Evaluation of the effects of garlic powder and oil on growth performance and physiological parameters of common carp (*Cyprinus carpio* L.)

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Received 19/04/2025 Accepted 30/05/2025 Published 25/06/2025

Abstract

This study evaluated the effects of dietary garlic powder (1%), garlic oil (1%), and their combination (0.5%) each on the growth performance and some biochemical parameters of common carp (*Cyprinus carpio* L.) over a 75 day period. The results showed that the treatments with added garlic powder and garlic oil improved growth performance compared to the control group (C). Notably, the synergistic blend treatment removes (T3) demonstrated significant improvements in final weight (30.4 g), weight gain (18.3 g), relative growth rate (151.2%), specific growth rate (1.65%/day) and feed conversion ratio (1.81) with statistically significant differences (P<0.05) compared to other treatments. Digestibility was also significantly enhanced in all treatments containing garlic powder, garlic oil and their combination with the highest total digestibility recorded in treatment T3 (84.8%), which differed significantly (P<0.05) from the other treatments. Blood analyses indicated a gradual increase in values with the use of the garlic powder and oil mixture, with the highest levels observed in fish fed the T3 diet. The total blood protein concentration reached 2.08 mg/dl. An increase in albumin concentration was noted in all fish-fed diets supplemented with garlic powder and oil compared to the control, reaching the highest value in T3 (0.96 mg/dl). Regarding globulin concentration, a significant increase (P<0.05) was observed in treatment T3 compared to the other treatments, with a value of 1.12 mg/dl. Liver enzyme analysis (AST, ALT, and ALP) in serum showed reduced enzyme levels indicative of improved liver function in treatments T1, T2, and T3 compared to the control group, with the lowest values recorded in T3: 82.7 IU/l (AST), 7.79 IU/l (ALT), and 45.2 IU/l (ALP), The study concluded supplementing diets with garlic powder or oil, particularly their synergistic blend for *Cyprinus carpio* L. was effective in improving growth performance, enhancing general health status and increasing feed efficiency.

Keywords: Fish diet, Garlic Powder, Garlic Oil, Hematological parameters.

Introduction

The success of aquaculture largely depends on nutritionally balanced diets that contain all the essential components and additives necessary to support growth rates, improve digestibility, enhance immunity, increase disease resistance, provide energy, build tissues and reduce stress and mortality (Silva, 2022). The physiological status of fish is affected

P-ISSN: 1812-237X, E-ISSN: 2788-5720, https://ijaqua.uobasrah.edu.iq/index.pip/iaqua

largely by rearing conditions, especially in intensive culture systems where space is limited. This can lead to competition, deterioration of water quality, stress, immune suppression, increased disease outbreaks, growth inhibition and ultimately severe economic losses (Nie *et al*., 2021).

Thus, enhancing growth performance and fish health remains a major challenge due to their high susceptibility to diseases and the suboptimal conditions of intensive rearing systems (Shehata *et al*., 2024). Antibiotics and growth promoters are commonly used to control aquatic animal diseases (Yu *et al*., 2021). However, their use may disrupt the natural gut flora in fish, contributing to the emergence of dangerous antibiotic-resistant bacterial strains (Fierro-Coronado *et al*., 2018) and causing residue accumulation in fish meat. As a result, their usage has been banned in many countries around the world (Arsene, 2021). Currently, there is a growing trend toward the use of safe natural substances to enhance immunity, overall health, and growth performance in fish, while minimizing stress and avoiding synthetic chemicals (Hien *et al*., 2017). Among the most important alternatives introduced as dietary supplements are prebiotics and probiotics, which help enhance beneficial gut bacteria in fish, thereby improving nutrient utilization, digestibility of indigestible components, and reducing the toxicity of certain dietary compounds.

They also provide protective effects against pathogens and bacterial infections (Güroy *et al*., 2024). The use of natural products and medicinal plants as prebiotics can improve nutritional value, growth performance, enzymatic efficiency and physiological traits in fish (Hossain *et al*., 2024), as well as help reduce the need for antibiotics (Eroldoğan *et al*., 2023). Garlic *Allium sativum* is one such medicinal herb widely used as a spice, natural antibiotics, and immune booster. It has been used to control pathogenic bacteria and fungi in animals, including fish (Kaur and Ansal, 2020). Garlic contains no fewer than 33 sulfur compounds, 17 amino acids, various enzymes, minerals, vitamins, and bioactive compounds such as flavonoids, steroidal saponins, phytosterols and both water and fat soluble nutrients (Putnam *et al*., 2019).

