JKAU: Mar. Sci., **Vol. 33** No. 2 pp: 51 - 66 (2023 A.D.)
DOI :10.4197/Mar.33-2.5

The Effects of Dietary Administration of Two Sources of β-Glucan on Growth and Physiological Activity of Common Carp

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Abstract. A growth experiment has been established to estimate the influence of two diverse sources of β-glucan, fungal derived from baker's yeast *Saccharomyces cerevisiae* and vegetal derived from barley bran *Hordeum vulgare* as long-term effect on the growth performance, survival rate, and physiological status in fingerlings of common carp (*Cyprinus carpio*) after 60 days of feeding on artificial diets containing 3% fungal β-glucan (A group), 3% vegetal β-glucan (B group), as well as 0% β-glucan (C group) as a control in duplicate for each group. Some of the blood parameters such as Packed cell volume PCV, osmotic pressure OP, total protein content TP, glucose content GLU., enzymes of ALP, AST, and ALT were estimated. Results of growth performance including weight increase, growth rates, relative growth rates, and specific growth rates as well as survival rates showed no significant variances ($P > 0.05$) among the three groups, although there were rises in these values in groups of fungal (A) and vegetal (B) sources of β-glucan additives than the control group C. Contrariwise, most of the physiological parameters estimated in the fish blood showed a significant improvement in performance in group A and then B, where PCV, OP, TP, GLU, ALP, AST, and ALT values showed a significant decline ($P < 0.05$) for A group and for B group, from the control group C. The study confirmed that the addition of β-glucan, especially that derived from a fungal source to fish diets, led to a non-significant increase in growth and survival rates, while it guided to a significant improvement in the physiological activities of the parameters PCV, OP, TP, GLU, ALP, AST, and ALT in the fish blood. The study encourages adding the fungal source of β-glucan to the artificial diets of common carp as an Immunostimulatory agent for its health enhancement

Keywords: β-glucan, Fungal source, Vegetal source, Common carp, Growth, Physiological indicators.

1. Introduction

There were great fears about the widespread usage of antibiotics in the treatment of fish diseases (Di Domenico *et al*., 2017; Brudeseth *et al*. 2013), due to the gush apparition of antibiotic-resistant bacteria, and the harmful action of antibiotics Remnants in aquatic environments and in fish body. This prompted researchers to take alternative methods of treatment, including the use of vaccines and immunomodulatory materials to enhance the immunity of fish to resist diseases (Bairwa *et al*., 2012; Plant & Laptra, 2011; Bricknell & Dalmo, 2005; Sommerset *et al*., 2005). Different sources of β-glucan, one of the immunomodulatory compounds, have been used to stimulate the immunity of cultured fishes (Meena *et al*., 2013). β-glucans are polymers of D-glucose found in the cell walls of many plants, fungi, and bacteria (Hunter *et al*., 2002). There are soluble and insoluble β-glucans depending on the β-glucan linkages side

groups, given different chemical structures which are substantial in regarding the solubility, style of operation, and general physiological activity (Dalmo & Bogwald, 2008), the insoluble β-glucan, has greater biological activity than the soluble β-glucan (Ooi & Liu, 2000). β-glucans were known as "physiological response modifiers" because of their capability to enhance innate immunity without extensive activities by lowering many elevated physiological factors associated with stress and infections (Misra *et al*., 2006). They are considered as safe, non-toxic compounds and without side effects in aquaculture utilizations as immunostimulators (Meena *et al*., 2013).

There are extensive studies discussing the immunostimulation effects of these natural polymers in aquaculture. β-glucans are found to be highly useful in decreasing fish mortality caused by bacterial phages, inhibiting viral diseases, enhancing resistance to parasite diseases, and raising the efficiency of vaccine (Raa, 2000). Diets supplemented with both prepared and commercial β-glucans exhibited enhancement in the health, growth, and physiological operation of farmed fish. A study by Cook *et al*. (2003) found an enhancement of the growth of *Pagrus auratus* with oral giving of commercially available β-glucan (EcoActiva). Similar results were found in the studies of (Ai *et al*., 2007; Misra *et al*., 2006) in *Pseudosciaena crocea*, and *Labeo rohita* fingerlings, respectively. The β-glucans derived from the yeasts, especially *Saccharomyces cerevisiae* are extensively utilized in nutritional supplements (Hunter *et al*., 2002). Many studies found that these types of β-glucans were more active than the commercial types in fish immunostimulation (Machuca *et al*., 2022). Also, barley sources of β-glucans were widely used in fish feed and had an affirmative effect in improving immunity against different diseases (Ringo *et al*., 2010; Sealey *et al*., 2008; Misra *et al*., 2006).

