Modulatory role of dietary curcumin and resveratrol on growth performance

by Abd Aziz

Submission date: 20-Dec-2022 12:21PM (UTC-0500)
Submission ID: 1985120489
File name: Pre_Proof_Asli-2.docx (92.87K)
Word count: 10838
Character count: 59632

Modulatory role of dietary curcumin and resveratrol on growth performance, serum immunity responses, mucus enzymes activity, antioxidant capacity and serum and mucus biochemicals in the Common carp, Cyprinus carpio exposed to Abamectin

Martina Kurnia Rohmah 1*, Omar Dheyauldeen Salahdin 2, Reena Gupta 3**, Khursheed Muzammil 4, Maytham T. Qasim 5, Zahraa Haleem Al-qaim 6, Nada Fadhil Abbas 7, Mohammed Abed Jawad 8, Ghulam Yasin 9, Yasser Fakri Mustafa 10, Aadel Heidary 11, Safoura Abarghouei12

1Department of Pharmacy, Anwar Medica University, Sidoarjo, Indonesia.

2Al-maarif University College, Medical Laboratory Techniques Department, Al-anbar-Ramadi, Iraq.

3Assistant Professor, Institute of pharmaceutical research, GLA University, Mathura, Uttar Pradesh 281406.

4Associate Professor, Department of Public Health, College of Applied Medical Sciences, Khamis Mushait Campus, King Khalid University, Abha, Saudi Arabia

5Department of Anesthesia, College of Health and Medical Technololgy, Al-Ayen University, Thi-Qar, Iraq.

6Department of Anesthesia techniques, Al-Mustaqbal University College, Iraq.

7Al-Manara College for Medical Sciences, Maysan, Iraq.

8Department of pharmacy, Al-Nisour University College, Baghdad, Iraq.

9Assistant Professor, Department of Botany, Bahauddin Zakariya University, Multan, Pakistan.

10Department of Pharmaceutical Chemistry, College of Pharmacy, University of Mosul, Mosul-41001, Iraq.

11Environmental Expert of Farsan Municipality, Shahrekord, Iran.

12Vice- Chancellor for Research and Technology Affairs, Bahavaran Nastaran University of Applied Sciences Qom, Qom, Iran.

* Corresponding author: Martina Kurnia Rohmah; Email: Rohmah.Martina@gmail.com

Abstract

The potential of dietary curcumin and resveratrol on blood biochemistry, immune response and resistance to the toxicity of pesticides, abamectin is investigated in this study. The distribution of carp with a total (of 30.78 ± 0.17 g) was carried out randomly into 18 tanks (with a total of 30 fish in each tank), which were used as six experimental groups (T1: fish that did not receive supplements and fish that were exposed, T2: 300 mg/kg curcumin, T3: 300 mg/kg resveratrol, T4: 12.5% LC50 abamectin, T5: 300 mg/kg curcumin +12.5% LC50 abamectin, T6: 300 mg/kg resveratrol + 12.5% LC50 abamectin). The use of 300 mg/kg resveratrol in fish feed exposed to non-abamectin increased growth performance ($P < 0.05$) improved by fish feed exposed to non-abamectin containing 300 mg/kg resveratrol, while no effect was observed on curcumin. ($P > 0.05$). Final weight (FW), feed conversion ratio (FCR) and body weight gain (BB) between control and fish treated with resveratrol + abamectin and curcumin + abamectin ($P < 0.05$) were not different. Various patterns of changes are seen in immune components in blood [lysozyme, complement activity, total immunoglobulin (total Ig), protease, myeloperoXidase (MPO), nitro-blue-tetrazolium (NBT), peroXidase, albumin] and mucus [acid phosphatase (ACP), alkaline phosphatase (ALP), esterase, antiprotease)] and antioxidant enzymes [(superoxide dismutase (SOD), glutathione peroxidase (GPX)) when juxtaposed with the control group, however, the fish that were supplemented with curcumin and resveratrol on abamectin-free media were the majority of the components this was higher than the control and other groups ($P < 0.05$). There was no significant difference between the resveratrol + abamectin and curcumin + abamectin treatments ($P > 0.05$), as indicated by the levels of immune components and antioxidants in the controls in the majority of cases. Abamectin induced oxidative stress in fish because there was a significant increase in malondialdehyde (MDA) levels in exposed fish when compared to the unexposed group ($P<0.05$). It seems that oxidative stress was prevented effectively by curcumin and resveratrol because the exposed fish had higher levels of MDA (abamectin, curcumin + abamectin, resveratrol + abamectin) when compared to controls and individuals who were not exposed ($P < 0.05$).

Curcumin and resveratrol also showed a protective effect on the liver because fish that were supplemented with abamectin-free

media had lower levels of liver metabolic enzymes [aspartate transaminase (AST), ALP, lactate dehydrogenase (LDH)] compared to controls ($P < 0.05$). The stress response in the exposed fish was reduced with curcumin and resveratrol. A significant reduction in the supplemented fish was seen in their cortisol and glucose levels ($P<0.05$). In conclusion, this study found that growth and immunity in carp can be suppressed using abamectin. Although the toxic effect of abamectin is reduced in the presence of resveratrol and curcumin, it seems that the effectiveness of resveratrol is higher when compared to curcumin.

62

1. Introduction

The use of pesticides increased significantly to control pests in line with growing agricultural activities [1,2]. However, the environment and humans have always had problems with insecticides. Includes ecosystems, the life of aquatic organisms are threatened by insecticides and their derivatives which contaminate water through runoff and drainage [3]. The transmission and expansion of insecticides from a biological point of view in aquatic ecosystems can be carried out in the food chain without exception, where the toxicity is intensified, especially to the end consumer [4–7]. In aquatic ecosystems, one of the organisms that are adversely affected by insecticides and pesticides is fish [8]. The toxic effects of pesticides on fish can be reduced by using immune-stimulating food supplements, some studies have shown [9–15]. Antioxidant and immunogenic properties of medicinal plants and their derivatives have recently attracted much human attention [16–25]. Some studies related to this have shown that fish get a protective effect against pesticide toxicity in the presence of medicinal plants and their derivatives [11–14, 26]. In China and India, *Curcuma* longa is a well-known plant whose rhizomes can be used as a medicine that cures many diseases [27–29]. Curcumin, or C. longa, is a yellow pigment that is the origin of curcumin or diferuloylmethane; its functions are antibacterial, anti-inflammatory, immunomodulatory, and antioxidant [30–32]. The immune-stimulating properties of curcumin in fish are obtained from many studies that have been conducted [33–38].

Another plant-derived polyphenolic compound that functions as an antioxidant and anti-inflammatory is

resveratrol [39–42]. Research has also found fish to exhibit the antioxidant and immune-stimulating effects of resveratrol [43–49]. The effects of pesticide-induced immunotoxic and oxidative stress are rarely known, although there have been reports on the immunogenic and antioXidant functions of curcumin and resveratrol in fish.

needs use the most abundant avermectin compound (a macrocyclic

lactone compound extracted from the fungus Streptomyces avermitilis)

called abamectin. Abamectin is a neurotoxic insecticide whose action uses glutamate and γ-amino butyric acid-gated chloride channels in the brain [50,51]. Toxic effects on fish have been widely reported, although abamectin is relatively safe for humans [52–55]. The advice given in this study is to increase the natural carp immune system against the toxicity stimulated by abamectin.

24

2. Materials and methods

2.1. Fish and experiment design

A local farm in Isfahan province, Iran, prepared 600 juvenile goldfish with an average weight of 27.18 ± 0.2 g and then acclimated to laboratory conditions within two weeks at a water temperature of 24–25 ◦C. Fish get food in the form of staple food ad libitum daily in this period (Table 1). When the adaptation period was complete, the fish (n 540, average weight: 30.78 ± 0.17 g) were separated into 18 tanks. One tank contained 30 fish randomly; the purpose of this separation was to carry out six experiments which were repeated three times. The experimental was grouped into control (T1): cultured fish on abamectin-free media that did not get supplements, T2: cultured fish on abamectin-free media supplemented with 300 mg/kg curcumin, T3: cultured fish on abamectin-free media supplemented with resveratrol 300 mg/kg, T4: cultured fish in media containing 12.5% abamectin LC50 without supplementation, T5: cultured fish in media containing 12.5% abamectin supplemented with 300 mg/kg curcumin, T6: cultured fish in media containing 12.5% LC50 abamectin supplemented with 300 mg/kg resveratrol. Abamectin concentration adjustments and 75% water replacement was done daily during the experimental period. Aeration is continuously carried out in the tanks, suction of suspended particles is carried out every day, and every two weeks, the biomass of each tank is weighed so that the feeding rate can be adjusted. Water quality parameters are checked every day, which include: temperature: 24 0.5 ◦C, dissolved oxygen 6.5 0.78 mg/l (Portable Dissolved OXygen Meter, Hanna, HI9146, Hanna instruments CO., UK), pH: 7.3 ± 0.2 (pH meter, Hanna-HI 98128, Hanna instruments CO., UK) and un-ionized ammonia 0.03 ± 0.025 mg/l (Hi-700 Ammonia Low Range Colorimeter – Examiner, Hanna Instruments CO., UK). Feed is given a maximum of twice a day [56].

2.2. Preparation of experimental diets

Merck CO. and Sigma Aldrich CO provided curcumin (820354, purity:75%) and resveratrol (R5010, purity: 99%). To be able to prepare a trial ration, the first step is to prepare and weigh the food ingredients and then mix the ingredients evenly. The next step is to form the dough by mixing water with the supplement at an adjusted level. Next is the production of pellets using a meat grinder and drying the pellets at 37 ◦C and the storage process at 4 ◦C. [56,57].

2.3. Determination of acute toxicity of abamectin and exposure trial

For the dose to be given correctly, the lethal range and acute concentration of carp abamectin must be known before the main

exposure test. That is why exposure of carp to different concentrations of abamectin is carried out after the adaptation period to obtain a lethal range. To achieve this goal, the fish (n 30, 10 fish per replicate) were exposed to concentrations of 0 (control), 0.25, 0.5, 1, 1.5, 2 and 4 mg/l abamectin agar LC50 according to the standard method, which can be specified [58] Recording of fish mortality was carried out for 96 hours at 24, 48, 72 and 96 hours after the fish were exposed. The final step, referring to the probit statistical analysis method, calculates the LC10, LC30, LC50, LC70, and LC90 values at 24, 48, 72 and 96 hours (Table 2).

2.4. Sampling

Feeding the fish for 24 hours, anaesthesia using eugenol solution (100 mg/l) and calculating the growth index and nutrition using fish biometry were carried out at the end of the 30th day, in addition to using the following formula to determine the feed consumed [59]:

Weight gain (WG; g) = Final weight (FW) − Initial weigh (IW). Specific growth rate (SGR; %) 100 [(in FW − in IW)/d],

Feed conversion ratio (FCR) Feed intake/ (FW-IW).

Survival rate (SR; %) (Number of alive fish/total number of fish) 100.

Eugenol solution (100 mg/l) was used to anaesthetize three fish from each tank to allow the evaluation of serum immune parameters to be carried out [59]. A 2 ml syringe takes blood samples from the caudal vein. The blood sample was poured into a tube and stored at room temperature for 2 hours. Subsequently, centrifugation (3000 g for 10 min at 4 ◦C) was used to separate the serum samples. The serum obtained was stored at 70 ◦C until the biochemical tests were carried out. Randomly capturing three fish from each tank and transferring them to a polyethene bag containing 10 ml of 50 mM saline solution was carried out so the slime samples could be collected. Slime centrifugation was carried out after 3 minutes (2500×g for 10 minutes at 4 ◦C) and supernatant storage at -80 ◦C [60].

2.5. Serum and mucus immune assays

Ellis described the turbidity method, which is the basis for measuring the activity of serum and mucus lysozyme [61] Micrococcus lysodeikticus in phosphate buffer (0.2 mg/ml in 0.05 M sodium phosphate buffer (pH 6.2) was used as a target. The amount of protein before and after polyethene glycol was added as a basis for the assay of total serum immunoglobulin (total Ig) (mg/dL). A commercial assay kit (Pars Azmun Co., Tehran, Iran) with ELISA [(ELX800), Bio-Tek, Vermont, USA)] was used to determine serum complement component concentrations (C3 and C4) (mg/dL). Yano describes the method on which the evaluation of alternative complementary activities (ACH50) is based [62]. Sheep red blood cells in the vernal buffer containing EGTA and Mn are the targets in this method. Preparation of different serum sample concentrations (0.312, 0.625, 1.25, 2.5, 5 and 10%) and mixing of 25 µl of serum with 125 ml of buffer containing 50 µl of blood cells was carried out. Centrifugation (13000×g for 5 minutes) of the mixture was carried out after 2 hours of incubationand storage was carried out at room temperature; then, the absorption rate was recorded at 412 nm.