It has been proven effective against pathogenic bacteria, viruses, fungi and parasites (Valenzuela-Gutiérrez *et al*., 2021). In terms of immune function, garlic increases the number of white blood cells, enhances phagocytic activity and stimulates immune responses by boosting immune efficiency (Öz *et al*., 2024). Garlic also regulates oxidative stress, modulates enzyme secretion, improves gastrointestinal motility and enhances nutrient absorption (Mohammad, 2023). Additionally, it promotes digestion by enhancing gut microbial performance, thus increasing energy utilization and improving growth (Motlagh *et al*., 2021). Therefore, the present study aimed to evaluate the effect of adding garlic powder and garlic oil to the diet of common carp (*Cyprinus carpio* L.) as a prebiotic supplement, focusing on growth performance and some hematological parameters in fish.

Materials and methods

Fish and Experimental System

In this study, common carp (*Cyprinus carpio* L.) with an average weight of 12.8 g and an average length of 8.44 cm were used. A total of 150 fish were obtained from the fish farm at the Aquaculture Unit, College of Agriculture, University of Basrah. Upon arrival at the Aquaculture Laboratory, the fish were disinfected using a 3% saline solution for one minute to eliminate attached bacteria and parasites. Afterward, the fish were stocked in 30-liter glass tanks that had been previously sterilized with sodium hypochlorite solution at a concentration of 200 ppm for one hour (Herwig *et al.*, 1979). The tanks were equipped with perforated lids to prevent fish from jumping, as well as aeration systems and submersible determining temperature of to maintain a stable water temperature. The experiment was designed with four treatments, each in triplicate (12 tanks total), and the fish were distributed at a density of 10 fish per tank at the beginning of the trial. The fish were acclimated to the experimental conditions for 10 days and fed a standard control diet during this period.

Feed Formulation

After determining the proportions of the feed ingredients used to formulate the experimental diets, as presented in Table 1, The ingredients, procured from local markets in Basrah Governorate were considered as primary raw materials for diet preparation. The ingredients were finely ground and passed through a 2-mm mesh sieve.

Table 1. Ingredient formulation and chemical composition of experimental diets.

Ingredients	C	T1	T2	T3
Fish meal	25	25	25	25
Soybean meal	15	15	15	15
Whole Wheat flour	20	20	20	20
Whole barley flour	20	20	20	20
Wheat bran	17	16	16.5	16.5
Vegetable oil	1	1	0.5	0.5
Vitamin and mineral premix	2	2	2	2
Garlic powder	0	1	0	0.5
Garlic oil	0	0	1	0.5
Chemical composition (%)				
Moisture	6.38±0.15	6.88±0.19	7.22±0.09	7.18±0.12
Crude protein	32.11±1.15	32.56±0.95	33.14±1.23	32.98±0.90
Crude lipid	6.11±1.91	6.25±1.34	6.09±1.09	6.19±0.96
Carbohydrate	48.16±2.05	46.19±1.96	45.56±2.17	45.76±1.89
Ash	7.24±0.90	8.12±0.79	7.99±0.88	7.89±0.78
Gross energy (Kcal/100 g)	437.9±12.1	433.7±11.7	432.9±10.9	433.8±11.8

They were then mixed thoroughly according to calculated ratios to ensure homogeneity. Approximately 100 ml of boiling water was added per 250 g of feed mixture to facilitate binding of the feed mixture. After cooling, vitamins and minerals were added. Four experimental diets were then formulated: C (Control): no additives, T1: supplemented with 1% garlic powder, T2: supplemented with 1% garlic oil and T3: supplemented with a combined addition of 0.5% garlic powder and 0.5% garlic Oil. The feed was then formed into pellets using a Brawn meat grinder with 4-mm diameter holes. The pelleted feed was air-dried in the laboratory for 48 hours with continuous turning to ensure complete moisture removal. After drying, the feed was stored in 2 kg plastic containers and kept in a refrigerator until use.