The study aimed to evaluate the influence of long-term dietary application of fungal and vegetal β-glucans on the physiological status, growth performance, and survival rates in fingerlings of common carp *Cyprinus carpio*.

2. Materials and Methods

2.1 Experimental Diets

The details of raw material percentage and approximate chemical composition of artificial diets used in the growth experiment are shown in Tables 1 and 2. The supplemented β-glucans were prepared in the laboratory from two sources: The first was the fungal source from Baker's yeast *Saccharomyces cerevisiae*, and the second was the vegetal source from brown barley bran *Hordeum vulgare*, according to Al-Jumaiee *et al*. (2019), in the following proportions: The first diet containing 3% fungal β-glucan (A group), the second diet containing 3% vegetal β-glucan (B group) and the third diet containing 0% β-glucan (C group) as a control. Specified proportions of β-glucan were mixed with raw materials of fish diets for 20min, cooked in the water bath until 60°C pelleted, exsiccated and kept in the refrigerator in glass vessels pending utilization (Sahan & Duman 2010; Lovell, 1989).

2.2 Experiment Design

Fingerlings of common carp *C. carpio* (with an initial length of 14.64±0.41 cm and initial weight of 44.21±4.58 g) were collected from earthen ponds in the Marine Sciences Centre, University of Basrah, Iraq, on December 18th, 2022, the fish were transferred to the aquaculture laboratory in the vertebrate department, convergent sizes of fish were distributed randomly into 6 plastic containers in a volume of 54L, and every container was stocked with 10 fish in duplicate for each group of β-glucan diets used in growth experiment which extended for 60 days. Prior the beginning of experiment, the fish were adapted to the laboratory environment for one week and fed

on the control diet C. The fish were fasted for 24h, then their weight was recorded and considered as initial weight; Fish were fed manually twice daily by the empirical diets in the proportion of 3% of body weight for five days a week. A recycle aquaculture system (RAS) consisting of 12 plastic containers with a volume of 54 L supplied with both mechanical and biological filtration for each treatment was used. Automatic heaters with thermostats were used to maintain the water temperature constant. The growth experiment lasted for 60 days, from December 25th to February 23rd. Some of the water quality parameters [temperatures (°C), salinity psu, dissolved oxygen (mg/l), and pH] were measured throughout the experimental period once daily using the YSI device model (556 MPS).

2.3 Growth Performance

The growth performance of common carp fed with fungal and vegetal sources of β-glucan integrated diets was studied by determining weight increase (WI), growth rate (GR), relative growth rate (RGR), specific growth rate (SGR), and survival rate pursuant to Jobling (1993).

$WI\ (g) = W_2 - W_1$

$GR\ (g/day) = W_2\text{-}W_1 / T_2\text{-}T_1$

$RGR(\%) = [(W_2 - W_1)/ W_1] \times 100$

$SGR\ (\%\ g/day) = [(\ln W_2 - \ln W_1) / (T_2 - T_1)] \times 100$

$Survival\ rate\ \% = (N_2 / N_1) \times 100$

Whereas:

W_1= initial weight (g)

W_2= final weight (g)

$T_2 - T_1$= days of the experiment (60 days)

N_1= number of fish at the beginning of experiment

N_2= number of fish at the end of the experiment

2.4 Physiological Assays

2.4.1 Blood Parameters

Blood samples were taken from 3 fishes one day before starting the experiment (time 0), and blood from all fishes at the end of the feeding period (60 days) was immediately taken. A clove oil 0.05 ml/L was used for fish anesthetizing (Durville & Collet, 2001) before handling. In packed cell volume PCV, blood samples were gathered by the cut of the caudal vein and taking blood using a heparinized capillary tube, centrifuged then in micro-centrifuge (hematocrit 210) at 3500 rpm for a duration of 5 min for plasma separation. The Micro-Capillary Reader type DAMON/IEC was used to estimate the PCV %. In Osmotic pressure OP, the plasma was gathered from the capillary tubes by 100 µm Micro Syringe, after finishing the PCV measurements, plasma in a volume of 50 µm was drawn to 0.5 ml eppendorf tubes. The freezing point depression method was depended on using the OSMOMAT 030 instrument, which directly measured the osmolality (mosmol/kg) (Saoud *et al*., 2007).