In this method, mixing 100 µl of slime with 100 µl of ammonium bicarbonate buffer (100 mM) was performed. The mixture contained 0.7% azocasein solution and was then incubated at 30 ◦C for approximately 20 hours. Trichloroacetic acid was used to stop the reaction, and the supernatant was not removed by centrifugation (15 000 g, approximately 5 minutes). Then, the supernatant was mixed with 0.5 N hydroxide, and the absorption rate was recorded at 450 nm. Hank's Buffer (HBSS) at 450 nm wavelength refers to the method directed by Quade and Roth, was used to measure serum peroxidase activity [64]. Pars Azmun (Pars Azmun Co., Tehran, Iran), which did not contradict the manufacturer's protocol, was used to test the mucilage alkaline phosphatase activity.

The Anderson and Siwicki method was used to test nitro-blue-tetrazolium (NBT) serum [65]. It can be said, add 100 µl blood to 100 µl NBT 0.2% and incubate the mixture for approximately 25 minutes at 25 ◦C. About 50 µl of the resulting suspension was poured into 1 ml of N, N-dimethyl formamide, then centrifuged at 3000 g for approximately 5 minutes, and the adsorption of the supernatant was recorded at 540 nm.

The Quade and Roth method measured serum myeloperoxidase (MPO) activity [64]. The 96-well microplate reader well at this stage obtained an additional ten µl of serum and 90 µl of Na+ and Mn2+ mixed without Hank's balanced salt solution (HBSS) (Thermo Fisher Scientific, Inc., USA). Furthermore, the wells received an additional 35 µl of the tetramethylbenzidine hydrochloride (TMB) system. 35 µl sulfuric acid (0.5 M) was added to stop the color change, and the absorption rate was recorded at 450 nm.

Garen and Levinthal reported p-nitrophenyl phosphate as the substrate used to test the activity of mucus acid phosphatase (ACP) at 37 ◦C in 0.1 M acetate buffer (pH 5.0) [66]. Trypsin activity is slowed by using the ability of mucus to be the basis for measuring total antiprotease activity [67]. Ten µl of mucus was incubated with 5 mg trypsin at 22 ◦C for 10 minutes. Next, the mixture was subjected to adding 100 µl of ammonium bicarbonate (100 mM) and 125 µl of 0.7% azocasein. Samples were incubated for 2 hours at 30 ◦C, and then 250 µl of trichloroacetic acid was added. The mixture was centrifuged at 6000 × g for 10 minutes. The supernatant was placed into a 96-well microplate reader well containing 100 µl sodium peroxide, and absorption rate readings were taken at 450 nm. Guardiola is the basis for measuring esterase activity [67]. Incubation was performed with equal volumes of mucilage and 0.4 mM nitrophenyl meristic in ammonium bicarbonate buffer containing 0.5% Triton X100 at 30 ◦C, and absorption rate readings were carried out at 405 nm in this method.

2.6. Serum and mucus biochemical parameters

A commercial assay (IBL Co., Gesellschaft für Immunchemieund Immunbiologie, Germany) with ELISA was used to test serum and mucus cortisol levels (ng/ml). A commercial assay (Pars Azmun Co., Tehran, Iran) was used to determine serum and mucus glucose concentrations (mg/dL). Measurement of each oxidation rate of glutathione oxide and reduction rate of cytochrome C (ZellBio GmbH, Veltinerweg, Germany) is a medium for testing the activity of serum glutathione peroxidase (GPX) (U/ml) and superoxide dismutase (SOD) (U/ml). The decomposition rate of H2O2 was estimated to calculate the serum catalase (CAT) activity (U/ml), as Goth described [68]. The thiobarbituric acid (TBARS) method with a commercial assay kit (ZellBio GmbH, Veltinerweg, Germany) was used to evaluate the lipid peroxidation indicator, malondialdehyde (MDA). A commercial assay kit

(Pars Azmun CO., Tehran, Iran) with biochemical autoanalysis (Beckman Coulter, Avanti J-26 XPI, CA, USA) was used to measure the activities of the enzymes ALP, AST and alanine aminotransferase (ALT) and lactate dehydrogenase (LDH) (U/l) in serum.

2.7. Data analysis

SPSS software is used to analyze the data in this study. The Kolmogorov-Smirnov test was used to evaluate the normality of the data. One-way analysis of variance (ANOVA) was used to determine the differences among means, and then Tukey's test ($P<0.05$) used to compare means. Mean ± SE is the data in the figures and tables presented.

3. Results

3.1. Growth performance

In the T3 treatment (300 mg/kg resveratrol), the FW value was significantly higher compared to the control after receiving 30 days of feed (Table 3, $P<0.05$). In addition, the FW value at T5 (Table 3, $P<0.05$) was lower than T2. It can be seen from FW that there was no significant difference between the other groups (Table 3, $P > 0.05$). Compared with the control, the WG value increased significantly at T3; the lowest WG value was seen at T4 (Table 3, $P<0.05$). There was no significant difference in the WG between the control and other groups (Table 3, $P > 0.05$). The lowest and highest FCR values were observed at T3 and T4 (Table 3, $P<0.05$). Compared to the control, the FCR value at T3 shows a significant decrease, while at T4 (Table 3, $P<0.05$), it has increased. Between T3, T5, and T6 (Table 3, $P> 0.05$), there was no significant difference in FCR. Compared with the other experimental groups (Table 3, $P<0.05$), the SGR value at T4 was significantly lower. There was no significant difference between groups in SGR (Table 3, $P > 0.05$). Between all groups (Table 3, $P > 0.05$), there was no significant difference in SR.

3.2. Serum immune components

The T2 and T3 treatments showed a significant increase in lysozyme activity compared to the control and other groups (Table 4, P <0.05). There was no significant difference in the training of lysozyme between the management and other groups (Table 4, P > 0.05). At each T2 and T4 ACH50 activity significantly compared to the control (Table 4, P > 0.05) showed higher and lower action In other groups, ACH50 activity, compared to controls (Table 4, P > 0.05), did not show a significant difference. In the T3 treatment, there was an increase in the total concentration of Ig compared to control (Table 4, P < 0.05). Significant differences with the other groups (Table 4, P > 0.05) were not seen in total Ig concentrations in the controls. There was no significant difference in total Ig concentrations between T2, T3, and T6 and between T5 and T6 (Table 4, P > 0.05). In the T2 treatment compared to the control (Table 4, P <0.05), there was a significant increase in protease activity. There was no significant difference with the other groups (Table 4, P > 0.05) in the protease activity of the control group. There was no significant difference in protease activity between T3 and T5 and between T4, T5, and T6 T2 than in T4 (Table 4, P < 0.05). The NBT activity

Significant differences with the other groups (Table 4, P > 0.05) were not seen in total Ig concentrations in the controls. There was no significant difference in total Ig concentrations between T2, T3, and T6 and between T5 and T6 (Table 4, P > 0.05). In the T2 treatment compared to the control (Table 4, P <0.05), there was a significant increase in protease activity. There was no significant difference with the other groups (Table 4, P > 0.05) in the protease activity of the control group. There was no significant difference in protease activity between T3 and T5 and between T4, T5, and T6 (Table 4, P > 0.05). There was no significant difference with the other MPO activity groups in control (Table 4, P > 0.05). However, compared to T4 (Table 4, P<0.05), MPO activity was significantly lower than T2. In the T3 and T6 treatments, when compared to the controls (Table 4, P<0.05), there was a significant increase in NBT activity. There was no significant difference in NBT activity between T3 and T6 and between controls, T2, T4, and T5 (Table 4, P > 0.05). There was a significant increase in peroxidase activity in the T3 treatment compared to the control (Table 4, P <0.05). Furthermore, compared to T4 and T5 (Table 4, P<0.05), the peroxidase activity was significantly lower than that of T2. In the T2 and T3 treatments,

compared to the controls (Table 4, $P < 0.05$), there was a significant increase in C3 activity. In addition, T4 and T5 activity (Table 4, $P > 0.05$), when compared to C3 at T2, showed lower levels. Between the control and T4, T5, and T6 (Table 4, Pb>0.05), there was no significant difference in C3 activity. Although C4 training in the T3 treatment was not lower than in T4, there was no significant difference in this component between the control and other groups (Table 4, $P > 0.05$).

3.3. Mucus immune components

Protease activity showed a significant decrease. In the T4 treatment, there was a decrease in protease activity compared to T3 (Figure 1A, $P < 0.05$). There was no significant difference in protease activity with the control in the other groups (Fig. 1A, $P > 0.05$). Between all groups, there was no significant difference in lysozyme activity (Fig. 1B, $P > 0.05$). It can be seen from the ACP activity that the T2 and T3 treatments increased, significantly when compared to the control (Fig. 1C, $P > 0.05$). difference In ACP activity, there was no significant difference between control and treatment, T4, T5, and T6 (Fig. 1C, at T3, ALP activity increased significantly compared to controls (Fig. 1D, $P > 0.05$). The ALP activity with the control difference is shown in Figure 1D (Fig. 1D, $P > 0.05$).

In the T2 treatment, there was a significant increase in esterase activity compared to the control (Fig. 1E, $P > 0.05$). There was no significant difference in the esterase activity between the control and the other groups (Fig. 1E, $P > 0.05$). In addition, in the T4 treatment, the esterase activity was significantly lower when compared to T3 (Figure 1E, $P > 0.05$). A significant increase in T3 compared to the control can be seen in the antiprotease activity (Fig. 1F, $P > 0.05$). In addition, in the T2 treatment, the antiprotease activity was higher when compared to T4, T5, and T6 (Fig. 1F, $P > 0.05$).

There was no significant difference in the antiprotease activity between the control and treatment, T4, T5, and T6 (Fig. 1F, $P > 0.05$). In addition, there was no significant difference in the antiprotease activity between T4, T5, and T6 (Figure 1F, $P > 0.05$).

3.4. Serum biochemicals

There was no significant difference between the experimental groups after the feeding period, as indicated by CAT activity (Table 5, $P > 0.05$). Compared to T4, SOD activity was significantly higher in T3 (Table 5, $P < 0.05$). There was no significant difference between the control and other groups in SOD activity (Table 5, $P<0.05$). There was no significant difference in GPx activity between the control and other groups (Table 5, $P > 0.05$). In the T4, T5, and T6 treatments, compared to the control and other groups, there was a significant increase in the MDA level (Table 5, $P<0.05$).

There were no significant differences in the MDA between controls, T2 and T3, T4, T5, and T6 (Table 5, $P > 0.05$). The experimental diet affected liver metabolizing enzymes in serum (Table 6, $P < 0.05$).

In the T3 treatment, when compared to the control, there was a significant reduction in the ALT level (Table 6, $P <0.05$). There was no significant difference in the ALT level between the control and the other groups (Table 6, $P > 0.05$). There was no significant difference between the different groups' ALP and AST levels in the controls (Table 6, $P > 0.05$).

However, compared to T4, there was a significant decrease in the ALP level at T3 (Table 6, $P<0.05$). In the T2 and T3 treatments, when compared to the controls, there was a significant reduction in LDH levels (Table 6, $P > 0.05$). There was no significant difference in LDH activity between the control and other groups (Table 6, $P > 0.05$).

There was no significant difference between the experimental groups after the feeding period in total protein and globulin concentrations (Table 7, $P > 0.05$). At T3, when compared to the control, there was a significantly increased albumin level (Table 7, $P<0.05$). There was no significant difference in albumin concentrations between the control and other groups (Table 7, $P > 0.05$).

At T3, compared to the control, glucose concentration was significantly decreased (Table 7, $P <0.05$). There was no significant difference in glucose concentration with the control group (Table 7, $P > 0.05$). At T3, when compared to controls, cortisol levels decreased significantly, while at T4, there was an increase (Table 7, $P <0.05$). There was no significant difference between the controls, T5 and T6, in cortisol levels (Table 7, $P > 0.05$).