Feeding experiment

Fish growth

The fish were fed four formulated diets (four treatments), with three replicates per treatment and 10 fish per replicate. The diets were provided at a feeding rate of 3% of the live body weight per day throughout the 75 day feeding trial. The feeding was conducted in two meals daily: the first at 9:00 AM and the second at 2:00 PM. Fish were weighed every 15 days using a precision electronic balance to adjust the feeding rate according to changes in biomass. The siphon method was used daily to remove waste and uneaten feed one hour after each feeding session to maintain hygiene in the tanks. Additionally, 70% of the tank water was replaced weekly to maintain water quality. The following growth performance parameters were calculated: The total weight gain (TWG) and daily weight gain (DWG) were calculated following Sevier *et al*. (2000), while the relative growth rate (RGR) and specific growth rate (SGR) were determined according to the method described by Jobling (1993). Furthermore, values for the food conversion ratio (FCR), protein intake (PI), and protein efficiency ratio (PER), were calculated using the method applied by Tacon (1990) as follows:

TWG (g/fish) = Final weight – Initial weight
DWG (g/fish/day) = TWG / time (day)
RGR (%) = TWG / Initial wt. × 100
SGR (%/day) = (ln final wt. – ln Initial wt.) / time (day) × 100
FCR = Consumed feed (g) / TWG (g)
PER (%) = TWG / PI

Feed apparent digestibility

To measure total apparent digestibility (TADC) and nutrient apparent digestibility (NADC) coefficients, the indirect method described by Talbot (1985) was applied using chromium oxide Cr_2O_3 as a marker. The marker content in experimental diets and collected fish feces was assessed by measuring absorbance spectrophotometric ally at 350 nm as follows:

TADC (%) = 100 – [100 × (% marker in feed) / (%marker in feces)

NADC = 100 – [100 × {(% marker in feed)/(%marker in feces)}/ {(%marker in feces)/(%marker in feed)}]

Hematological Parameters

At the end of the experimental period, three fish were randomly selected from each tank for hematological analysis. Blood samples were collected from the caudal vein by severing the caudal peduncle and positioning the fish laterally. The blood was collected into 5 ml plastic test tubes containing K-EDTA as an anticoagulant. Gentle pressure was applied to the peduncle to facilitate blood flow, and the tubes were gently shaken by hand after sealing to ensure proper mixing of the blood with the anticoagulant, as described by (Blaxhall and Daisly, 1973).

Total Protein Measurement

The total protein concentration in the blood serum was determined using a commercial kit (Randox, USA) and a spectrophotometer at a wavelength of 546 nm. The protein concentration was calculated using the following equation:

Total protein concentration (mg/100 ml)=(Sample absorbance/Standard absorbance)× 6

Albumin Measurement

Serum albumin concentration was measured using a commercial kit (Randox, USA) and a spectrophotometer at a wavelength of 630 nm. The albumin concentration was calculated using the following formula:

Albumin concentration (mg/100 ml) = (Sample absorbance/Standard absorbance) × 4.5

Globulin Measurement

Globulin concentration was determined according to Wolf and Darlington (1971) by subtracting the albumin concentration from the total protein concentration:

Globulin concentration = Total protein concentration – Albumin concentration.

Measurement of Liver Enzymes: Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), and Alkaline Phosphatase (ALP)

The serum activities of AST and ALT enzymes were measured using a commercial diagnostic kit from Mindray (China) and analyzed with a BS–230 Mindray autoanalyzer at a wavelength of 550 nm. The enzyme activity was calculated using the following formula:

AST, ALT (IU/L) = (Sample absorbance – Standard absorbance) × 1746

The ALP enzyme activity was also determined using the same method, but with a reading at a wavelength of 405 nm. The calculation was performed using the following equation:

ALP (IU/L) = (Sample absorbance – Standard absorbance) × 2764

Statistical analysis

The growth experiment was designed according to the complete randomized design (CRD) with four treatments, each with three replications. The same statistical analysis approach was applied to other studied feeding and growth parameters. The significant differences between treatment means were determined using the least significant difference (LSD) test. All statistical analyses were conducted using the Statistical Package for Social Sciences (IBM SPSS) version 26.0.