Measurement of Total Protein TP in the serum was done by collecting blood samples from the heart using a syringe of 3ml and transferring them into sterile tubes at room temperature for 1h to allow it to cool and then preserved in the refrigerator for a whole day. Afterward, a refrigerate centrifugation in 3000 rpm for 10 min for serum separation, which preserved frozen until assay. The Biuret method was used for estimating the serum protein content (g/l) using a commercial kit (ARCHITEC, 7D73-20) in an automated dilution protocol for specimens. Glucose level GLU in the serum (mg/dl) was estimated by using a commercial kit (ARCHITEC, 3L82-22 /Canada) in a colorimetric Hexokinase/ G-6-PDH method, by the production of one micromole of NADH for each micromole of glucose consumed. The NADH-produced absorbent was measured at 340 nm in a spectrophotometer.

2.5 Enzymatic Assays

Alkaline phosphatase ALP enzyme activity (U/L) in the serum of *C. carpio* was determined using a commercial kit (ARCHITEC, 7D55-21) in a colorimetric para-nitrophenyl phosphate (*p*-NPP) method by hydrolyzing the colorless *p*-NPP to the yellow *p*-nitrophenol product, the absorbance estimated at 404 nm**.** Aspartate aminotransferase AST enzyme activity (U/L) in fish serum was determined using a commercial kit (ARCHITEC, 7D81) by the colorimetric method of NADH (without P-5 '-P) depending on the decreased absorbance rate in wavelength of 340 nm because of NADH oxidation to NAD based on the construction recommended by the International Federation of Clinical Chemistry (IFCC) (Schumann *et al*., 2002). Alanine aminotransferase ALT enzyme activity (U/L) in the serum of common carp was determined using a commercial kit (ARCHITEC, 8L92-20). The wavelength of 340 nm was set to measure the absorbance decrease in samples because of NADH oxidation to NAD. The instructions of the International Federation of Clinical Chemistry (IFCC) were followed (Bergmeyer & horder, 1986).

2.6 Statistical Analyses

The three groups of cultured fish fed on diets that added fungal and vegetal sources of β-glucan were compared using analysis of variance (ANOVA) in one-way, and Least Significant Difference (LSD). A significant range ($P < 0.05$) was set, using IBM SPSS program (version 26). All values were expressed as mean ± S.E.M. (the standard error of the mean) (Steel & Torrie, 1997).

3. Results

3.1 RAS System Environmental Factors

Table 3 shows the mean of some environmental factors in the water of the RAS culture system recorded during the growth experiment period. Statistical analysis found no significant variances ($P > 0.05$) amongst the three groups A, B, and C as well as the RAS system in all environmental factors recorded; this indicates that all recorded environmental factors were relatively stable throughout the cultivation period. Total rates of water temperature, pH, salinity, and dissolved oxygen were 22.91 ± 0.33 °C, 7.25 ± 0.02, 2.78 ± 0.05 psu, and 5.86 ± 0.08 mg/l, respectively.

Table 3, Environmental factors in the water of RAS culture system recorded during the cultivation period (mean ± S.E.).

3.2 Growth Performance

The total length and total weight rates of common carp *C. carpio* fingerling at the beginning and end of the growth experiment were shown in Tables 4 and 5. Growth performance factors including WI, GR, RGR, and SGR as well as survival rates, are illustrated in Table 6. Group A showed the highest recorded values of growth performance factors: 8.31 ± 0.14 g, 0.14 ±0.02 g/day, 20.17 ± 4.00 % and 0.31 ± 0.05 %g/day respectively, followed by group B: 7.41 ± 0.35 g, 0.11 ± 0.005 g/day, 18.91 ± 0.15 % and 0.29 ±0.002 %g/day, respectively and then group C: 5.7 ± 0.5 g, 0.095 ± 0.005 g/day, 10.72 ± 0.77 % and 0.17 ± 0.01 %g/day respectively. Statistically, there were no significant variances ($P > 0.05$) among the three groups of all growth performance factors.

