33%)	T4 (60%)
Animal protein*	12	10	8	6
Duck weed	0	2.6	5.2	7.8
Soybean meal	30	30	30	30
Wheat bran	19	19	19	19
Maize	16.5	15.9	15.3	14.7
Local Barley	20	20	20	20
Bentonite	0.5	0.5	0.5	0.5
Mix (Vits. & Minerals)	0.5	0.5	0.5	0.5
Salt	1	1	1	1
Lime stone	0.5	0.5	0.5	0.5

* Protein concentrates blend WAFI HOLLAND designed fish carp (protein 37.5, Ether extract 3.5, fiber 1.14, moisture 2.76, Ash 37.31and mixture of vitamins, minerals, antioxidants and amino acids).

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

Ingredients \ Treatment Diets	T1 (0%) control	T2 (21.67%)	T3 (43.33%)	T4 (60%)
Dry matter	92.41	92.38	92.42	92.44
Moisture	7.59	7.62	7,58	7.56
Crude protein	25.54	25.50	25.48	25.45
Either extract	6.34	6.31	6.32	6.30
Ash	5.67	5.73	6.77	6.81
NFE	54.86	54.84	53.82	53.81
ME (MG/KG) *	14.35	14,4	14.32	14.27

*Based on the Smith's equation (1971): Fat × 33.5+ Protein × 18.5 + NFE × 13.8.

Chemical composition (%) of the duckweed plant

The duckweed content ratio, dry matter 92.0, moisture 8.0, crud protein 26.8, either extract 0.42, ash 22.8 and NFE 41.98.

Fish fed

The fish were fed three meals a day, at a rate of three percent of their body weight, on various diets for fifty-six days. Based on the increase in live weight, the amount of feed was raised every two weeks using a sensitive electronic scale (0.01 g).

Chemical analysis

The fish were anesthetized with the anesthetic MS-222 (150 mg/l of water) (Al-Taee *et al.*, 2021), followed by dissection of the fish for the purpose of obtaining the edible portion, determination of moisture, crude protein, ether extract, and ash, which was carried out based on AOAC (2023).

Methods for estimating growth in fish

The following criteria were used to determine the effect of replacing different levels of animal protein by duckweed: weight gain, growth rate, relative growth rate, specific growth rate, growth rate, food conversion ratio, feed efficiency ratio and protein productive value, according to the following equation:

$$\text{Growth daily gain} = [(\text{Wt} - \text{Wi})/\text{t}]$$

where Wt= is the final weight of fish (g), Wi = Initial weight of fish (g) and t = day.

Initial and final weights (IW and FW, respectively) were taken into account for calculation of specific growth rate and relative growth rate formula:

$$\text{SGR}(\%) = [(\text{Ln FW} - \text{Ln IW})/\text{time (day)}] \times 100, \text{RGR} = [\text{FW} - \text{IW}/\text{IW}] \times 100$$

$$\text{Food Conversion Ratio} = \text{g dry feed intake/g wet weight}$$

$$\text{PER} = \text{weight gain/g apparent protein intake/g}$$

$$\text{Protein productive value} = [\text{protein in final wt(g)} - \text{initial wt(g)/protein intake(g)}] \times 100$$

$$\text{survival rate} = [\text{number of dead fish/ total number of fish}] \times 100$$

Statistical analysis

The statistical program SPSS (Landau and Everitt, 2003) was used to analyze the data using a one-way variance method according to a completely randomized design (CRD). The means were compared using Duncan's multiple range test at $P \leq 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSION

Initial weight, daily gain, total gain, and final weight

According to Table (2), the results showed that there were no significant differences between the second, third, and fourth treatments for any of the studied traits. However, the third treatment, which included the addition of duckweed, showed a significant increase, outperforming the control treatment by 5.2% in all the studied traits, with values of 39.06, 70.09, 31.02, and 0.55, respectively.

According to Patra *et al*. (2013), duckweed may be used in replace of 15% of fish meal. Asimi *et al*. (2018) found that increasing the percentage to 45% resulted in a decline in growth and weight gain and the survival rate criteria, and the best percentage was 15% replacement of duckweed produced the best results in terms of growth and weight gain in their study. According to Stadtlander *et al*. (2019), the parameters for growth declined when rainbow trout (Oncorhynchus mykiss) received varying amounts of duckweed.