Results

Table (2) shows the initial and final body weights as well as the weight gain rates for the different treatments. The results indicated a significant superiority (P<0.05) of treatment T3 over other treatments, where the final body weight reached 30.4 g, while the lowest value was recorded in the control treatment (C) at 23.8 g. The final weight gains in treatments T1 and T2 were 25.9 g and 27.2 g, respectively. Statistical analysis showed that the weight gain in treatment T3 was 18.3 g, which differed significantly (P<0.05) from the other treatments, which recorded gains of 12.5 g, 15 g, and 15.7 g for treatments C (control, without any additive), T1, and T2, respectively. Moreover, statistical analysis indicated no significant differences (P>0.05) among treatments C, T1, and T2. The results showed that the relative growth rate (RGR) was highest in treatment T3 at 151.2%, which was significantly higher (P<0.05) than the other treatments. The lowest RGR value was recorded in the control treatment C at 110.6%, which also differed significantly (P<0.05) from the rest of the treatments. The values for T1 and T2 varied, reaching 173.6% and 136.5%, respectively. Statistical analysis showed no significant differences (P>0.05) between treatments T1 and T2. The results also showed variation in the specific growth rate (SGR) among the treatments, with the highest value recorded in T3 at 1.65%/day, which was significantly higher (P<0.05) than the other treatments. The lowest value was in the control treatment C, reaching 1.33%/day. The values for T1 and T2 were close, at 1.55%/day and 1.54%/day, respectively. Statistical results indicated no significant differences (P>0.05) among treatments C, T1, and T2. The results also indicated that the best feed conversion ratio (FCR) was 1.81 in treatment T3, which differed significantly (P<0.05) from the other treatments C, T1, and T2, whose FCR values were 2.33, 2.05, and 1.98, respectively. Statistical analysis confirmed significant differences (P<0.05) in FCR between treatments C, T1, and T2. Furthermore, treatment T3 showed the best protein efficiency ratio (PER) at 1.67, significantly higher (P<0.05) than the other treatments. The lowest PER was 1.34, also significantly different (P<0.05) from the rest. The PER values for T1 and T2 were 1.50 and 1.52, respectively, with no significant differences (P>0.05) between them.

Table 2. Feeding and growth efficiency parameters.

Parameter	C	T1	T2	T3
IW (g)	11.3^{a}	10.9^{a}	11.5^{a}	12.1^{a}
FW (g)	23.8^{a}	25.9^{a}	27.2^{a}	30.4^{b}
WG (g)	12.5^{a}	15^{a}	15.7^{a}	18.3^{b}
RGR (%)	110.6^{a}	137.6^{b}	136.5^{b}	151.2^{c}
SGR (%/day)	1.33^{a}	1.55^{a}	1.54^{a}	1.65^{b}
FCR	2.33^{a}	2.05^{b}	1.98^{b}	1.81^{c}
PER	1.34^{a}	1.50^{b}	1.52^{b}	1.67^{c}

*Different letters within one row indicate the presence of significant differences at the level (P< 0.05).

The results in Table (3) show the values of the apparent digestibility coefficient (ADC) for the nutritional components of the experimental diets. The results showed that the highest total digestibility value was recorded in fish-fed diet T3, reaching 84.8%, and statistical analysis indicated a significant difference (P<0.05) compared to the other treatments. The lowest total digestibility value was recorded in the control diet (C) at 77.4%. The values for the other treatments varied, reaching 79.9% for T1 and 80.9% for T2, with no significant differences (P>0.05) between them, according to statistical analysis. The highest protein digestibility 83.9 % was observed in diet T3, significantly higher (P<0.05) than T2 79.3%, T1 78.8%and the control diet C 75.1%. Fat digestibility values were 79.8% in the control diet, 80.9 % in T1 (garlic powder), and 84.1% in T2 (garlic oil), with the highest value recorded in T3 (86.1%) containing a combination of both additives, Statistical analysis indicated significant differences (P<0.05) between diet T3 and the other treatments. The results also showed that the highest carbohydrate digestibility was recorded in diet T3, reaching 83.1%, and statistical analysis indicated a significant difference (P<0.05) compared to the other treatments. The values in diets C, T1, and T2 were 73.9%, 76.5%, and 75.9%, respectively, with no significant differences (P>0.05) between them. Concerning the ash digestibility, statistical analysis showed significant differences (P<0.05) among diet T3, which had the highest value (86.1%), and the other diets, which recorded 80.8% for C, 83.3% for T1, and 84.9% for T2. However, no significant differences (P>0.05) were observed among C, T1, and T2.