Survival rates were 100% in groups A and B, while in the control group, C was 91.67 ± 8.34%. Statistics exhibited no significant variances ($P > 0.05$) among the three groups in survival rates.

3.3 Physiological Status

3.3.1 Blood Parameters

Results for PCV values presented a significant rise ($P < 0.05$) in the control group C from the fungal and vegetal β-glucan added diets

groups A and B and also from fish in time 0 of the experiment (Fig. 1). Fishes from the A and B groups showed a remarkable improvement in hematocrit values, as they did not have significant differences ($P > 0.05$) from fish over time 0. Total rates of PCV values were (38.17 ± 1.05, 42.13 ± 2.21, 41.7 ± 3.0, and 53.87 ± 1.14%) for time 0, A, B, and C groups respectively.

In the same pattern, osmotic pressure OP results indicated a significant rise ($P < 0.05$) in the control group C (350.75 ± 5.75 mosmol/kg) and no significant differences ($P > 0.05$) among groups A and B and time 0 fishes which were (327.92 ± 0.09, 329.08 ± 3.73 and 322.33 ± 0.92 mosmol/kg) respectively, Fig. 2.

Results for total protein TP gave a significant rise ($P < 0.05$) in groups C and B (38.19 ± 0.65, 33.056 ± 1.36 g/l), respectively, and no significant variances ($P > 0.05$) between fishes from group A and time 0 fish (24.16 ± 0.92, 22.26 ± 0.19 g/l) respectively, Fig. 3.

Glucose content in the serum of common carp presented significant improvement ($P < 0.05$) in fishes from group A with the fungal source of β-glucan (123.18 ± 4.27 mg/dl), and significant rises ($P < 0.05$) in control group C and group B (133.72 ± 2.68, 133.11 ± 1.56 mg/dl) respectively, Fig. 4.

3.3.2 Enzymes activity

Results for ALP enzyme activity presented significant rises ($P < 0.05$) in the control group C and vegetal source of β-glucan group B from group A and time 0 fishes, the values were (35.62 ± 2.1, 34.47 ± 1.34, 24.30 ± 0.98 and 22.2 ± 0.1 U/l) respectively. Fishes from the group A with the fungal source of β-glucan diet had no significant variances ($P > 0.05$) with time 0 fishes, Fig. 5.

Figure 6 showed the AST enzyme activity in the serum of common carp fingerlings. Fishes from control group C gave the highest values 374.60 ± 16.34 U/l in significant differences ($P < 0.05$) from other groups, followed by fishes from B group 223.75 ± 8.35 U/l and after fishes from A group 181.46 ± 9.12 in a significant variance ($P < 0.05$) from those in time zero 134.21 ± 1.55 U/l.

In the same pattern as AST enzyme activity, results for ALT enzyme activity in the serum of common carp fingerlings presented the highest values in the control group C 2.9 ± 0.09 U/l, followed by group B 2.38 ± 0.26 U/l and after group A 1.52 ± 0.13 U/l in a significant variances ($P < 0.05$) among the three groups and also significant variances ($P < 0.05$) with fishes from time zero 0.64 ± 0.12 U/l, Fig. 7.

Table 1. Raw materials (%) used in preparing diets of growth experiment.

Raw Materials %	A	B	C
Fish Meal	20	20	20
Soybean Meal	30	30	30
corn	10	10	10
Barley	10	10	10
wheat bran	24	24	27
Vitamins and minerals	3	3	3
fungal β-Glucan	3	----	----
vegetal β-Glucan	----	3	----
Total	100	100	100

Table 2. Approximate chemical composition of the artificial diet used in the growth experiment.

Factors	%
Moisture	92.02
Protein	32.62
Fat	6.21
Ash	11.24
Carbohydrate	49.93

Table 3. Environmental factors in the water of RAS culture system recorded during the cultivation period (mean ± S.E.).

Environmental factor	RAS System	A	B	C
Temperature °C	22.11 ± 0.83[a]	22.44 ± 0.77[a]	24.21 ± 1.08[a]	22.89±0.96[a]
pH	7.19 ± 0.07[a]	7.25 ± 0.08[a]	7.27 ± 0.06[a]	7.3 ± 0.06[a]
Salinity psu	2.76 ±0.14[a]	2.77 ± 0.15[a]	2.81 ± 0.19[a]	2.76 ± 0.14[a]
D.O mg/l	5.76 ± 0.3[a]	6.08 ± 0.19[a]	5.65 ± 0.29[a]	5.91 ± 0.2[a]

*Different letters means there were significant differences (P > 0.05) between groups.