3.5. Mucus biochemicals

In treatment T3, compared to treatments T4, T5, and T6, there was a significant decrease in cortisol levels (Figure 2A, $P < 0.05$). Between the control and other groups, there was no significant difference in cortisol levels (Fig. 2A, $P < 0.05$). In the T4 treatment, when compared to T4, the glucose concentration increased significantly (Fig. 2B, $P < 0.05$). There was no significant difference in glucose concentrations between the control and other groups (Fig. 2B, $P<0.05$). There was no significant difference between the experimental groups after the feeding period in lactate concentration (Fig. 2C, $P > 0.05$)

4. Discussion

Growth performance in this study increased with 300 mg/kg of resveratrol in fish feed exposed to non-abamectin because the FW and WG values increased and the FCR in this treatment decreased compared to other groups. Curcumin was not observed for such an effect because the growth performance in the 300 mg/kg curcumin treatment was not different from the control. There are many reports on the growth-promoting effects of resveratrol and curcumin in fish [31,36,40,47,49,57,69–75]. However, fish species, level of supplementary feed, feeding duration,

and experimental conditions affect growth results and may vary. For example, the combination of resveratrol (400-800 mg/kg) and probiotics, Lactobacillus acidophilus and Bifidobacterium bifidum in the rainbow trout diet resulted in improvements in fish growth and immunity [49].

In the crucian carp Carassius auratus, which received a curcumin supplement of 5 g/kg of feed, its growth index increased, and the activity of digestive enzymes in the fish which received the supplement was a related factor [69]. Growth in the common carp, Ctenopharyngodon Idella, was boosted by curcumin at a dietary level of 438.20 mg/kg, which was associated with increased immune and antioxidant systems in fish receiving curcumin supplements [36]. Research by Ashry et al. [73] also obtained similar results, where adding 2-3% curcumin increased the growth performance of gilthead seabream and Sparus aurata. Li et al. [72] reported that the growth of fish could be encouraged by making growth and development of the intestine and the ability of the

intestine to absorb and transport amino acids increase. Curcumin can also increase feed intake in fish. It can also be increased with amino acids because of its unique taste [31,76]. Beneficial effects on turbot, Scophthalmus Maximus [47] and southern flounder, Paralichthys lethostigma [40], pacu, Piaractus mesopotamicus [71] and silverfish, Channa argus is also produced by curcumin and resveratrol [74]. Repair of intestinal damage [47], reduction of protein degradation [40], improvement of antioxidant defense [71] and lipid and glucose metabolism all have the effects of resveratrol boosting on fish growth [77]. In this study, fish exposed to abamectin-free supplementation were the same as those in previous studies, namely reduced growth [78,79]. Reduced food intake, suppressed digestive enzymes and growth hormone, induction of intestinal tissue damage accompanied by impaired digestion and absorption of nutrients, and impaired liver function makes fish growth reduced in the presence of pesticides, including abamectin [55,80-87]. FW showed a higher FW value in the fish in this study resulting in the 300 mg/kg curcumin treatment compared to the 300 mg/kg curcumin 12.5% LC50 abamectin treatment. Not only that, no differences in FW, FCR and WG between control and treated fish, resveratrol abamectin and curcumin abamectin were observed, which allows suggestions of a remedial function for supplementation on the growth inhibitory effect of abamectin..

Immune components in the blood (lysozyme, C3, ACH50, total Ig, protease, MPO, NBT, peroXidase, albumin) and mucus (ACP, ALP, esterase, antiprotease) and antioxidant enzymes (SOD, GPX) in this study several changes can be seen when compared to the control group, however, in fish that received curcumin and resveratrol in abamectin-free media, almost all of these components were higher than the control and other groups. Several studies also concur with our study in that they have found immune-stimulating effects of curcumin and resveratrol in fish [33,35, 38,44,74,88-91]. Studies in other vertebrates show that their involvement in the system may occur by influencing cytokine production and modulating the inflammatory response. However, the mechanism of action of curcumin and resveratrol in fish is unknown. [92–94].

Oxidative stress can cause free radicals in fish which the presence of an antioxidant system can fight as the first step of resistance. In this study, oxidative stress in the fish was stimulated by abamectin because indicators of oxidative stress in MDA levels showed a significant increase in exposed fish. Scavenging effects on free radicals acquired in oxidative stress are known to exist in curcumin and resveratrol [95-97]. It has also been reported that fish have this scavenging function [45,98,99]. Thus, the immune system can be strengthened with these two supplements. However, it seems that oxidative stress can be prevented effectively by both curcumin and resveratrol because the treatment got lower MDA levels; curcumin and resveratrol complemented the control and unexposed fish when compared to only abamectin and abamectin supplements.

Significant differences between groups were not shown by the levels of immune components and antioxidants in the controls in this study; an indication of the moderate action of these supplements on the immunotoxic effects of abamectin may well be seen from abamectin's resveratrol and abamectin's curcumin.

Liver disorders and damage are generally indicated by several causes, such as elevated blood levels of hepatic metabolic enzymes (LME), although this is not necessarily a specific symptom [100,101]. In fish, elevated blood LME levels have been found after exposure to contaminants, especially pesticides, which are associated with liver damage due to toxins [102-104]. There was no significant difference in LME levels in the blood of the control group and the abamectin-exposed group in our study, which could indicate a non-significant effect of the pesticide at a dose of 12.5% LC50 on the liver. A significant reduction was shown in fish exposed to non-abamectin, levels of ALT, LDH and ALP in fish that received resveratrol supplements and LDH in fish that received curcumin supplements compared to controls, which allows the protective role of the supplement to be seen with the liver. Cortisol is the most important stress hormone; secretion is carried out into the bloodstream in response to stressors and separates glycogen in the liver so that glucose can be produced and energy needs in stressful situations can be provided [105]. In the present study, there was an increase in cortisol levels in non-supplemented fish after exposure to abamectin; the stress-inducing effect of the pesticide was apparent in this, as previously reported concerning other pesticides in fish [106-110]. Our results showed a significant decrease in non-exposed fish supplemented with acortisol and glucose levels, suggesting a stress-mitigating effect for resveratrol. Not only that, the glucose and cortisol levels in control were the same as those in resveratrol abamectin and curcumin abamectin, which strengthened this mitigating effect.

5. Conclusion

It can be concluded that the growth and immunity of carp can be decreased in the presence of abamectin. Resveratrol is more effective than curcumin, although both can reduce the disturbances brought on by abamectin. Abamectin did not significantly affect the survival rate of fish even though the growth and immunity in the treatment without supplements were reduced.

5. References

A Santos, J., SG de Carvaho, G., Oliveira, V., RB Raposo, N., & D da Silva, A. (2013). Resveratrol and analogues: a review of antioxidant activity and applications to human health. Recent patents on food, nutrition & agriculture, 5(2), 144-153.

Abdel-Daim, M. M., Eissa, I. A., Abdeen, A., Abdel-Latif, H. M., Ismail, M., Dawood, M. A., & Hassan, A. M. (2019). Lycopene and resveratrol ameliorate zinc oxide nanoparticles-induced oxidative stress in Nile tilapia, Oreochromis niloticus. Environmental Toxicology and Pharmacology, 69, 44-50.

Abdelhamid, F. M., Elshopakey, G. E., & Aziza, A. E. (2020). Ameliorative effects of dietary Chlorella vulgaris and β-glucan against diazinon-induced toxicity in Nile tilapia (Oreochromis niloticus). Fish & Shellfish Immunology, 96, 213-222.

Abdel-Tawwab, M., Eissa, E. S. H., Tawfik, W. A., Abd Elnabi, H. E., Saadony, S., Bazina, W. K., & Ahmed, R. A. (2022). Dietary curcumin nanoparticles promoted the performance, antioxidant activity, and humoral immunity, and modulated the hepatic and intestinal histology of Nile tilapia fingerlings. Fish Physiology and Biochemistry, 1-17.

Abdel-Tawwab, M., Eissa, E. S. H., Tawfik, W. A., Abd Elnabi, H. E., Saadony, S., Bazina, W. K., & Ahmed, R. A. (2022). Dietary curcumin nanoparticles promoted the performance, antioxidant activity, and humoral immunity, and modulated the hepatic and intestinal histology of Nile tilapia fingerlings. Fish Physiology and Biochemistry, 1-17.

Adeyemi, J. A., Olise, C. C., Bamidele, O. S., & Akinola, B. K. (2020). Effects of ultraviolet photooxidation of cypermethrin on the activities of phosphatases and digestive enzymes, and intestinal histopathology in African catfish, Clarias gariepinus (Burchell, 1822). Journal of Experimental Zoology Part A: Ecological and Integrative Physiology, 333(8), 454 543-549.

Ajdari, A., Ghafarifarsani, H., Hoseinifar, S. H., Javahery, S., Narimanizad, F., Gatphayak, K., & Van Doan, H. (2022). Effects of Dietary Supplementation of PrimaLac, Inulin, and Biomin Imbo on Growth Performance, Antioxidant, and Innate Immune Responses of Common Carp (Cyprinus carpio). Aquaculture Nutrition, 2022.

Alagawany, M., Farag, M. R., Abdelnour, S. A., Dawood, M. A. O., Elnesr, S. S., & Dhama, K. (2021). Curcumin and its different forms: A review on fish nutrition. Aquaculture, 532, 736030

Aldegunde, M., Soengas, J. L., Ruibal, C., & Andrés, M. D. (1999). Effects of chronic exposure to γ-HCH (lindane) on brain serotonergic and gabaergic systems, and serum cortisol and thyroxine levels of rainbow trout, Oncorhynchus mykiss. Fish Physiology and Biochemistry, 20(4), 325-330.

Al-Kahtani, M. A. (2011). Effect of an insecticide abamectin on some biochemical characteristics of tilapia fish (Oreochromis niloticus). American Journal of Agricultural and Biological Sciences, 6(1), 62-68.

Ammon, H. P., & Wahl, M. A. (1991). Pharmacology of Curcuma longa. Planta medica, 57(01), 1-7.

Anderson, D.P., & Siwicki, A. K. (1995). Basic haematology and serology for fish healthprograms. In: Shariff, M., Arthur, J. R., Subasinghe, R. P. (Eds.), Diseases in Asianaquaculture II. Fish Health Section, Asian Fisheries Society, Manila, Philippines, 185–202

Araujo, C. A. C., & Leon, L. L. (2001). Biological activities of Curcuma longa L. Memórias do Instituto Oswaldo Cruz, 96(5), 723-728.

Asha Devi, R. (2015). The Impact of Pesticide (Nuvon) On Feeding, Digestive Enzyme Activity and Body Composition of Oreochromis mossambicus (Peters). Survival, 5(04.75), 4-65.

Ashry, A. M., Hassan, A. M., Habiba, M. M., El-Zayat, A., El-Sharnouby, M. E., Sewilam, H., & Dawood, M. A. (2021). The impact of dietary curcumin on the growth performance, intestinal antibacterial capacity, and haemato-biochemical parameters of gilthead seabream (Sparus aurata). Animals, 11(6), 1779.

Asouri, M., Ataee, R., Ahmadi, A. A., Amini, A., & Moshaei, M. R. (2013). Antioxidant and free radical scavenging activities of curcumin. Asian Journal of Chemistry, 25(13), 7593-5.

Awad, E., & Awaad, A. (2017). Role of medicinal plants on growth performance and immune status in fish. Fish & Shellfish Immunology, 67, 40-54.

Baldissera, M. D., Souza, C. F., Zeppenfeld, C. C., Descovi, S., Machado, V. S., Santos, R. C., & Baldisserotto, B. (2018). Efficacy of dietary curcumin supplementation as bactericidal for silver catfish against Streptococcus agalactiae. Microbial pathogenesis, 116, 237-240.

Banaei, M., Sureda, A., Shahaf, S., & Fazilat, N. (2015). Protective effects of silymarin extract on malthion-induced zebra cichlid (Cichlasoma nigrofasciatum) hepatotoxicity. Iranian Journal of Toxicology, 1239-1246.

Banez, M. J., Geluz, M. I., Chandra, A., Hamdan, T., Biswas, O. S., Bryan, N. S., & Von Schwarz, E. R. (2020). A systemic review on the antioxidant and anti-inflammatory effects of resveratrol, curcumin, and dietary nitric oxide supplementation on human cardiovascular health. Nutrition Research, 78, 11-26.

Braunbeck, T., & Appelbaum, S. (1999). Ultrastructural alterations in the liver and intestine of carp Cyprinus carpio induced orally by ultra-low doses of endosulfan. Diseases of aquatic organisms, 36(3), 183-200.

Canli, E. G., Dogan, A., & Canli, M. (2018). Serum biomarker levels alter following nanoparticle (Al_2O_3, CuO, TiO_2) exposures in freshwater fish (Oreochromis niloticus). Environmental toxicology and pharmacology, 62, 181-187.