Table 3. Apparent digestibility coefficients of major nutrients in experimental diets

Nutrients	C	T1	T2	T3
Total digestibility	77.4^{a}	79.9^{a}	80.9^{a}	84.8^{b}
Protein	75.1^{a}	78.8^{a}	79.3^{a}	83.9^{b}
Lipid	79.8^{a}	80.9^{a}	84.1^{a}	86.1^{b}
Carbohydrate	73.9^{a}	76.5^{a}	75.9^{a}	83.1^{b}
Ash	80.8^{a}	83.3^{a}	84.9^{a}	86.1^{b}

*Different letters within one row indicate the presence of significant differences at the level (P< 0.05).

Table (4) illustrates the blood test results of common carp (*Cyprinus carpio* L.) fingerlings, showing a gradual increase in total blood protein concentration with the use of a mixture of garlic powder and garlic oil. The highest value was recorded in fish fed the T3 diet, reaching 2.08 mg/dl, compared to the control diet C (without garlic addition), which showed the lowest value of 1.86 mg/dl. The total blood protein concentrations in diets T1 and T2 were 1.95 mg/dl and 1.94 mg/dl, respectively. Statistical analysis indicated significant differences (P<0.05) between treatment T3 and the other treatments. The results also showed an increase in albumin concentration in all fish-fed diets containing garlic powder and garlic oil, compared to the control diet C, which recorded the lowest albumin concentration at 0.76 mg/dl. The highest value was observed in treatment T3, which contained equal proportions of garlic powder and oil, reaching 0.96 mg/dl, while the concentrations in T1 and T2 were 0.88 mg/dl and 0.87 mg/dl, respectively. Statistical analysis of serum albumin concentration revealed significant differences ($P<0.05$) between treatment T3 and the other treatments. Regarding globulin concentration, the results showed a significant increase ($P<0.05$) in treatment T3, which reached 1.12 mg/dl, compared to the other treatments. However, no significant differences ($P>0.05$) were observed between treatment T3 and treatments C, T1, and T2, which recorded globulin concentrations of 1.10 mg/dl, 1.07 mg/dl, and 1.07 mg/dl, respectively.

Table 4. Blood serum proteins (mg/dl) of experimental fish.

Parameter	C	T1	T2	T3
Total serum protein	1.86^{a}	1.95^{a}	1.94^{a}	2.08^{b}
Albumin	0.76^{a}	0.88^{a}	0.87^{a}	0.96^{b}
Globulin	1.1^{a}	1.07^{a}	1.07^{a}	1.12^{b}
ALB/GLU	0.691^{a}	0.822^{a}	0.813^{a}	0.857^{b}

*Different letters within one row indicate the presence of significant differences at the level ($P< 0.05$).

The results shown in Table (5) analyzing liver enzymes in serum AST, ALT, and ALP indicated improvement with the addition of treatments T1, T2, and T3 compared to the control treatment (C). The AST values were lower in the treated groups than in the control. The lowest AST value was observed in treatment T3 at 82.7 IU/l, showing a significant difference ($p < 0.05$) compared to the other treatments, which recorded values of 91.1, 88.7, and 89.2 IU/l for treatments C, T1, and T2, respectively. Regarding ALT enzyme levels, a decrease was observed with the addition of garlic powder, garlic oil, and their combination. The results revealed significant differences ($p < 0.05$) between treatment T3, which recorded 7.79 IU/l, and the other treatments, which had values of 8.52, 8.12, and 8.11 IU/l for treatments C, T1, and T2, respectively. As for ALP enzyme, statistical analysis showed a significant difference ($p < 0.05$) between treatment T3 and the other treatments. The control group (C) recorded the highest value at 50.7 IU/l, while the lowest value was in treatment T3 at 45.2 IU/l. Treatments T1 and T2 recorded values of 49.1 and 48.8 IU/l, respectively.