Table 4. Total length (cm) in the three groups of common carp fingerlings at the first and the end times of the growth experiment (mean ± S.E.).

Time (day)	A	B	C
0	14.44 ± 0.11[ab]	14.05 ± 0.28[b]	15.43 ± 0.41[a]
60	15.06 ± 0.09[a]	14.57 ± 0.3[a]	15.7 ± 0.3[a]

*Different letters means there were significant differences (P > 0.05) between groups.

Table 5. Total weight (g) in the three groups of common carp fingerlings at the first and the end times of the growth experiment (mean ± S.E.).

Time (day)	A	B	C
0	41.84 ± 3.31[b]	37.73 ± 1.53[b]	53.06 ± 0.8[a]
60	50.15 ± 2.31[b]	44.79 ± 1.21[b]	58.76 ± 1.3[a]

*Different letters means there were significant differences (P > 0.05) between groups.

Table 6. Growth performance factors in the three groups of common carp fingerlings fed on fungal and vegetable sources of β glucan.

Growth factors	A	B	C
WI g	8.31 ± 1.01[a]	7.14 ± 0.35[a]	5.7 ± 0.5[a]
GR g/day	0.14 ± 0.02[a]	0.11 ± 0.005[a]	0.095 ± 0.005[a]
RGR %	20.17 ± 4.00[a]	18.91 ± 0.15[a]	10.72 ± 0.77[a]
SGR % g/day	0.31 ± 0.05[a]	0.29 ± 0.002[a]	0.17 ± 0.01[a]
Survival rate %	100[a]	100[a]	91.67 ± 8.34[a]

*Different letters means there were significant differences (P > 0.05) between groups.

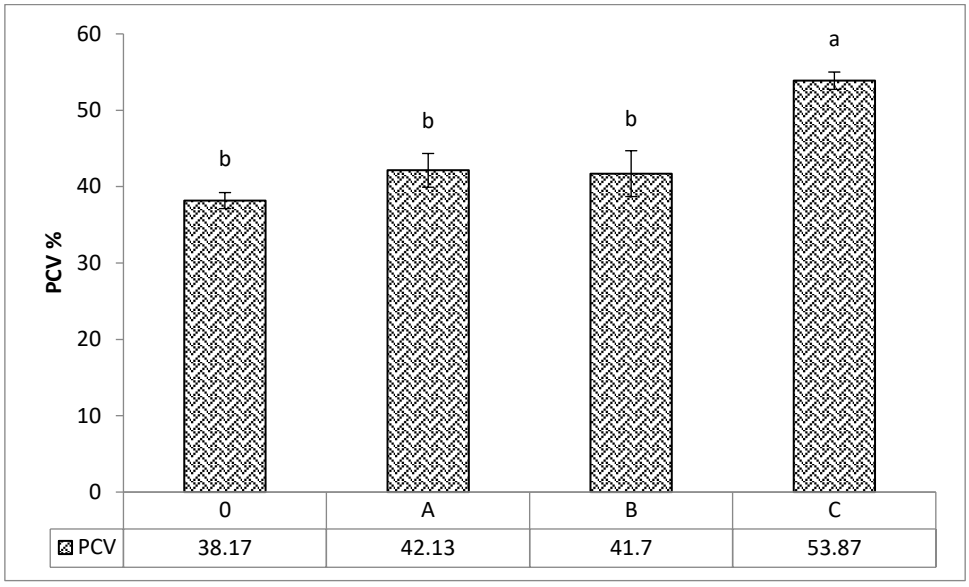

Fig. 1. PCV % in the blood of the three groups of common carp fingerlings fed on fungal and vegetable sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