Castillo, L. E., de la Cruz, E., & Ruepert, C. (1997). Ecotoxicology and pesticides in tropical aquatic ecosystems of Central America. Environmental Toxicology and Chemistry: An International Journal, 16(1), 41-51.

Colica, C., Milanović, M., Milić, N., Aiello, V., De Lorenzo, A., & Abenavoli, L. (2018). A systematic review on natural antioxidant properties of resveratrol. Natural product 507 communications, 13(9), 1934578X1801300923.

Duce, I. R., Bhandal, N. S., Scott, R. H., & Norris, T. M. (1995). Effects of ivermectin on γ-aminobutyric acid and glutamate-gated chloride conductance in arthropod skeletal muscle. Molecular Action of Insecticides on Ion Channels, 251-263

Dügenci, S. K., Arda, N., & Candan, A. (2003). Some medicinal plants as immunostimulant for fish. Journal of ethnopharmacology, 88(1), 99-106.

Ellis, A. I. (1990). Lysozyme assays. Techniques in fish immunology, 1, 101-103.

El-Shazly, H. A., El-Tawil, H. S., & Hammam, M. G. (2011). Utilization of turmeric as a natural pigment in ras cheese. Journal of Food and Dairy Sciences, 2(2), 91-100.

Falchetti, R., Fuggetta, M. P., Lanzilli, G., Tricarico, M., & Ravagnan, G. (2001). Effects of resveratrol on human immune cell function. Life sciences, 70(1), 81-96.

Farag, M. R., Alagawany, M., Khalil, S. R., Abd El-Aziz, R. M., Zaglool, A. W., Moselhy, A. A., & Abou-Zeid, S. M. (2022). Effect of parsley essential oil on digestive enzymes, intestinal morphometry, blood chemistry and stress-related genes in liver of Nile tilapia fish exposed to Bifenthrin. Aquaculture, 546, 737322.

Farsani, M. N., Hoseinifar, S. H., Rashidian, G., Farsani, H. G., Ashouri, G., & Van Doan, H. (2019). Dietary effects of Coriandrum sativum extract on growth performance, physiological and innate immune responses and resistance of rainbow trout (Oncorhynchus mykiss) against Yersinia ruckeri. Fish & shellfish immunology, 91, 233-240.

Fathy, M., Mohamed, I. A., Farghal, A. I., Temerak, S. A., & Sayed, A. E. D. H. (2019). Hemotoxic effects of some herbicides on juvenileof Nile tilapia Oreochromis niloticus. Environmental Science and Pollution Research, 26(30), 30857-30865.

Fırat, Ö., Cogun, H. Y., Yüzereroğlu, T. A., Gök, G., Fırat, Ö., Kargin, F., & Kötemen, Y. (2011). A comparative study on the effects of a pesticide (cypermethrin) and two metals (copper, lead) to serum biochemistry of Nile tilapia, Oreochromis niloticus. Fish Physiology and 532 Biochemistry, 37(3), 657-666.

Fleeger, J. W., Carman, K. R., & Nisbet, R. M. (2003). Indirect effects of contaminants in aquatic ecosystems. Science of the total environment, 317(1-3), 207-233.

Forouhar Vajargah, M., Ghafari Farsani, H., Gerami, M. H., Hedayati, S. A., & Nezhadheydari, H. (2017). Effects of the prebiotic in reducing histopathological changes and

immune response of Cyprinus carpio after exposer to abamectin. Iranian Journal of Toxicology, 11(6), 21-26.

Garen, A., & Levinthal, C. (1960). A fine-structure genetic and chemical study of the enzyme alkaline phosphatase of E. coli I. Purification and characterization of alkaline phosphatase. Biochimica et biophysica acta, 38, 470-483

Ghafarifarsani, H., Hoseinifar, S. H., Javahery, S., & Van Doan, H. (2022). Effects of dietary vitamin C, thyme essential oil, and quercetin on the immunological and antioxidant status of common carp (Cyprinus carpio). Aquaculture, 553, 738053.

Ghasemzadeh, J., Sinaei, M., & Bolouki, M. (2015). Biochemical and histological changes in fish, spotted scat (Scatophagus argus) exposed to diazinon. Bulletin of environmental contamination and toxicology, 94(2), 164-170.

Ghelichpour, M., Mirghaed, A. T., Hoseini, S. M., & Jimenez, A. P. (2020). Plasma antioxidant and hepatic enzymes activity, thyroid hormones alterations and health status of liver tissue in common carp (Cyprinus carpio) exposed to lufenuron. Aquaculture, 516, 734634.

Giordo, R., Nasrallah, G. K., Al-Jamal, O., Paliogiannis, P., & Pintus, G. (2020). Resveratrol inhibits oxidative stress and prevents mitochondrial damage induced by zinc oxide nanoparticles in zebrafish (Danio rerio). International journal of molecular sciences, 21(11), 3838.

Goth, L. (1991). A simple method for determination of serum catalase activity and revision of reference range. Clinica Chimica Acta, 196(2–3), 143–151.

Gu, T., Wang, N., Wu, T., Ge, Q., & Chen, L. (2021). Antioxidative stress mechanisms behind resveratrol: A multidimensional analysis. Journal of Food Quality, 2021.

Guardiola, F. A., Cuartero, M., del Mar Collado-González, M., Baños, F. G. D., Cuesta, A., Moriñigo, M. Á., & Esteban, M. Á. (2017). Terminal carbohydrates abundance, immune related enzymes, bactericidal activity and physico-chemical parameters of the Senegalese sole (Solea senegalensis, Kaup) skin mucus. Fish & shellfish immunology, 60, 483-491.

Hajirezaee, S., Mirvaghefi, A. R., Farahmand, H., & Agh, N. (2016). Effects of diazinon on adaptation to sea-water by the endangered Persian sturgeon, Acipenser persicus, fingerlings. Ecotoxicology and environmental safety, 133, 413-423.

Hajirezaee, S., Rafieepour, A., Shafiei, S., & Rahimi, R. (2019). Immunostimulating effects of Ginkgo biloba extract against toxicity induced by organophosphate pesticide, diazinon in rainbow trout, Oncorhynchus mykiss: innate immunity components and immune-related genes. Environmental Science and Pollution Research, 26(9), 8798-8807.

Helfrich, L. A., Weigmann, D. L., Hipkins, P. A., & Stinson, E. R. (2009). Pesticides and aquatic animals: a guide to reducing impacts on aquatic systems.

Hill, I. R., Shaw, J. L., & Maund, S. J. (2018). Review of aquatic field tests with pyrethroid insecticides. In Freshwater field tests for hazard assessment of chemicals, 249-272

Hong, Y., Huang, Y., Yang, X., Zhang, J., Li, L., Huang, Q., & Huang, Z. (2020). Abamectin at environmentally-realistic concentrations cause oxidative stress and genotoxic damage in juvenile fish (Schizothorax prenanti). Aquatic Toxicology, 225, 105528.

Hoseinifar, S. H., Zoheiri, F., & Lazado, C. C. (2016). Dietary phytoimmunostimulant Persian hogweed (Heracleum persicum) has more remarkable impacts on skin mucus than on serum in common carp (Cyprinus carpio). Fish & shellfish immunology, 59, 77-82.

Jia, E., Yan, Y., Zhou, M., Li, X., Jiang, G., Liu, W., & Zhang, D. (2019a). Combined effects of dietary quercetin and resveratrol on growth performance, antioxidant capability and innate immunity of blunt snout bream (Megalobrama amblycephala). Animal Feed Science and
583 Technology, 256, 114268.

Jia, R., Li, Y., Cao, L., Du, J., Zheng, T., Qian, H., ... & Yin, G. (2019b). Antioxidative, anti-inflammatory and hepatoprotective effects of resveratrol on oxidative stress-induced liver damage in tilapia (Oreochromis niloticus). Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 215, 56-66.

Jiang, J., Wu, X. Y., Zhou, X. Q., Feng, L., Liu, Y., Jiang, W. D., ... & Zhao, Y. (2016). Effects of dietary curcumin supplementation on growth performance, intestinal digestive enzyme activities and antioxidant capacity of crucian carp Carassius auratus. Aquaculture, 463, 174-180.

Katuli, K. K., Amiri, B. M., Massarsky, A., & Yelghi, S. (2014). Impact of a short-term diazinon exposure on the osmoregulation potentiality of Caspian roach (Rutilus rutilus) fingerlings. Chemosphere, 108, 396-404.

Kestemont, P., & Baras, E. (2001). Environmental factors and feed intake: mechanisms and interactions. Food intake in fish, 131-156.

Korkmaz, N., & Örün, İ. (2022). Effects of pesticide NeemAzal-T/S on thyroid, stress hormone and some cytokines levels in freshwater common carp, Cyprinus carpio L. Toxin 598 Reviews, 41(2), 496-505.

599 Kowalska, A., & Małaczewska, J. (2020). Effect of dietary resveratrol on cell-mediated 600 immunity and hepatocyte morphometry in the model organism medaka (Oryzias latipes Temminck 601 & Schlegel). Fisheries & Aquatic Life, 28(1). 19.

602 Kowalska, A., Siwicki, A. K., & Kowalski, R. K. (2017). Dietary resveratrol improves 603 immunity but reduces reproduction of broodstock medaka Oryzias latipes (Temminck & 604 Schlegel). Fish physiology and biochemistry, 43(1), 27-37.
605 Kushwaha, S., Anerao, I., Rajput, S., Bhagriya, P., & Roy, H. (2020). Evaluation of
606 abamectin induced hepatotoxicity in Oreochromis mossambicus. Cogent Biology, 6(1), 1761277.

607 Leonard, S. S., Xia, C., Jiang, B. H., Stinefelt, B., Klandorf, H., Harris, G. K., & Shi, X. 608 (2003). Resveratrol scavenges reactive oxygen species and effects radical-induced cellular 609 responses. Biochemical and biophysical research communications, 309(4), 1017-1026.

610 Li, G., Zhou, X., Jiang, W., Wu, P., Liu, Y., Jiang, J., ... & Feng, L. (2020). Dietary 611 curcumin supplementation enhanced growth performance, intestinal digestion, and absorption and 612 amino acid transportation abilities in on-growing grass carp (Ctenopharyngodon 613 idella). Aquaculture Research, 51(12), 4863-4873.

614 Li, M., Kong, Y., Wu, X., Guo, G., Sun, L., Lai, Y., ... & Wang, G. (2022). Effects of
615 dietary curcumin on growth performance, lipopolysaccharide-induced immune responses,

616 oxidative stress and cell apoptosis in snakehead fish (Channa argus). Aquaculture Reports, 22,
617 100981.

618 Mahmoud, H. K., Al-Sagheer, A. A., Reda, F. M., Mahgoub, S. A., & Ayyat, M. S. (2017). 619 Dietary curcumin supplement influence on growth, immunity, antioxidant status, and resistance to 620 Aeromonas hydrophila in Oreochromis niloticus. Aquaculture, 475, 16-23.

621 Mahmoud, E. A., El-Sayed, B. M., Mahsoub, Y. H., & Neamat-Allah, A. N. (2020). Effect 622 of Chlorella vulgaris enriched diet on growth performance, hemato-immunological responses, 623 antioxidant and transcriptomics profile disorders caused by deltamethrin toxicity in Nile tilapia 624 (Oreochromis niloticus). Fish & shellfish immunology, 102, 422-429.

625 Mahmoud, H. K., Reda, F. M., Alagawany, M., & Farag, M. R. (2021). The stress of 626 abamectin toxicity reduced water quality, growth performance, immunity and antioxidant capacity 627 of Oreochromis niloticus fish: Modulatory role of Simmondsia chinensis extract as a dietary 628 supplement. Aquaculture, 534, 736247.

629 Malaguarnera, L. (2019). Influence of resveratrol on the immune
630 response. Nutrients, 11(5), 946.

631 Maltby, L., Blake, N., Brock, T. C., & Van den Brink, P. J. (2005). Insecticide species 632 sensitivity distributions: importance of test species selection and relevance to aquatic 633 ecosystems. Environmental Toxicology and Chemistry: An International Journal, 24(2), 379-388.

634 Ming, J., Ye, J., Zhang, Y., Xu, Q., Yang, X., Shao, X., ... & Xu, P. (2020). Optimal dietary 635 curcumin improved growth performance, and modulated innate immunity, antioxidant capacity 636 and related genes expression of NF-κB and Nrf2 signaling pathways in grass carp 637 (Ctenopharyngodon idella) after infection with Aeromonas hydrophila. Fish & shellfish 638 immunology, 97, 540-553.