Herawati *et al*. (2020) found that feeding duckweed (2.5%) to tilapia fish as an alternative to soybeans gave the fish's best growth performance and resulted in the largest overall weight gain (33.03 g/fish) due to the high lysine and arginine content of duckweed plants., and these amino acids are in higher proportions than those found in soybeans. This was also agreed upon by the researchers Aslam and Zuberi (2017) in their results, which led to a significant increase in the final weight gain of grass carp fingerlings in a diet containing duckweed, amounting to 15.84 g compared to a soybean ration, which contains 12.63 g. Eid *et al*. (2017) indicated that adding 25% duckweed causes an increase in body weight.

Table (2): Effect of Duckweed on final weight, daily growth rate and weight gain criteria of common carp fish (Means ±SE).

Parameters / Treatment Diets	Initial weight (g\fish)	Final weight (g\fish)	Total weight gain (g\fish)	Daily weight gain (g/fish/day)
T1 (0%) control	38.79 ± 0.16 a	55.92 ± 0.37 b	17.12 ± 0.20 b	0.30 ± 0.01 b
T2 (16.67%)	38.83 ± 0.09 a	61.95 ± 1.12 ab	23.11 ± 1.11 ab	0.41 ± 0.01 ab
T3 (33.33%)	39.06 ± 0.15 a	70.09 ± 3.03 a	31.02 ± 3.17 a	0.55 ± 0.05a
T4 (50%)	38.88 ± 0.15 a	62.62 ± 3.69 ab	23.73 ± 3.54 ab	0.42 ± 0.06 ab

Different letters within a column indicate the presence of significant differences at P≤ 0.05.

Relative growth rate, specific growth rate, and survival rate

The outcomes of Table (3) revealed significant differences between the treatments. As an example, the T3, which added duckweed, outperformed the control treatment in all studied traits coming in at 79.46 and 1.03%, to RGR and SGR respectively, while it was found that there were no significant differences (P≤0.05) between the second, third, and fourth treatments for all the traits studied, and the survival rate was 100% for the experimental fish. Eid *et al.* (2017) found that adding 25% duckweed led to an increase in the rate of RGR as well as SGR growth.

Table (3): The effect of duckweed on parameters of relative growth rate, specific growth rate, and survival rate of common carp fish (Means ±SE).

Parameters / Treatment Diets	Relative Growth Rate (RGR) (%)	Specific Growth Rate (SGR) (%)	Survival Rate (%)
T1 (0%) control	43.27 ± 0.73 b	0.64 ± 0.11b	100 %
T2 (16.67%)	59.53 ± 2.87 ab	0.82 ± 0.33 ab	100 %
T3 (33.33%)	79.46 ± 8.36 a	1.03 ± 0.09 a	100 %
T4 (50%)	60.96 ± 8.85 ab	0.84 ± 0.09 ab	100 %

Different letters within a column indicate the presence of significant differences at P≤ 0.05.

Food intake, feed conversion ratio and feed efficiency ratio

There were significant differences (P≤0.05) in the results of the statistical analysis Table (4) in the amount of feed consumed and the feed conversion ratio between treatments, such as the second treatment had a superiority of 3.06% of duckweed over the first and third treatments and amounted to 102.63 grams.

Table (4): The effect of duckweed on the feed conversion ratio, feed efficiency ratio, and amount of feed consumed for common carp fish (Means ±SE).

Parameters / Treatment Diets	Food intake (g/fish)	Feed conversion ratio (FCR)	Feed efficiency ratio (%)
T1 (0%) control	94.39 ± 0.07 b	5.51 ± 0.06 a	18.14 ± 0.21b
T2 (16.67%)	102.63 ± 0.90 a	4.46 ± 0.25 ab	22.54 ± 1.27 b
T3 (33.33%)	93.25 ± 1.60 b	3.06 ± 0.29 c	33.16 ± 2.87a
T4 (50%)	98.02 ± 2.42 ab	4.29 ± 0.56 b	24.07 ± 3.02 a

Different letters within a column indicate the presence of significant differences at P≤ 0.05.

It was also shown that there were no significant differences between the first, third, and fourth treatments in feed intake. There were statistically significant differences in the food efficiency ratio, as the third and fourth treatments outperformed the rest of the treatments, and the third treatment's percentage, amounting to 33.16%, was significantly greater than the other treatments.