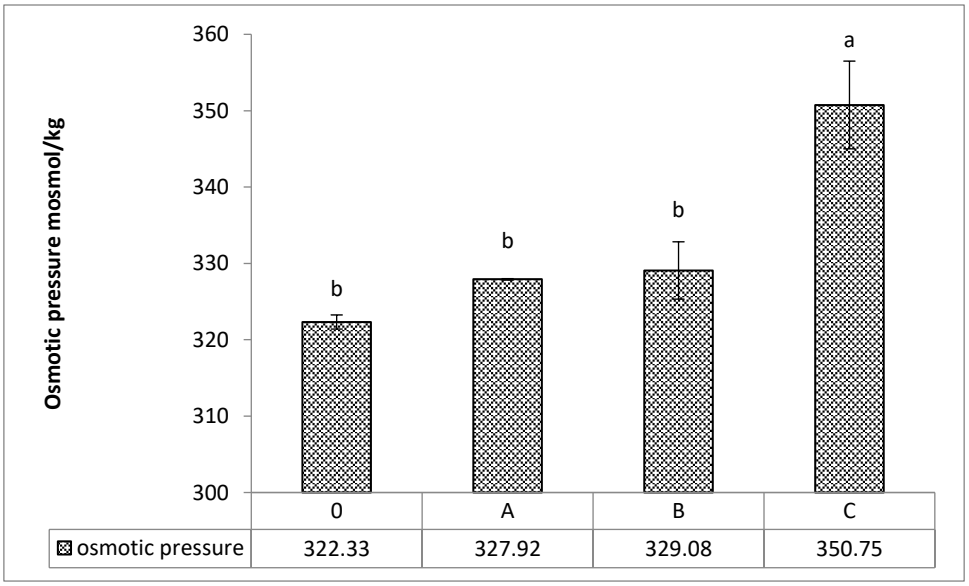

Fig. 2. Osmotic pressure in plasma of the three groups of common carp fingerlings fed on fungal and vegetable sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

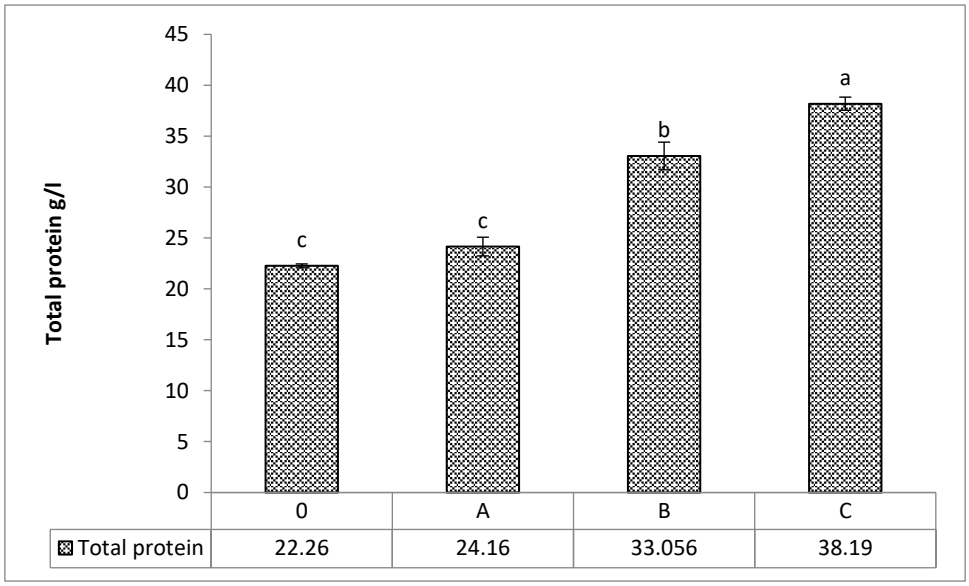

Fig. 3. Total protein (g/l) in serum of the three groups of common carp fingerlings fed on fungal and vegetable sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