639 Mirvaghefi, A., Mohsen, A. L. İ., & Poorbagher, H. (2016). Effects of vitamin C on 640 oxidative stress parameters in rainbow trout exposed to diazinon. Ege Journal of Fisheries and 641 Aquatic Sciences, 33(2), 113-120.

642 Murthy, K. S., Kiran, B. R., & Venkateshwarlu, M. (2013). A review on toxicity of
643 pesticides in Fish. International Journal of Open Scientific Research, 1(1), 15-36.

644 Naderi Farsani, M., Meshkini, S., & Manaffar, R. (2021). Growth performance, immune 645 response, antioxidant capacity and disease resistance against Yersinia ruckeri in rainbow trout 646 (Oncorhynchus mykiss) as influenced through singular or combined consumption of resveratrol 647 and two-strain probiotics. Aquaculture Nutrition, 27(6), 2587-2599.
648 Naiel, M. A., Ismael, N. E., Abd El-hameed, S. A., & Amer, M. S. (2020). The 649 antioxidative and immunity roles of chitosan nanoparticle and vitamin C-supplemented diets 650 against imidacloprid toxicity on Oreochromis niloticus. Aquaculture, 523, 735219.
651 Narra, M. R., Rajender, K., Reddy, R. R., Rao, J. V., & Begum, G. (2015). The role of 652 vitamin C as antioxidant in protection of biochemical and haematological stress induced by 653 chlorpyrifos in freshwater fish Clarias batrachus. Chemosphere, 132, 172-178.
654 Neamat-Allah, A. N., Abd El Hakim, Y., & Mahmoud, E. A. (2020). Alleviating effects of 655 β-glucan in Oreochromis niloticus on growth performance, immune reactions, antioxidant, 656 transcriptomics disorders and resistance to Aeromonas sobria caused by atrazine. Aquaculture 657 Research, 51(5), 1801-1812.
658 Neamat-Allah, A. N., Mahmoud, E. A., & Mahsoub, Y. (2021a). Effects of dietary white 659 mulberry leaves on hemato-biochemical alterations, immunosuppression and oxidative stress 660 induced by Aeromonas hydrophila in Oreochromis niloticus. Fish & Shellfish Immunology, 108, 661 147-156.
662 Neamat-Allah, A. N., Mahsoub, Y. H., & Mahmoud, E. A. (2021b). The potential benefits 663 of dietary β-glucan against growth retardation, immunosuppression, oxidative stress and 664 expression of related genes and susceptibility to Aeromonas hydrophila challenge in Oreochromis 665 niloticus induced by herbicide pendimethalin. Aquaculture Research, 52(2), 518-528.
666 Nicolopoulou-Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., & Hens, L. (2016). 667 Chemical pesticides and human health: the urgent need for a new concept in agriculture. Frontiers 668 in public health, 4, 148.

669 Novelli, A., Vieira, B. H., Braun, A. S., Mendes, L. B., Daam, M. A., & Espíndola, E. L. 670 G. (2016). Impact of runoff water from an experimental agricultural field applied with Vertimec® 671 18EC (abamectin) on the survival, growth and gill morphology of zebrafish 672 juveniles. Chemosphere, 144, 1408-1414.

OECD. (1994). OECD Guidelines for the Testing of Chemicals: Organization for Economic.

Omura, S. (2008). Ivermectin: 25 years and still going strong. International journal of antimicrobial agents, 31(2), 91-98.

Pandya, P., Upadhyay, A., Thakkar, B., & Parikh, P. (2018). Evaluating the toxicological 678 effects of agrochemicals on glucocorticoid receptor and serum cortisol level in Mozambique 679 tilapia. Cogent Biology, 4(1), 1480338.

680 Pirani, F., Moradi, S., Ashouri, S., Johari, S. A., Ghaderi, E., Kim, H. P., & Yu, I. J. (2021). 681 Dietary supplementation with curcumin nanomicelles, curcumin, and turmeric affects growth 682 performance and silver nanoparticle toxicity in Cyprinus carpio. Environmental Science and 683 Pollution Research, 28(45), 64706-64718.

684 Quade, M. J., & Roth, J. A. (1997). A rapid, direct assay to measure degranulation of 685 bovine neutrophil primary granules. Veterinary immunology and immunopathology, 58(3-4), 239- 686 248.

687 Rabie, M., Asri, Y., & Ahmadi, K. (2016). Effect of Milk thistle plant, Vitis vinifera extract 688 on immune system of rainbow trout (Oncorhynchus mykiss) challenge by diazinon. International 689 journal of aquatic biology, 4(3), 208-214.

690 Rafieepour, A., Hajirezaee, S., & Rahimi, R. (2019). Dietary oregano extract (Origanum 691 vulgare L.) enhances the antioxidant defence in rainbow trout, Oncorhynchus mykiss against 692 toxicity induced by organophosphorus pesticide, diazinon. Toxin Reviews.

693 Rajabiesterabadi, H., Ghelichi, A., Jorjani, S., Hoseini, S. M., & Akrami, R. (2020). Dietary 694 olive (Olea europaea) leaf extract suppresses oxidative stress and modulates intestinal expression 695 of antioxidant-and tight junction-related genes in common carp (Cyprinus 696 carpio). Aquaculture, 520, 734676.

697 Rajmohan, K. S., Chandrasekaran, R., & Varjani, S. (2020). A review on occurrence of 698 pesticides in environment and current technologies for their remediation and management. Indian 699 Journal of Microbiology, 60(2), 125-138.
700 Ross, N. W., Firth, K. J., Wang, A., Burka, J. F., & Johnson, S. C. (2000). Changes in 701 hydrolytic enzyme activities of naive Atlantic salmon Salmo salar skin mucus due to infection 702 with the salmon louse Lepeophtheirus salmonis and cortisol implantation. Diseases of Aquatic 703 Organisms, 41(1), 43–51.
704 Salomão, R. A. S., De Paula, T. G., Zanella, B. T. T., Carvalho, P. L. P. F., da Silva Duran, 705 B. O., Valente, J. S., ... & Dal-Pai-Silva, M. (2019). The combination of resveratrol and exercise 706 enhances muscle growth characteristics in pacu (Piaractus mesopotamicus). Comparative 707 Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 235, 46-55.
708 Shi, H. J., Xu, C., Liu, M. Y., Wang, B. K., Liu, W. B., Chen, D. H., ... & Li, X. F. (2018).
709 Resveratrol improves the energy sensing and glycolipid metabolism of blunt snout bream 710 Megalobrama amblycephala fed high-carbohydrate diets by activating the AMPK–SIRT1–PGC- 711 1α network. Frontiers in physiology, 1258.

712 Simon, L. M., Laszlo, K., Kotorman, M., Vertesi, A., Bagi, K., & Nemcsok, J. (1999). 713 Effects of synthetic pyrethroids and methidation on activities of some digestive enzymes in carp 714 (Cyprinus carpio L.). Journal of Environmental Science & Health Part B, 34(5), 819-828.

715 Smith, N. C., Christian, S. L., Taylor, R. G., Santander, J., & Rise, M. L. (2018). Immune 716 modulatory properties of 6-gingerol and resveratrol in Atlantic salmon macrophages. Molecular 717 immunology, 95, 10-

718 Stohs, S. J., Chen, O., Ray, S. D., Ji, J., Bucci, L. R., & Preuss, H. G. (2020). Highly 719 bioavailable forms of curcumin and promising avenues for curcumin-based research and 720 application: A review. Molecules, 25, 1397.

721 Taheri Mirghaed, A., Fayaz, S., & Hoseini, S. M. (2019). Dietary 1, 8-cineole affects serum 722 enzymatic activities and immunological characteristics in common carp (Cyprinus carpio) 723 exposed to ambient ammonia. Aquaculture Research, 50(1), 146-153.

724 Tan, C., Zhou, H., Wang, X., Mai, K., & He, G. (2019). Resveratrol attenuates oxidative 725 stress and inflammatory response in turbot fed with soybean meal based diet. Fish & shellfish 726 immunology, 91, 130-135.
727 Tian, J., Han, G., Li, Y., Zhao, L., & Wang, G. (2021). Effects of resveratrol on growth, 728 antioxidative status and immune response of snakehead fish (Channa argus). Aquaculture 729 Nutrition, 27(5), 1472-1481.
730 Tiwari, P., Kushwaha, S. S., Singh, A., & Tiwari, P. (2020). Herbs in Oral Precancerous 731 Lesions and Conditions. Journal of Advanced Medical and Dental Sciences Research, 8(8), 21- 732 25.
733 Torno, C., Staats, S., de Pascual-Teresa, S., Rimbach, G., & Schulz, C. (2019). Effects of 734 resveratrol and genistein on growth, nutrient utilization and fatty acid composition of rainbow 735 trout. Animal, 13(5), 933-940.
736 Vajargah, M. F., Mohsenpour, R., Yalsuyi, A. M., Galangash, M. M., & Faggio, C. (2021). 737 Evaluation of histopathological effect of roach (Rutilus rutilus caspicus) in exposure to sub-lethal 738 concentrations of Abamectin. Water, Air, & Soil Pollution, 232(5), 1-8.
739 Verma, R. K., Kumari, P., Maurya, R. K., Kumar, V., Verma, R. B., & Singh, R. K. (2018). 740 Medicinal properties of turmeric (Curcuma longa L.): A review. International journal of chemical 741 studies, 6(4), 1354-1357.

742 Vijayan, M. M., Aluru, N., & Leatherland, J. F. (2010). Stress response and the role of
743 cortisol. Fish diseases and disorders, 2, 182-201.

744 Wilson, W. N., Baumgarner, B. L., Watanabe, W. O., Alam, M. S., & Kinsey, S. T. (2015). 745 Effects of resveratrol on growth and skeletal muscle physiology of juvenile southern 746 flounder. Comparative Biochemistry and Physiology Part A: Molecular & Integrative 747 Physiology, 183, 27-35.
748 Xavier, M. J., Navarro-Guillén, C., Lopes, A., Colen, R., Teodosio, R., Mendes, R., ... & 749 Engrola, S. (2022). Effects of dietary curcumin in growth performance, oxidative status and gut 750 morphometry and function of gilthead seabream postlarvae. Aquaculture Reports, 24, 101128.

751 Xia, S. L., Ge, X. P., Liu, B., Xie, J., Miao, L. H., Ren, M. C., ... & Pan, L. K. (2015).
752 Effects of supplemented dietary curcumin on growth and non-specific immune responses in 753 juvenile wuchang bream (Megalobrama amblycephala). The Israeli Journal of Aquaculture- 754 Bamidgeh.

755 Xing, H., Li, S., Wang, Z., Gao, X., Xu, S., & Wang, X. (2012). Oxidative stress response 756 and histopathological changes due to atrazine and chlorpyrifos exposure in common 757 carp. Pesticide biochemistry and physiology, 103(1), 74-80.

758 Xu, M., Lian, Z., Chen, X., Yao, X., Lu, C., Niu, X., ... & Zhu, Q. (2021). Effects of 759 resveratrol on lipid and protein co-oxidation in fish oil-enriched whey protein isolate 760 emulsions. Food Chemistry, 365, 130525.

761 Yadav, V. S., Mishra, K. P., Singh, D. P., Mehrotra, S., & Singh, V. K. (2005). 762 Immunomodulatory effects of curcumin. Immunopharmacology and immunotoxicology, 27(3), 763 485-497.

764 Yan, Y., Xia, S., Tian, H., Xu, C., Jia, E., Liu, W., & Zhang, D. (2017). Effects of 765 Resveratrol supplementation on growth performance, immunity, antioxidant capability and disease 766 resistance of blunt snout bream fed high-fat diet. Acta Hydrobiologica Sinica, 41(1), 155-164.
767 Yang, G., Yu, R., Qiu, H., Wu, H., Yan, Q., Chen, W., ... & Peng, M. (2020). Beneficial 768 effects of emodin and curcumin supplementation on antioxidant defence response, inflammatory 769 response and intestinal barrier of Pengze crucian carp (Carassius auratus var. 770 Pengze). Aquaculture Nutrition, 26(6), 1958-1969.
771 Yano, T. (1992). Assays of hemolytic complement activity. Techniques in fish
772 immunology, 131-141.
773 Yonar, M. E., Yonar, S. M., İspir, Ü., & Ural, M. Ş. (2019). Effects of curcumin on 774 haematological values, immunity, antioxidant status and resistance of rainbow trout 775 (Oncorhynchus mykiss) against Aeromonas salmonicida subsp. achromogenes. Fish & shellfish 776 immunology, 89, 83-90.