Kamil and Taha (2022) indicated that the best treatment is by adding 5% to a mixture of duckweed and azolla in terms of feed efficiency ratio, and the mixture ratio is 2.5% in the feed conversion factor for fish compared with the rest of the diets for other treatments due to the protein and amino acid content of duckweed. As well as essential nutrients such as lysine and methionine, the lack of fiber makes them more useful in feeding carp fish, as reported in Hugel (2020) research on duckweed for fish feeding. Asimi *et al.* (2018) found a reduction in the FCR of duckweed compared to a first treatment given to common carp when different proportions of duckweed were substituted as a partial fish food substitute.

Protein intake protein retention, protein production value, and protein efficiency ratio

It was found in Table (5) that the results of the statistical analysis indicate that there are statistically significant differences between the treatments in the percentage of protein consumed. A superiority appeared in the second and fourth treatments over the first and third treatments, reaching 26.97 and 27.22 g/fish, respectively, and it was observed that no discernible differences were seen in the T1, T3, T4, or second treatments. The amount of precipitated protein did not significantly differ between the treatments, according to the statistical analysis's findings.

The results recorded in Table (5) indicated that the fish that were fed the third diet were different significantly in terms of protein efficiency ratio protein productive value criteria over all other diets, including the control diet. Al-Shkakrchy and Ahemed (2013) reported a significant increase in protein retention value and protein productive value when feeding duckweed to two types of carp fish (grass and common) in the same breeding tank.

Table (5): Effect of duckweed on parameters of protein intake, protein retention, protein efficiency ratio, protein productive value of common carp fish (Means ±SE).

Parameters / Treatment	Protein Consumption (g/fish)	Protein Retention (g/fish)	Protein Efficiency Ratio (PER)	Protein Productive Value (PPV%)
T1 (0%) control	24.10 ± 0.01 b	6.59 ± 0.27 a	0.71± 0.01 b	25.73± 1.11 b
T2 (16.67%)	26.97 ± 0.23 a	6.28 ± 0.01 a	0.85± 0.04 b	23.29 ± 0.15 b
T3 (33.33%)	25.20 ± 0.43 b	7.91 ± 1.35 a	1.22± 0.10 a	31.39 ± 5.12 a
T4 (50%)	27.22 ± 0.67 a	6.78 ± 0.78 a	0.86± 0.10 b	25.24 ± 2.39 b

Different letters within a column indicate the presence of significant differences at $P \leq 0.05$.

This increase is a result of the duckweed containing a high percentage of protein, and the duckweed protein contains all the essential acids, especially lysine and methionine, which reached 3.5 and 1.7%, respectively, and a lower percentage of fiber. Kamil and Taha (2022) found that there was an increase in both the amount of protein intake and the percentage of PER for fish in mixed feeding of duckweed and Azolla by 2.5% compared to control. This makes duckweed more useful for feeding carp fish and meets all of their essential amino acid needs. According to Hugel (2020) research, feeding carp fish with duckweed increased the amount of protein consumed and the PER. When feeding diets containing *Azolla filiculoids* and duckweed (*Spirodela polyrhiza*) at 15% to *Cachama blanca* and *Nile tilapia* fish, Cruz-Velasquez *et al.* (2014) saw a significant increase in the protein efficiency ratio. This is because duckweed and azolla contain significant concentrations of protein and necessary amino acids. According to Eid *et al.* (2017), the best treatment in terms of the benefit from protein intake was a 25% addition of duckweed.

Edible portion

There were no appreciable variations between the treatments, according to the fish's body composition analysis results for total protein, ash, fat percentage, dry matter percentage, and moisture percentage Table (6).

Table (6): Effect of duckweed on chemical composition (%) of the edible portion of common carp fish (Means ±SE).

Parameters / Treatment	Moisture	Dry matter	Ether extract	Crude protein	Ash
Before Experimental Feeding	76.41 ± 0.46	23.59 ± 0.46	6.19 ± 0.00	14.99 ± 0.01	2.07 ± 0.04
T1 (0%) control	77.64 ± 0.19 a	22.36 ± 0.19 a	3.03 ± 0.15 a	21.49 ± 0.47 a	5.12 ± 0.70 a
T2 (16.67%)	77.64 ± 0.01 a	22.35 ± 0.01 a	2.83 ± 0.04 a	19.53 ± 1.21 a	5.09 ± 0.20 a
T3 (33.33%)	77.60 ± 0.03 a	22.40 ± 0.03 a	3.02 ± 0.26 a	19.65 ± 0.34 a	5.26 ± 0.33 a
T4 (50%)	77.23 ± 0.06 a	22.77 ± 0.06 a	3.28 ± 0.13 a	20.28 ± 1.35 a	6.24 ± 0.08 a

Different letters within a column indicate the presence of significant differences at $P \leq 0.05$.