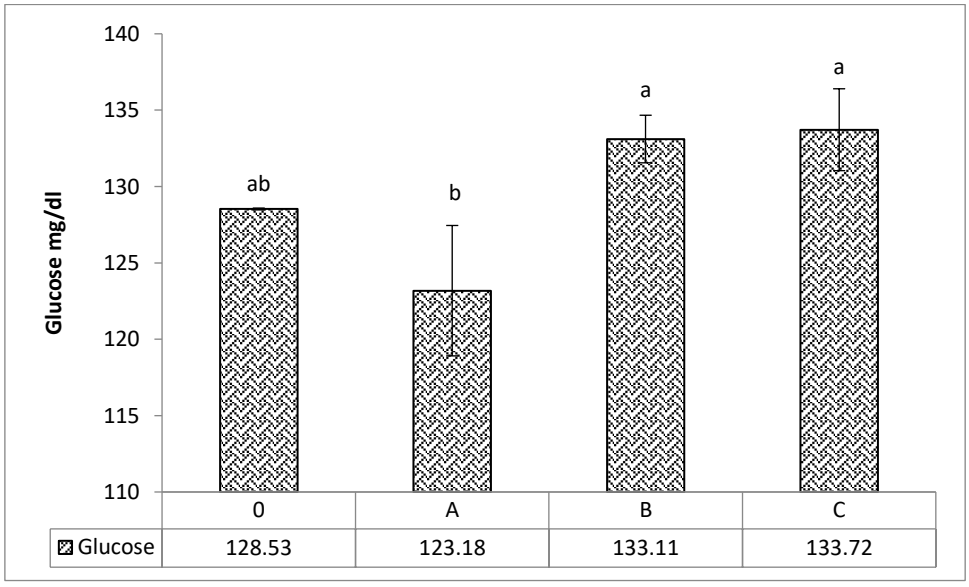

Fig. 4. Glucose content (mg/dl) in serum of the three groups of common carp fingerlings fed on fungal and vegetable sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

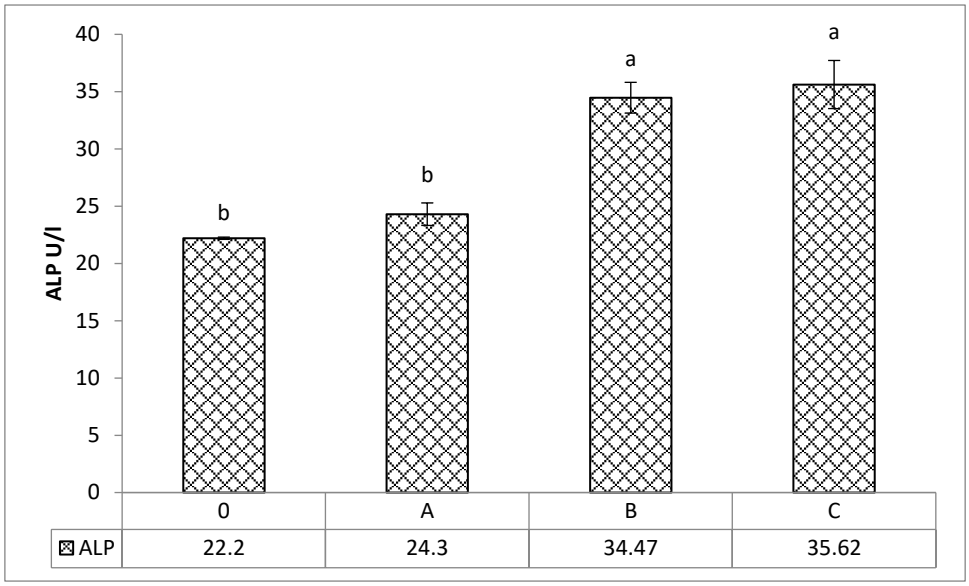

Fig. 5. ALP (U/l) in serum of the three groups of common carp fingerlings fed on fungal and vegetal sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