777 Yousefi, M., Vatnikov, Y. A., Kulikov, E. V., Plushikov, V. G., Drukovsky, S. G., 778 Hoseinifar, S. H., & Van Doan, H. (2020). The protective effects of dietary garlic on common carp 779 (Cyprinus carpio) exposed to ambient ammonia toxicity. Aquaculture, 526, 735400.
780 Yonar, M. E., Yonar, S. M., ˙Ispir, Ü., & Ural, M. S. (2019). Effects of curcumin on 781 haematological values, immunity, antioxidant status and resistance of rainbow trout 782 (Oncorhynchus mykiss) against Aeromonas salmonicida subsp. Achromogenes. Fish & Shellfish 783 Immunology, 89, 83–90
784 Yousefi, M., Ghafarifarsani, H., Hoseinifar, S. H., Rashidian, G., & Van Doan, H. (2021). 785 Effects of dietary marjoram, Origanum majorana extract on growth performance, hematological, 786 antioxidant, humoral and mucosal immune responses, and resistance of common carp, Cyprinus 787 carpio against Aeromonas hydrophila. Fish & Shellfish Immunology, 108, 127-133.
788 Zhang, D., Yan, Y., Tian, H., Jiang, G., Li, X., & Liu, W. (2018). Resveratrol 789 supplementation improves lipid and glucose metabolism in high-fat diet-fed blunt snout 790 bream. Fish physiology and biochemistry, 44(1), 163-173.
791

792 Table 1. Feedstuffs and compositions of the basal diet.
793

Ingredients	g/kg	Proximate composition	% in dry basis
Fishmeala	160	Crude protein	393
Soybean meal b	170	Crude lipid	88.7
Wheat flour (Res or cur)	381	ash	62.1
Poultry mealc	150	Dry matter	908
Wheat glutend	100		
Phytasee	5		
Fish oil	10		
Lysine f	6		
Soybean oil	10		
Methioninef	3		
Mineral mixg	2.5		
Vitamin mixh	2.5		
Total	1000		

794 a Peygir Co (crude protein 55.8 %). 795 b Soyabean Co (crude protein 45.5 %). 796 c Peygir Co (crude protein 50.0 %).
d Shahdineh Aran Co (crude protein 78.3 %).
e CheilJedang Co.
f Golbid Co (10,000 IU).
g The premix provided following amounts per kg of diet: Mg: 350 mg; Fe:
13 mg; Co: 2.5 mg; Cu: 3 mg; Zn: 60 mg; NaCl: 3 g; dicalcium phosphate:
802 10 g.
803 h The premix provided following amounts per kg of feed: A: 1,000 IU;
804 D3: 5,000 IU; E: 20 mg; B5: 100 mg; B2: 20 mg; B6: 20 mg; B1: 20 mg;
805 H: 1 mg; B9: 6 mg; B12: 1 mg; B4: 600 mg; C: 50 mg
806
807
808 Table 2. Lethal Concentrations (LC10-90) of Abamectin depending on time (24-96h) for Cyprinus
809 carpio (mean ± SE) Point Concentration (ppm) (95 % of confidence limits)

	24h	48h	72h	96h
LC_{10}	0.95 ± 0.38	0.84 ± 0.33	0.70 ± 0.33	0.62 ± 0.41
LC_{30}	1.24 ± 0.38	1.15 ± 0. 33	1.01 ± 0.33	0.87 ± 0.41
LC_{50}	**1.45 ± 0.38**	**1.37 ± 0**. 33	**1.22 ± 0.33**	**1.04 ± 0.41**
LC_{70}	1.65 ± 0.38	1.59 ± 0. 33	1.43 ± 0.33	1.22 ± 0.41
LC_{90}	1.95 ± 0.38	1.91 ± 0. 33	1.74 ± 0.33	1.47 ± 0.41

810

811

812 Table 3. The growth and survival of the common carp, Cyprinus carpio over 30 days feeding with 813 experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: non- abamectin 814 exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed fish 815 supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 816 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 817 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. Data are 818 presented as mean ± SE. Different letters in the same row show significant differences (P<0.05).

Parameters	T1 (control)	T2	T3	T4	T5	T6
IW (g)	30.43±0.34a	31.43±0.47a	30.93±0.43a	30.46±0.43a	30.83±0.72a	30.60±0.20a
FW (g)	46.66±0.72bcd	49.83±0.92ab	50.16±0.72a	43.36±0.44d	46.46±0.77cd	46.73±0.53bc
WG (g)	16.23±0.39b	18.40±0.49ab	19.23±0.88a	12.90±0.66c	15.63±0.36bc	16.13±0.72b
FCR	1.54±0.04b	1.38±0.03bc	1.29±0.04c	1.86±0.05a	1.46±0.06bc	1.51±0.06bc
SGR (%/d)	1.42±0.01ab	1.53±0.01ab	1.61±0.07a	1.17±0.06c	1.36±0.04bc	1.41±0.05abc
SR (%)	96.33±2.02a	97.33±1.33a	98.66±1.33a	93.00±1.73a	95.00±1.00a	96.33±2.02a

819 *IW: initial weigh; FW: final weight; WG: weight gain; FCR: feed conversion ratio; SGR: specific
820 growth rate; SR: survival rate.
821
822
823 Table 4. The serum immune components of the common carp, Cyprinus carpio over 30 days 824 feeding with experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: non- 825 abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed fish 826 supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 827 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 828 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. Data are 829 presented as mean ± SE. Different letters in the same row show significant differences (P<0.05).

	Parameters	**T1 (control)**	**T2**	**T3**	**T4**	**T5**	**T6**
(U/ml)	**Lysozyme**	22.60±1.51^{cd}	28.93±0.86^{ab}	31.36±1.19^{a}	18.76±0.72^{d}	22.10±1.15^{cd}	25.23±0.67^{bc}
(U/ml) (%)	**ACH_{50}**	106.50±3.29^{b}	123.50±2.46^{a}	118.03±1.88^{ab}	92.33±3.48^{c}	106.73±2.74^{b}	104.63±3.44^{bc}
(mg/ml)	**Protease**	5.73±0.66^{bc}	8.33±0.48^{a}	7.93±0.52^{ab}	3.76±0.43^{c}	6.13±0.49^{abc}	5.23±0.43^{c}
(OD 450)	**Total Ig**	17.50±0.81^{bc}	21.43±0.80^{ab}	22.23±1.01^{a}	13.36±0.78^{c}	7.33±1.20^{bc}1	18.50±0.73^{ab}
	MPO	1.23±0.20^{ab}	2.21±0.34^{a}	1.63±0.24^{ab}	1.00±0.17^{b}	1.50±0.15^{ab}	1.30±0.17^{ab}

NBT (OD 540) (U/ml)	1.21±0.11^{b}	1.56±0.22^{ab}	2.48±0.20^{a}	2.15±0.23^{ab}	2.11±0.27^{ab}	2.58±0.29^{a}
Peroxidase	7.83±0.46^{bc}	10.06±0.58^{ab}	11.83±0.89^{a}	6.20±0.62^{c}	6.43±0.47^{c}	8.16±0.52^{bc}
C3 (g/dL)	29.33±1.14^{cd}	34.60±0.87^{ab}	38.93±1.21^{a}	24.70±0.94^{d}	28.43±1.31^{cd}	30.83±1.01^{bc}
C4 (g/dL)	15.16±1.01^{ab}	15.86±1.04^{ab}	16.80±0.69^{a}	12.03±0.57^{b}	12.70±1.20^{ab}	13.16±0.88^{ab}

*ACH50: alternative complement activity; Total Ig: total immunoglobulin; MPO: myeloperoxidase; NBT: nitro-blue-tetrazolium; C3 and C4: concentration of serum complement components.

Table 5. The serum antioxidant enzyme activity in the common carp, Cyprinus carpio over 30 836 days feeding with experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: 837 non- abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed 838 fish supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 839 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 840 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. Data are presented as mean ± SE. Different letters in the same row show significant differences (P<0.05).

Parameters	T1 (control)	T2	T3	T4	T5	T6
CAT (U/ml)	100.16±3.89a	103.66±5.19a	105.00±3.75a	92.86±3.19a	93.90±3.03a	95.93±2.52a
SOD (U/ml)	25.33±1.16ab	26.43±1.65ab	29.40±1.05a	21.33±0.99b	24.63±1.24ab	25.46±1.31ab
MDA(nmol/ml)	35.56±1.66b	31.80±1.47b	28.63±1.12b	45.43±1.65a	44.06±1.76a	43.33±1.45a
GPx (U/ml)	150.33±3.17b	154.00±2.30ab	165.50±3.04a	142.50±2.35b	148.33±2.89b	152.83±2.45ab

*CAT: catalase; SOD: superoxide dismutase; MDA: malondialdehyde; GPx: glutathione peroxidase.

852 Table 6. The activity of liver metabolic enzymes in serum of the common carp, Cyprinus carpio 853 over 30 days feeding with experimental diets: T1: non-supplemenetd and non- abamectin exposed 854 fish, T2: non- abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin 855 exposed fish supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 856 12.5 % LC50 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 857 of abamectin, T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. 858 Data are presented as mean ± SE. Different letters in the same row show significant differences
859 (P<0.05).

Parameters	T1 (control)	T2	T3	T4	T5	T6
ALT (U/l)	21.53±1.01ab	18.66±0.88bc	17.10±0.51c	24.90±0.60a	20.50±0.76bc	21.26±0.89ab
AST (U/l)	80.40±1.53a	78.16±2.16a	80.16±2.20a	86.10±1.93a	81.20±1.74a	84.40±1.81a
ALP (U/l)	107.16±4.18ab	98.83±4.20b	95.50±2.59b	116.23±3.03a	104.50±2.59ab	98.50±2.75b
LDH (U/l)	287.00±3.78a	274.00±2.30b	270.83±1.58b	292.20±1.74a	288.83±2.74a	290.83±1.48a

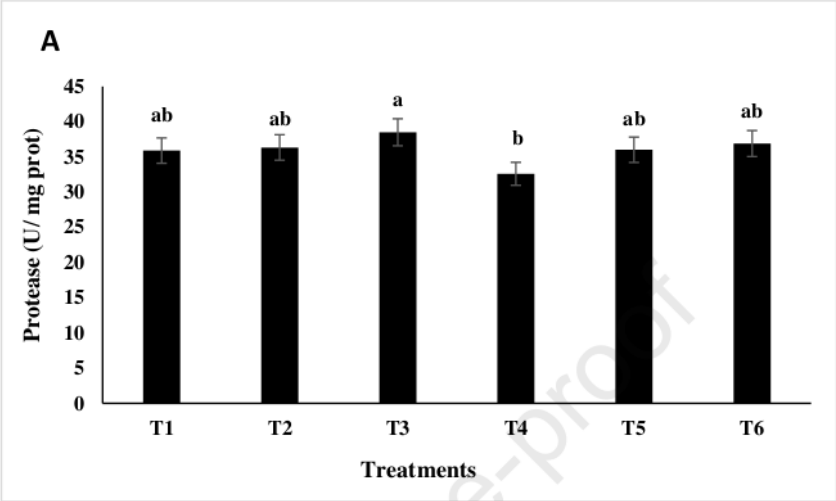
860 *ALT: alanine aminotransferase; AST: aspartate transaminase; ALP: alkaline phosphatase; LDH: lactate
861 dehydrogenase.
862
863
864 Table 7. The biochemicals in the serum of the common carp, Cyprinus carpio over 30 days feeding 865 with experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: non- 866 abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed fish 867 supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 868 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 869 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. Data are
870 presented as mean ± SE. Different letters in the same row show significant differences (P<0.05).