It was noted in the study conducted by Eid *et al.* (2017) that adding duckweed at a rate of 25% was the best treatment, as it showed the highest percentage of protein and fat in the fish's body. Asimi *et al.* (2018) observed an increase in the amount of fat and protein in common carp feed when various amounts of duckweed were added to the diet to partially replace fish meal.

Trace elements

The growth of duckweed was in an aqueous environment that does not contain high concentrations of iron, which comes from medications used to treat anemia, which is part of the Nineveh Pharmaceutical Laboratory's activities. The concentrations of this element were low, as no sensitivity to the spectrophotometer device appeared when measuring the iron concentration. Absorbed iron is represented, which contributes to the formation of chlorophyll. Through it, the exchange of gases used in the processes of photosynthesis and respiration takes place in the plant. However, its excess is more than the plant's need, it is a heavy element that negatively affects the food chain and the environment. The heavy elements present in the water can be transferred to the duckweed and multiply. Their concentration is greater than what is in the water, and they make their way to the plant by adsorption of those elements on the outer surface of the plant, or they are absorbed by the plant by slow or effective transfer of the element to the cell through the cell wall, or they are bound to some nutrients and enter the plant cell (Wepener *et al.,* 2001).

Percentage of removal of pollutants present in the treatment unit by duckweed

The statistical analysis's significant differences ($P \leq 0.05$) in the percentage of dissolved solids during the various study seasons, with the removal percentage increasing in the spring over the remaining seasons to reach 29.11% Table (7). It was also noted that the clearance rate rose to 23.90% in the autumn Table (8) as opposed to the winter. Significant differences in electrical conductivity were found by statistical analysis, which may have contributed to the spring season's higher percentage of electrical conductivity than previous seasons. It was also shown that there was little change in the electrical conductivity.

Table (7): Shows the effect of duckweed on the percentage of removal of pollutants present in the waste water of the pharmaceutical and medical supplies factory in Nineveh during spring seasons (Means ±SE).

parameters	Allowed limits*	processing unit		Removal rate (%)
		before	after	
Total Dissolved Solids (TDS) mg/l	1500	1240	679	29.11
Conductivity (E.C) s/cm	500	155	64	58.71
Chlorides (CL) mg/l	600	392.5	80	79.62
Nitrates (NO_3) mg/l	50	7.75	2.65	65.81
Phosphate (PO_4) mg/l	3	2.55	0.76	70.20
Temperature	35	25	25	
pH	6.5-9.2	6.92	6.90	

* American Public Health Association (APHA), (1989).

There were significant differences between the autumn and winter seasons. It was discovered from the statistical analysis results that the concentrations of phosphates and chlorides varied significantly between the study seasons. The percentage of removal rose in the winter over the autumn season, while the percentage of removal grew in the spring, reaching 79.62 and 70.20%, respectively, over the autumn and winter seasons, While the removal rate of phosphate and chlorine in winter reached to 21.29% and 33.34 respectively Table (9).

Table (8): Shows the effect of duckweed on the percentage of removal of pollutants present in the waste water of the pharmaceutical and medical supplies factory in Nineveh during autumn season (Means ±SE).

parameters	Allowed limits*	processing unit		Removal rate (%)
		before	after	
Total Dissolved Solids (TDS) mg/l	1500	936	712.3	23.90
Conductivity (E.C) s/cm	500	148.25	124.5	16.02
Chlorides (CL) mg/l	600	323.5	263.3	18.61
Nitrates (NO_3) mg/l	50	8.1	0.13	98.40
Phosphate (PO_4) mg/l	3	0.6	1.08	-80.00
Temperature	35	25	25	
pH	6.5-9.2	7.28	6.55	

* American Public Health Association (APHA), (1989).

The findings demonstrated that the concentration of nitrates varied significantly between the removal percentages in the study seasons and that the fall season had a higher removal percentage of 98.40% than the winter and spring seasons. Came Spring 79.33 percent.

It is noted from Table (8) that the concentration of phosphorus before entering the duckweed plant's treatment basin was 0.6 mg/L. After the water left the plant's treatment basin, the concentration increased to 1.08 mg/L. The phosphorus removal rate became -80%. There are several reasons. This is due to the high concentration of phosphorus: leads don't harvest the plant to a high density of the plant relative to the size of the medium in which it is located, in addition to the great competition between the plants, causing the death of a part of it, especially the weak one, and its decomposition and the return of the elements contained in it to the growth medium in which it lives. Thus, an increase in the concentration of phosphorus appears. In addition to the ability of the duckweed plant to secure its need for phosphorus to sustain its vital activities by possessing a distinctive characteristic that distinguishes the plant in its ability to grow in high concentrations of phosphorus in water containing nitrogen, it works to store phosphorus in its cells, and this contributes to the high concentration of phosphorus in the aquarium, as a result of its decomposition (Al-Taee, 2012).