Table 5. Hepatic enzymes (IU/l) as indicators of physiological and health status of experimental fish.

Enzyme	C	T1	T2	T3
AST	91.1^{a}	88.7^{a}	89.2^{a}	82.7^{b}
ALT	8.52^{a}	8.12^{a}	8.11^{a}	7.79^{b}
ALP	50.7^{a}	49.1^{a}	48.8^{a}	45.2^{b}

*Different letters within one row indicate the presence of significant differences at the level ($P< 0.05$).

Discussion

The results of the current study demonstrated that diet supplementation with garlic powder and/or oil caused a significant variation in growth parameters and hematological traits of common carp compared to the control diet (C) without additives. The positive effects of garlic on growth performance may be attributed to its Allicin content, a compound with a strong flavor that stimulate appetite in fish and improves digestion by enhancing beneficial gut bacteria and inhibiting pathogenic bacteria, thereby enhancing the overall health status of cultured fish (Shalaby *et al*., 2006). Various studies have documented the beneficial effects of dietary supplements and herbal plants like garlic on growth efficiency and hematological parameters of cultured fish (Elgendy *et al*., 2023). Luo *et al*. (2011) and Abarike *et al*., (2018) reported that garlic stimulates appetite in aquatic animals and acts as a feeding attractant by chemically stimulating feeding behavior in fish, thereby increasing growth performance, immune regulation, and antimicrobial capacity. In a study by Farahi *et al*. (2010), the effect of garlic (*Allium sativum*) on the body composition of rainbow trout (*Oncorhynchus mykiss*) was evaluated and results showed a significant increase in crude protein and ash content in fish fed a diet containing 30 g garlic per kilogram of feed. Current findings agree also with Güroy *et al*. (2024), who indicated that garlic supplementation in the diet of rainbow trout resulted increased growth rates, total weight gain, improved SGR (specific growth rate), PER (protein efficiency ratio), and blood parameters. Simultaneously, Mohammad (2023) concluded that feeding common carp for 56 days with diets containing different levels of garlic powder significantly enhanced blood parameters, including increased total protein and globulin levels, as well as improvements in blood properties such as hemoglobin concentration, cell volume, and biochemical characteristics. He also reported a significant reduction in ALT and AST enzymes compared to the control group. Lee *et al*. (2012) observed that using garlic extracts in the diet of sturgeon (*Acipenser ruthenus*) resulted in a marked increase in PCV (packed cell volume) and hemoglobin levels while lowering blood glucose levels. Mohammad (2020) reported that garlic reduces intestinal glucose absorption, while Rodge *et al*. (2018) observed a significant decrease in plasma glucose and triglyceride levels in fish fed diets with increasing garlic concentrations. The present results were in line with the findings of Umaru *et al*. (2022), who used garlic powder (*Allium sativum*) as a dietary supplement and investigated its effects on growth performance and some biological indicators of Nile tilapia (*Oreochromis niloticus*) fingerlings fed for three months. Their results indicated that garlic powder enhanced growth performance, improved nutrient utilization efficiency, and reduced the feed conversion ratio (FCR). Similarly, Saleh *et al*. (2015) found that the inclusion of garlic powder in the diet of European seabass (*Dicentrarchus labrax*) improved fish survival and growth, and led to significant increases in several blood parameters (hemoglobin content, hematocrit value, mean corpuscular volume, mean corpuscular hemoglobin and white blood cell count) in treated fish compared to the control group. Xu *et al*. (2019) studied the effect of garlic powder on feed attractant activity, growth performance, and digestive enzyme activities in Japanese seabass (*Lateolabrax japonicus*) using six dietary treatments over a 28 days feeding trial. Their results showed that garlic reduced FCR and improved the activity of digestive enzymes including trypsin, amylase, and lipase. They concluded that garlic powder provides a clear attractant effect and represents a promising and effective approach for healthy fish farming by enhancing growth and digestive efficiency. Ispir *et al*. (2022) examined the effect of garlic oil on the health and immune response of rainbow trout (*Oncorhynchus mykiss*), finding increased immune activity, lysozyme enzyme activity, and myeloperoxidase levels in serum, along with elevated levels of total protein and immunoglobulin in fish. Harikrishnan *et al*. (2011) reported that feeding olive flounder (*Paralichthys olivaceus*) a combination of probiotics and herbal extracts resulted in a significant increase in final body weight