Parameters	**T1 (control)**	**T2**	**T3**	**T4**	**T5**	**T6**
Total Protein (g/dL) (g/dL)	3.00±0.17^{a}	3.40±0.26^{a}	3.95±0.27^{a}	2.90±0.18^{a}	2.86±0.20^{a}	3.03±0.29^{a}
Albumin (g/dL)	1.30±0.05^{ab}	1.46±0.17^{ab}	1.63±0.13^{a}	1.05±0.10^{b}	1.36±0.08^{ab}	1.43±0.08^{ab}
Globulin (g/dL)	1.70±0.11^{a}	1.93±0.08^{a}	2.31±0.18^{a}	1.85±0.08^{a}	1.50±0.28^{a}	1.60±0.25^{a}
Glucose (ng/ml)	81.76±1.67^{ab}	74.16±2.45^{bc}	67.50±2.17^{c}	85.50±1.89^{a}	83.10±1.93^{ab}	76.86±1.27^{ab}

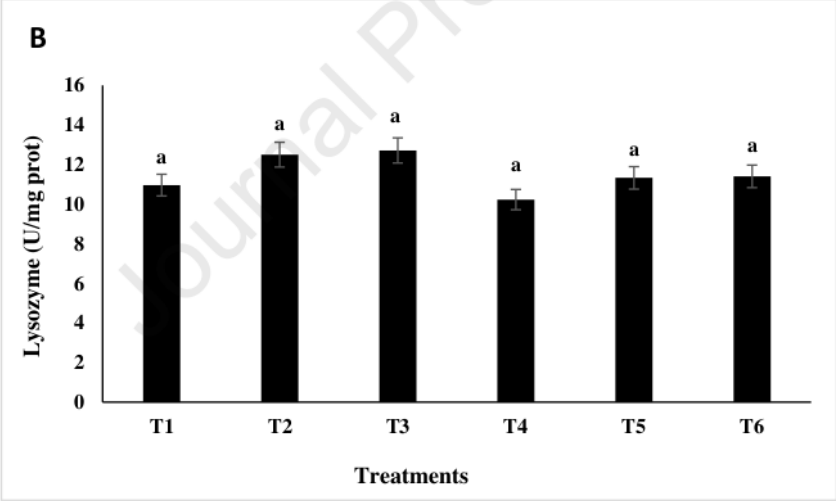
Cortisol 93.50±1.89b 86.76±1.29bc 81.26±1.75c 105.16±2.61a 93.50±1.32b 91.40±1.66b

871
872
873

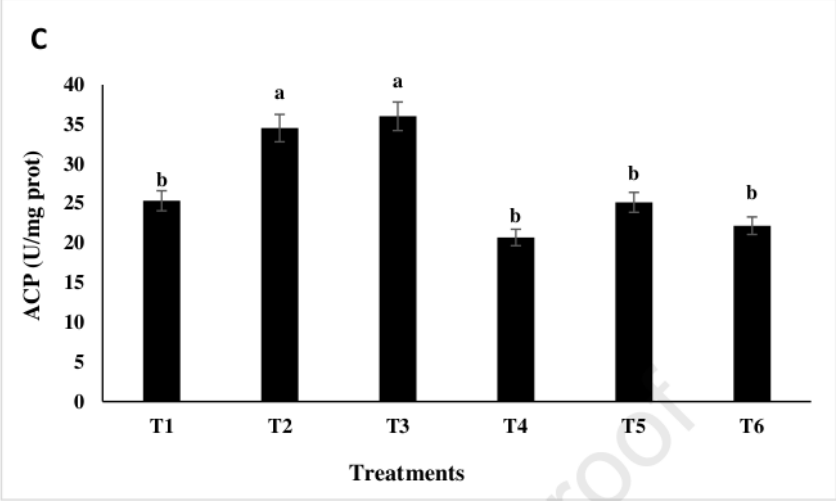
874
875



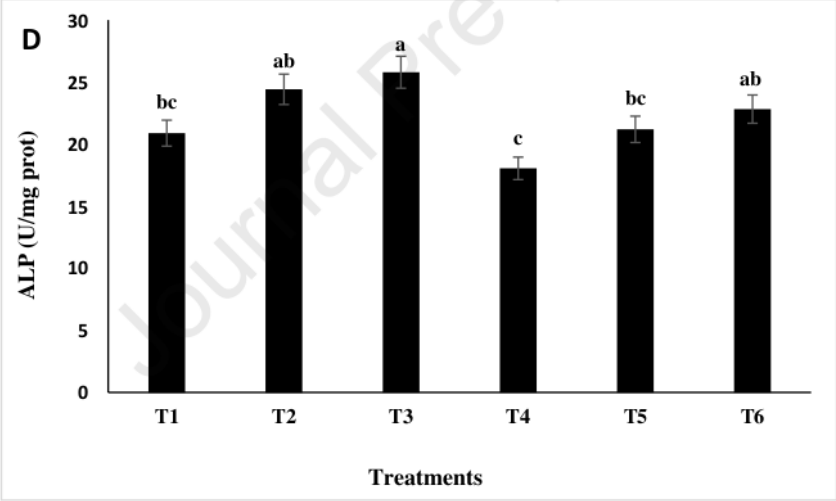
876
877



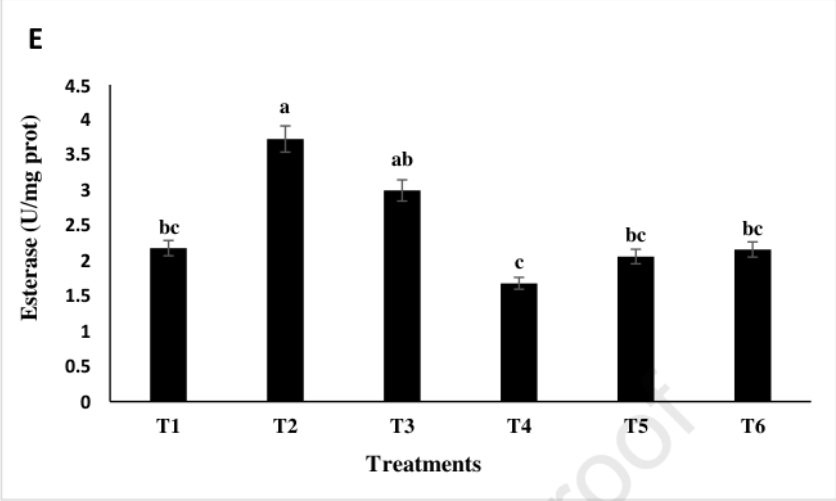
878
879



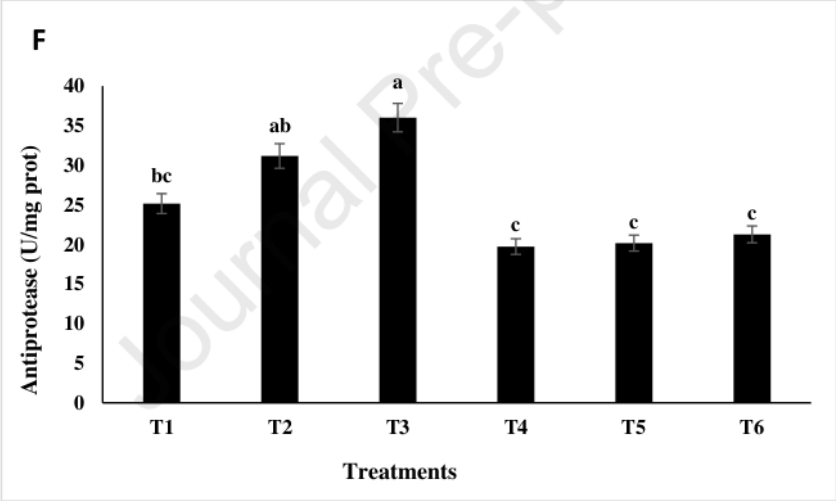
880
881
882
883



884
885
886
887



888
889
890

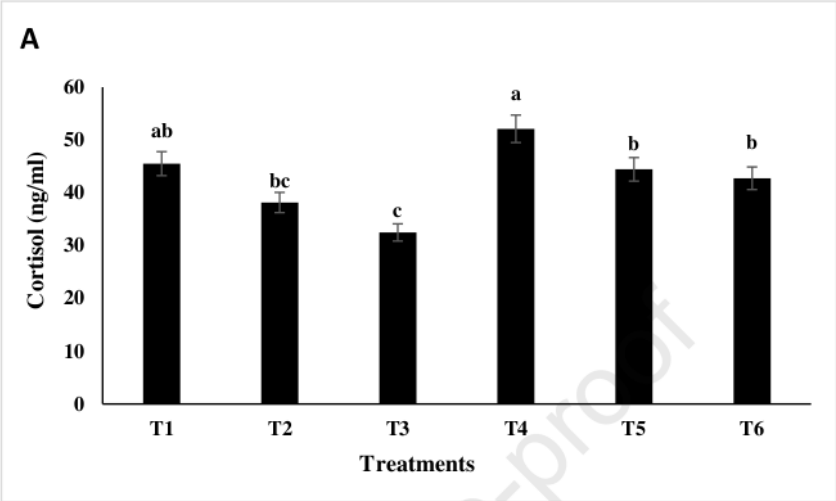


891
892
893

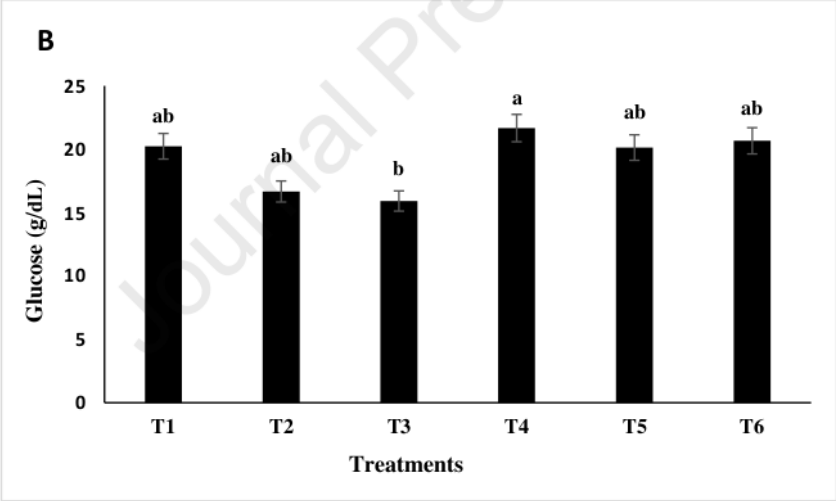
894 Fig. 1. The immune components in the mucus of the common carp, Cyprinus carpio over 30 days 895 feeding with experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: non- 896 abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed fish 897 supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 898 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 899 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. (ACP: acid 900 phosphatase; ALP: alkaline phosphatase). Data are presented as mean ± SE. Different letters in the 901 same row show significant differences ($P<0.05$).

902
903

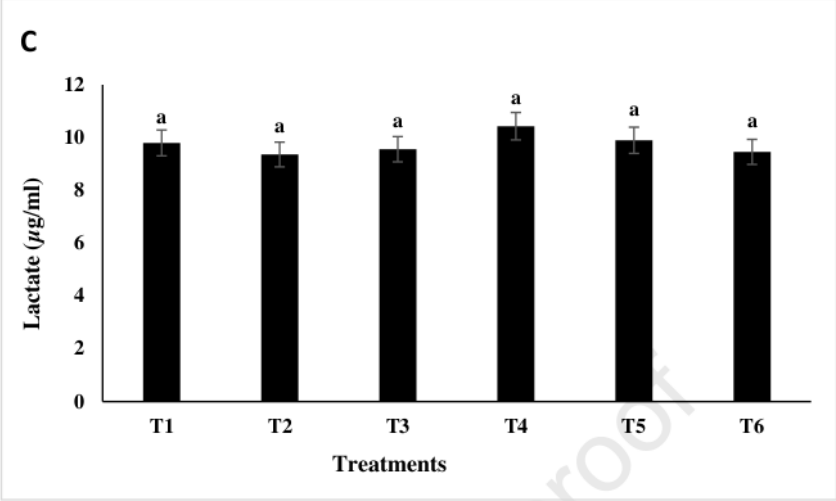
904



905
906



907
908



909
910
911 Fig. 2. The biochemicals in the mucus of the common carp, Cyprinus carpio over 30 days feeding 912 with experimental diets: T1: non-supplemenetd and non- abamectin exposed fish, T2: non- 913 abamectin exposed fish supplemented with 300 mg/kg curcumin, T3: non-abamectin exposed fish 914 supplemented with 300 mg/kg resveratrol, T4: non-supplemenetd fish exposed to 12.5 % LC50 915 of abamectin, T5: 300 mg/kg curcumin supplemented fish exposed to 12.5 % LC50 of abamectin, 916 T6: 300 mg/kg resveratrol supplemented fish exposed to 12.5 % LC50 of abamectin. Data are 917 presented as mean ± SE. Different letters in the same row show significant differences ($P<0.05$). 918
919
920
921
922
923
924
925
926
927
928
929
930

Credit Author Statement

Conceptualization: Martina Kurnia Rohmah, Data Curation: Omar Dheyauldeen Salahdin, Formal Analysis: Reena Gupta, Funding Acquisition: Khursheed Muzammil, Investigation: Maytham T. Qasim, Methodology, Field Study and Sampling: Aadel Heidary, Safoura Abarghouei, Project Administration: Zahraa Haleem Al-qaim, Resources: Nada Fadhil Abbas, Supervision: Mohammed Abed Jawad, Visualization: Ghulam Yasin, Writing -original draft: Martina Kurnia Rohmah, Yasser Fakri Mustafa, Writing -review and editing: Omar Dheyauldeen Salahdin, Reena Gupta, Ghulam Yasin.