Table (9): Shows the effect of duckweed on the percentage of removal of pollutants present in the waste water of the pharmaceutical and medical supplies factory in Nineveh during winter season (Means ±SE).

parameters	Allowed limits*	processing unit		Removal rate (%)
		before	after	
Total Dissolved Solids (TDS) mg/l	1500	693	650	6.13
Conductivity (E.C) s/cm	500	102.2	89.75	12.18
Chlorides (CL) mg/l	600	240	160	33.34
Nitrates (NO_3) mg/l	50	8.95	1.85	79.33
Phosphate (PO_4) mg/l	3	1.55	1.88	21.29
Temperature (C˚)	35	25	25	
pH	6.5-9.2	7.3	7.4	

* American Public Health Association (APHA), (1989).

The results of the removal of compounds contained in the water of the laboratory treatment unit revealed an effective effect of duckweed in its role in the assimilation of these compounds in building its living mass and vegetative growth, which requires nutrients for sustaining the life of the plant and increasing its living mass through sexual reproduction through budding, and in this way, the plant contributes, recycles pollutants, cleans water from them, and provides a clean environment.

Hussein *et al.* (2016) stated that duckweed is highly efficient in removing concentrations of solids and heavy metals from wastewater. It was found that in the spring, the best removal rate was due to the moderate air temperature and the availability of suitable growth conditions for duckweed. Al-Ahmady and Al-Shrefy (2015) indicated that duckweed contributes to improving the efficiency of removing organic materials. Bnayyan *et al.* (2021) indicated that advanced wastewater treatment achieved good results in the rate of removal of materials through duckweed.

CONCLUSIONS

The current research results showed the effectiveness of duckweed grown in the treatment unit at the Nineveh Pharmaceutical Factory, which varied depending on the season of year. On the other hand, there is the possibility of partially replacing animal protein with duckweed grown in the treatment unit for factories in common carp diets.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

تأثير الاستبدال الجزئي للبروتين الحيواني بنبات عدس الماء المنمى في ماء وحدة المعالجة لمعمل ادوية نينوى على اداء النمو لاسماك الكارب الشائع *Cyprinus carpio* L.

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قسم الإنتاج الحيواني/ كلية الزراعة والغابات/ جامعة الموصل/ الموصل/ العراق [1،2،3]

الخلاصة

أسهم نبات عدس الماء المنمى في وحدة معالجة مياه معمل أدوية نينوى الى خفض مسنوى التلوث، واستخدم كبديل جزئي عن البروتين الحيواني في علائق إصبعيات الكارب الشائع، في تجربة نمو استمرت لمدة 56 يوماً إذ بلغت نسب الاستبدال 16.67 و33.33 و50%، أي بنسبة 0 و2.6 و5.2 و7.8% للمعاملات T1 وT2 وT3 وT4 على التوالي من العليقة الكلية. أظهرت نتائج التحليل الإحصائي تفوق الأسماك التي غذيت على العليقة الثالثة معنويا (أ ≤0.05) على العلائق التجريبية الأخرى من حيث معايير الوزن النهائي والنمو الكلي واليومي ومعدل النمو النسبي، والغذاء المتناول ونسبة التحويل الغذائي ونسبة كفاءة التغذية ونسبة كفاءة البروتين مقارنة بمعاملة السيطرة. أظهرت النتائج أن أعلى نسبة إزالة من الملوثات للمياه التي تمت تصفيتها في وحدة المعالجة كانت خلال فصل الربيع والذي تمثل كل من المواد الصلبة الكلية والفوسفات مقارنة بفصلي الشتاء والخريف، في حين كانت أعلى نسبة للنترات في فصل الربيع. يتضح مما ذكر أعلاه أنه من الممكن استبدال عدس الماء جزئيًا بالبروتين الحيواني وأنه فعال في تقليل تلوث المياه التي يتم صرفها من وحدة المعالجة في مصنع الأدوية.

الكلمات المفتاحية: بروتين حيواني، كارب شائع، عدس الماء، فوسفات، تلوث.

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