after 6 to 12 weeks of feeding. Gabor *et al*. (2012) found that garlic may enhance the absorption of free amino acids by white muscle tissue, thereby promoting protein synthesis. The current findings align with those of Güroy *et al*. (2024), who reported that garlic supplementation increased hemoglobin (Hb) levels in the diet of *Oncorhynchus mykiss*. Total protein levels in fish serum are associated with protein synthesis in the liver, and the increase in serum protein is suggested to be linked to a stronger innate immune response (Weerties *et al*., 1996). Moreover, Nwakpa and Ikwor (2024) reported significant differences in growth indicators and feed utilization efficiency among African catfish (*Clarias gariepinus*) fed garlic-supplemented diets exhibited higher growth rates, greater weight gain, and notably better feed efficiency compared to the control group. Significant differences were observed in most hematological parameters studied, indicating the positive physiological effects of garlic on fish. The growth-promoting effects of herbal supplements are attributed to the stimulation of digestive enzyme activity and/or enhanced nutrient absorption and utilization (Hoseini *et al*., 2021). The increase in nutrient digestibility was clearly observed with the use of garlic in fish diets compared to the control diet without supplementation. In the current experiment, higher digestibility values were recorded in the garlic-supplemented treatments especially powder-oil blend, confirming that the presence of such dietary supplements leads to improved nutrient digestion (Huang *et al*., 2024). Abd-El-Hamid *et al*. (2002) reported that changes in AST and ALT activity affect amino acid synthesis and aminotransferase activity in the liver. Therefore, garlic may alter AST and ALT activity through a variety of chemical, biological, and physiological mechanisms, or by interfering with the Krebs cycle specifically by reducing the activity of intermediates such as α-ketoglutarate. Garlic may also act to stabilize the cell membrane and protect the liver from harmful agents and toxins that cause hepatic cell damage due to free radicals. It helps the liver maintain its normal function by accelerating the regenerative capacity of liver cells (Metwally, 2009). Motlagh *et al*. (2021) evaluated the effect of dietary supplementation with garlic extract on growth performance, immune parameters, and antibacterial activity in goldfish (*Carassius auratus*) over an 8-week feeding period. Fish fed garlic extract-enriched diets showed significant increases in lysozyme activity, alkaline phosphatase (ALP), total immunoglobulin levels, and soluble skin mucus proteins. Antibacterial activity also increased significantly with higher garlic extract concentrations in the diet. Oz and Dikel (2022) assessed the impact of different levels of garlic powder (*Allium sativum*) added to the diet of rainbow trout (*Oncorhynchus mykiss*) over a 90 days feeding period, using four dietary treatments. Their results indicated that garlic supplementation improved fish production performance, as evidenced by increased growth rate, reduced feed conversion ratio, higher total body protein content and lower body fat and moisture levels. Additionally, there was a decrease in monounsaturated fatty acids (MUFA) and an increase in polyunsaturated fatty acids (PUFA). These findings are consistent with those of El-Basuini *et al*. (2024), who investigated the addition of various concentrations of raw and fermented garlic powder to the diets of mullet (*Liza ramada*), focusing on growth performance, digestion efficiency, blood biochemistry, immune status, and antioxidant capacity. The results showed significant improvements in growth indicators such as specific growth rate and feed conversion efficiency. Moreover, reductions in glucose levels and increases in total protein were observed without adverse effects on liver or kidney function. Immune parameters also improved significantly, including lysozyme activity and antibacterial response against *Streptococcus agalactiae*, as well as enhancements in alternative complement pathway (ACP) and respiratory burst activity (NBT). Antioxidant enzyme activities SOD, CAT, and GPx – were significantly elevated, particularly in the fermented garlic treatment. Significant increases were also noted in digestive enzyme activities (amylase, lipase, and protease), which may be attributed to enhanced breakdown and absorption of undigested substances in the intestine. This effect is linked to the production of various enzymes that digest carbohydrates, proteins, and lipids, as well as the inhibition of anti-nutritional factors in feed ingredients, ultimately leading to higher digestibility values compared to the control group (EL-Haroun *et al*., 2006).