Modulatory role of dietary curcumin and resveratrol on growth performance

ORIGINALITY REPORT

16%	9%	12%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	internationalscienceindex.org Internet Source	1%
2	academic.oup.com Internet Source	1%
3	Submitted to Manchester Metropolitan University Student Paper	1%
4	dergipark.org.tr Internet Source	<1%
5	nbn-resolving.org Internet Source	<1%
6	Chang Tan, Huihui Zhou, Xuan Wang, Kangsen Mai, Gen He. "Resveratrol attenuates oxidative stress and inflammatory response in turbot fed with soybean meal based diet", Fish & Shellfish Immunology, 2019 Publication	<1%
7	Diana Ceballos-Francisco, Yussaira Castillo, Francisco De La Rosa, William Vásquez et al.	<1%

"Bactericidal effect on skin mucosa of dietary guava (Psidium guajava L.) leaves in hybrid tilapia (Oreochromis niloticus × O. mossambicus)", Journal of Ethnopharmacology, 2020
Publication

---

8 Maria J. Xavier, Carmen Navarro-Guillén, André Lopes, Rita Colen et al. "Effects of dietary curcumin in growth performance, oxidative status and gut morphometry and function of gilthead seabream postlarvae", Aquaculture Reports, 2022 <1%
Publication

---

9 Letian Yuan, Peng Zhao, Xiangtao Lin, Tianyi Yu, Ruiyuan Diao, Guqing Ning. "T1 mapping and reduced field - of - view DWI at 3.0 T MRI for differentiation of thyroid papillary carcinoma from nodular goiter", Clinical Physiology and Functional Imaging, 2022 <1%
Publication

---

10 jemds.com <1%
Internet Source

---

11 Firoozeh Abolhasani Zadeh, Saade Abdalkareem Jasim, Mohammad Javed Ansari, Dmitry Olegovich Bokov et al. "Boron carbide nanotube as targeted drug delivery system for melphalan anticancer drug", Journal of Molecular Liquids, 2022 <1%

Publication

12	Kang, Y.J.. "Eupatilin, isolated from Artemisia princeps Pampanini, enhances hepatic glucose metabolism and pancreatic @b-cell function in type 2 diabetic mice", Diabetes Research and Clinical Practice, 200810 Publication	<1 %
13	text.123doc.org Internet Source	<1 %
14	Anupam Bishayee, Neetika Dhir. "Resveratrol-mediated chemoprevention of diethylnitrosamine-initiated hepatocarcinogenesis: Inhibition of cell proliferation and induction of apoptosis", Chemico-Biological Interactions, 2009 Publication	<1 %
15	Duan, Xiang, Mei Li, Fengfeng Wu, Na Yang, Mehdi Nikoo, Zhengyu Jin, and Xueming Xu. "Postfertilization Changes in Nutritional Composition and Protein Conformation of Hen Egg", Journal of Agricultural and Food Chemistry, 2013. Publication	<1 %
16	www.fisheriesjournal.com Internet Source	<1 %
17	Ahmad Rafieepour, Saeed Hajirezaee, Ruhollah Rahimi. " Dietary oregano extract (	<1 %

L.) enhances the antioxidant defence in rainbow trout, against toxicity induced by organophosphorus pesticide, diazinon ", Toxin Reviews, 2019
Publication

---

18 Hien Van Doan, Seyed Hossein Hoseinifar, Sanchai Jaturasitha, Mahmoud A.O. Dawood, Ramasamy Harikrishnan. "The effects of berberine powder supplementation on growth performance, skin mucus immune response, serum immunity, and disease resistance of Nile tilapia (Oreochromis niloticus) fingerlings", Aquaculture, 2020 <1%
Publication

---

19 Paul M. Walker, Tim R. Kelley, Ken D. Smiciklas. "Evaluation of pulverized trommel fines for use as a soil amendment", Bioresource Technology, 2008 <1%
Publication

---

20 Shakila Veisi, Seyed Ali Johari, Charles R. Tyler, Borhan Mansouri, Milad Esmaeilbeigi. "Antioxidant properties of dietary supplements of free and nanoencapsulated silymarin and their ameliorative effects on silver nanoparticles induced oxidative stress in Nile tilapia (Oreochromis niloticus)", Environmental Science and Pollution Research, 2021 <1%
Publication

21	www.acarindex.com Internet Source	<1%
22	Reza Tarkhani, Ahmad Imani, Seyed Hossein Hoseinifar, Kourosh Sarvi Moghanlou, Ramin Manaffar. "The effects of host-associated Enterococcus faecium CGMCC1.2136 on serum immune parameters, digestive enzymes activity and growth performance of the Caspian roach (Rutilus rutilus caspicus) fingerlings", Aquaculture, 2020 Publication	<1%
23	acervodigital.ufpr.br Internet Source	<1%
24	Hossein Adineh, Mahdi Naderi, Hojatallah Jafaryan, Mohammad Khademi Hamidi, Morteza Yousefi, Ehsan Ahmadifar. "Effect of Stocking Density and Dietary Protein Level in Biofloc System on the Growth, Digestive and Antioxidant Enzyme Activities, Health, and Resistance to Acute Crowding Stress in Juvenile Common Carp (Cyprinus carpio)", Aquaculture Nutrition, 2022 Publication	<1%
25	Weiguang Zou, Zhideng Lin, Yisheng Huang, Samwel M. Limbu, Hua Rong, Chuanqi Yu, Fan Lin, Xiaobo Wen. " Effect of dietary vitamin C on growth performance, body composition	<1%

and biochemical parameters of juvenile Chu's croaker ( ) ", Aquaculture Nutrition, 2019
Publication

26	english.ksfme.or.kr Internet Source	<1%
27	"Hepatocyte Transplantation", Springer Science and Business Media LLC, 2017 Publication	<1%
28	M.P. Escribano, L. Ramos-Pinto, S. Fernández-Boo, A. Afonso, B. Costas, F.A. Guardiola. "Mucosal immune responses in Senegalese sole (Solea senegalensis) juveniles after Tenacibaculum maritimum challenge: A comparative study between ocular and blind sides", Fish & Shellfish Immunology, 2020 Publication	<1%
29	cris.leibniz-zmt.de Internet Source	<1%
30	Hien Van Doan, Seyed Hossein Hoseinifar, Chanagun Chitmanat, Sanchai Jaturasitha et al. "The effects of Thai ginseng, Boesenbergia rotunda powder on mucosal and serum immunity, disease resistance, and growth performance of Nile tilapia (Oreochromis niloticus) fingerlings", Aquaculture, 2019 Publication	<1%

31	Mona Ismail, Ali Wahdan, Mohamed, S. Yusuf, Elsayed Metwally, Mahmoud Mabrok. " Effect of dietary supplementation with a synbiotic (Lacto Forte) on growth performance, haematological and histological profiles, the innate immune response and resistance to bacterial disease in ", Aquaculture Research, 2019 Publication	<1 %
32	Morteza Yousefi, Yury Anatolyevich Vatnikov, Evgeny Vladimirovich Kulikov, Vadim Gennadievich Plushikov et al. "The protective effects of dietary garlic on common carp (Cyprinus carpio) exposed to ambient ammonia toxicity", Aquaculture, 2020 Publication	<1 %
33	pagepressjournals.org Internet Source	<1 %
34	www.physiciansweekly.com Internet Source	<1 %
35	Liping Yang, Wenlei Zhang, Shaoyang Zhi, Mengjuan Zhao, Mingyu Liu, Chaobin Qin, Junchang Feng, Xiao Yan, Guoxing Nie. "Evaluation of dietary genistein on the antioxidant capacity, non-specific immune status, and fatty acid composition of common carp (Cyprinus carpio .L)", Aquaculture, 2022 Publication	<1 %

36	www.e-sciencecentral.org Internet Source	<1%
37	Chetanjyoti Tuteja, Shanthanagouda A.H, S.S. Hundal, S.S. Dhaliwal. "Antioxidative role of dietary ascorbic acid against arsenic induced haematological, biochemical and histomorphological alterations in Cyprinus carpio", Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 2021 Publication	<1%
38	Yasmina M. Abd El-Hakim, Walaa El-Houseiny, Abd Elhakeem EL-Murr, Lamiaa L.M. Ebraheim et al. "Melamine and curcumin enriched diets modulate the haemato-immune response, growth performance, oxidative stress, disease resistance, and cytokine production in oreochromis niloticus", Aquatic Toxicology, 2020 Publication	<1%
39	neptjournal.com Internet Source	<1%
40	www.scielo.cl Internet Source	<1%
41	Barroso, Carolina, Rodrigo O A Ozório, António Afonso, Julieta R E Moraes, and Benjamín Costas. "Immune responses and gut	<1%

morphology in Senegalese sole (Solea senegalensis) fed dietary probiotic supplementation and following exposure to Photobacterium damselae subsp. piscicida", Aquaculture Research, 2014.
Publication

---

42 Mayank Bisht, Avdhesh Kumar, Tarang Kumar Shah. " Effect of leaf powder on skin mucosal immune responses and growth performance of guppy, (Peter, 1860) ", Aquaculture Research, 2020 — <1%
Publication

---

43 Saade Abdalkareem Jasim, Maria Jade Catalan Opulencia, Andrés Alexis Ramírez-Coronel, Walid Kamal Abdelbasset et al. "The emerging role of microbiota-derived short-chain fatty acids in immunometabolism", International Immunopharmacology, 2022 — <1%
Publication

---

44 ijaah.ir — <1%
Internet Source

---

45 ijramr.com — <1%
Internet Source

---

46 F. Maekawa. "Young Adult-Specific Hyperphagia in Diabetic Goto-Kakizaki Rats is Associated with Leptin Resistance and Elevation of Neuropeptide Y mRNA in the — <1%

Arcuate Nucleus", Journal of Neuroendocrinology, 10/2006
Publication

47 M Huang. "Stress-induced interleukin-6 release in mice is mast cell-dependent and more pronounced in Apolipoprotein E knockout mice", Cardiovascular Research, 07/01/2003 <1 %
Publication

48 Melika Ghelichpour, Ali Taheri Mirghaed, Ashkan Zargar. " The response of lufenuron - And flonicamid - exposed to saltwater challenge: Study on ion - regulation and stress genes expression and plasma antioxidant characteristics ", Aquaculture Research, 2020 <1 %
Publication

49 Mohammed A.E. Naiel, Ahmed G.A. Gewida, Abdel-Rahman M.A. Merwad, Eman A.A. Abdel-Hamid et al. "The effects of various organic fertilizers with or without adsorbents on the productivity, antioxidant status and immune responses of Nile tilapia raised in cement ponds", Aquaculture, 2022 <1 %
Publication

50 W.-W. XIAO. "Lipid peroxidation, protein oxidant and antioxidant status of muscle and serum for juvenile Jian carp (Cyprinus carpio <1 %

var. Jian) fed grade levels of methionine hydroxy analogue : MHA improves antioxidant status in muscle of carp", Aquaculture Nutrition, 02/2012
Publication

---

51 Zhifei Chen, Depeng Fan, Luqing Pan, Chen Su, Yanjun Ding, Mingxiang Lu. "Study of effects of dietary quercetin (Que) on growth performance and disease resistance mechanism of Litopenaeus vannamei", Aquaculture, 2023 <1%
Publication

---

52 Amrutha Gopan, Narottam P. Sahu, Tincy Varghese, Parimal Sardar, Manas K. Maiti. " Karanj protein isolate prepared from karanj seed cake: Effect on growth, body composition and physiometabolic responses in fingerlings ", Aquaculture Nutrition, 2019 <1%
Publication

---

53 Mayada R. Farag, Youssef A. Attia, Lafi S. Al Solami, Fulvia Bovera, Antonino Nizza, Mahmoud Alagawany. "Behavioral, physiological, and inflammatory responses of Oreochromis niloticus fish exposed to thallium and/or supplementation with Astragalus membranaceus polysaccharides", Aquaculture, 2022 <1%
Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		