In conclusion, the current study clearly indicated that using garlic powder or garlic oil, particularly their synergistic blend, as dietary supplements in the diet of *Cyprinus carpio* L. is effective in improving growth performance, enhancing general health status, and increasing feed efficiency. The synergistic blend of 0.5% garlic powder and 0.5% garlic oil is recommended due to its superior effect on growth.

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تقييم تأثير مسحوق وزيت الثوم على المعايير التغذوية والفسلجية لأسماك الكارب الشائع *Cyprinus carpio* L.

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تاريخ الاستلام: 2025/04/19 تاريخ القبول: 2025/05/30 تاريخ النشر : 2025/06/25

المستخلص

تمت دراسة تأثير مسحوق الثوم بنسبة 1% وزيت الثوم بنسبة 1% والخليط التأزري بنسبة 0.5 % لكل من مسحوق وزيت الثوم على أداء النمو وبعض الصفات الكيموحيوية لأسماك الكارب الشائع *Cyprinus carpio* L. على مدى 75 يوماً، أظهرت معاملة الأسماك المغذاة على مسحوق الثوم ومعاملة زيت الثوم يمكن أن يحسن من أداء النمو مقارنة بمعاملةC ، بينت النتائج الى أن معاملة الخليط التأزري T3 قد أظهرت تحسناً ملحوظاً في معدلات الوزن النهائي ومعدل الزيادة الوزنية والنمو النسبي والنوعي ومعامل التحويل الغذائي حيث بلغت القيم 30.4 غم، 18.3 غم، 151.2 %، 1.65 %/يوم و 1.81 على التوالي وبأختلاف معنوي (P<0.05) عن بقية المعاملات، كما تحسنت قابلية الهضم بشكل ملحوظ في جميع المعاملات الحاوية على مسحوق الثوم وزيت الثوم والخليط التأزري حيث سجلت النتائج أعلى قيمة لقابلية الهضم الكلي لأسماك T3 84.8 وبينت نتائج التحليل الأحصائي أختلافها معنوياً (P<0.05) عن بقية المعاملات، أوضحت نتائج فحوصات الدم حصول زيادة تدريجية في القيم مع أستعمال خليط مسحوق الثوم وزيت الثوم حيث بلغت أعلى القيم في عليقة T3 حيث بلغ تركيز البروتين الكلي للدم 2.08 mg/dl كما لوحظ زيادة تركيز الألبومين في جميع الأسماك المغذاة على العلائق المضاف اليها مسحوق الثوم وزيت الثوم مقارنة مع عليقة C ووصلت القيم الى أعلى قيمة لها في عليقة T3 الحاوية على نسبة أضافة متساوية من مسحوق وزيت الثوم mg/dl0.96، فيما يتعلق بتركيز الكلوبيولين بينت النتائج حصول أرتفاع معنوي (p<0.05) في التركيز للمعاملة T3 مقارنة ببقية المعاملات الأخرى حيث بلغ التركيز 1.12 mg/dl. أوضحت نتائج تحليل أنزيمات الكبد في مصل الدم AST وALT و ALP الى تحسن معاملات الأضافةT1،T2،T3 في تحليل أنزيمات الكبد إذ كانت أقل من معاملة C حيث جاءت أقل القيم في معاملة T3 82.7 IU/l، 7.79 IU/l و 45.2 IU/l وأوضحت نتائج التحليل الأحصائي وجود فرق معنوي (p<0.05) بين معاملة T3 وبقية المعاملات. وقد أستنتج من الدراسة الى أن أستعمال مسحوق الثوم أو زيت الثوم وخصوصاً الخليط التأزري كمكملات غذائية الى النظام الغذائي لأسماك الكارب الشائع *C. carpio* L. يعد فعالاً في تحسين أداء النمو وتعزيز الحالة الصحية العامة للأسماك وكفاءة استخدام العلف ويوصى بأستخدام الخليط التأزري لمسحوق وزيت الثوم بنسبة 0.5 % لكل منهما يمكن أن يعزز من النمو

الكلمات المفتاحية: علائق سمكية، مسحوق وزيت الثوم، معايير تغذوية وفسلجية