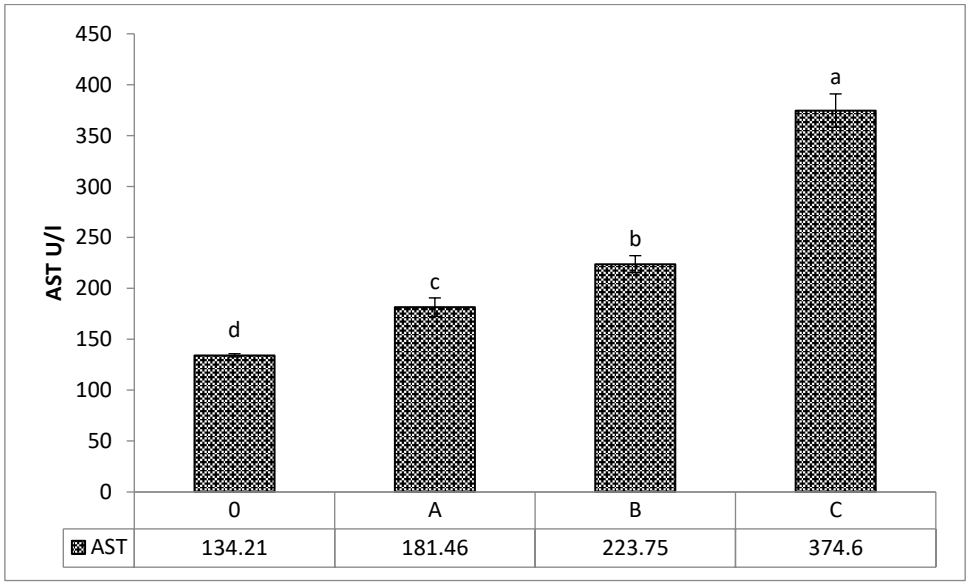

Fig. 6. AST (U/l) in serum of the three groups of common carp fingerlings fed on fungal and vegetal sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

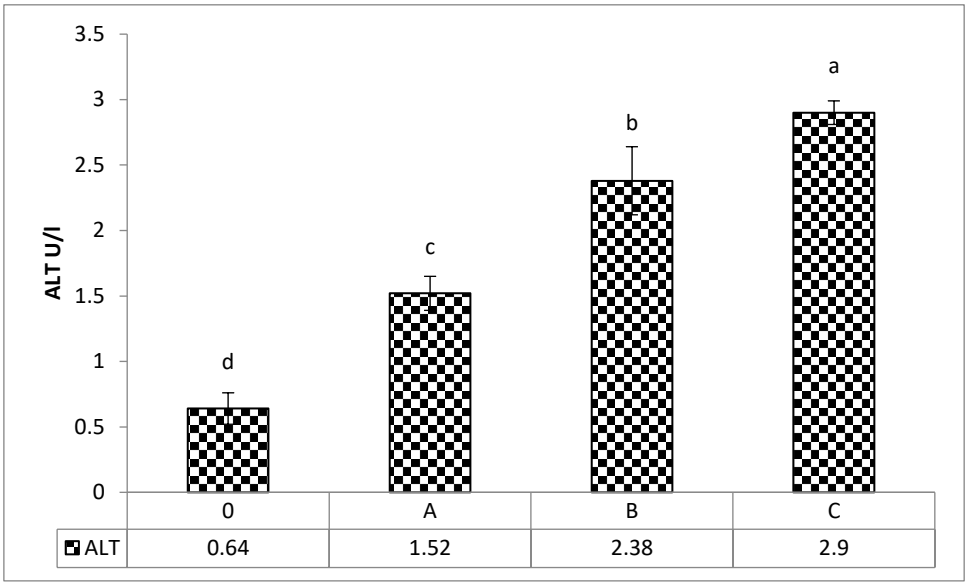

Fig. 7. ALT (U/l) in serum of the three groups of common carp fingerlings fed on fungal and vegetal sources of β glucan. *Different letters means there were significant differences (P > 0.05) between groups.

4. Discussion

Generally, the use of natural immunostimulators like β-glucan had advantageous effects in aquaculture as they could strengthen innate immunity, increase disease resistance and improve growth performance in cultured fish. Add to that, they are Environmentally friendly materials, decomposable, and safe for consumption (Ortuno *et al*., 2002). In intensive aquaculture, β-glucans could be used enormously because of their anti-stress and non-toxic features (Maqsood *et al*., 2011). And for this, it had been broadly employed to decrease the undesirable stress influences, rise disease impedance, and betters numerous physiological parameters (Shelby *et al*., 2009; Welker *et al*., 2007; Cain *et al*., 2003; Cook *et al*., 2003). There are many types of β-glucans that differ in their structure and immunostimulation activity. Many studies were done on the addition of different sources of β-glucans in fish diets, whether it is commercial or prepared, and had focused on the improvement of innate immunity and disease resistance. However, most of these studies were of short periods and didn't investigate fish growth performance. For this, in this research, the long-term impact (60 days) of fungal and vegetal sources of diet additive β-glucan on growth performance including WI, GR, RGR, SGR, and survival rates as well as physiological status of blood parameters PCV, OP, TP, GLU and ALP, AST, ALT enzymes activity were determined.

Results of our study exhibited that growing performance factors and survival rates were not influenced with long-term administration of the two dietary sources of β-glucan, as no significant variances (P > 0.05) among groups A, B and C in these parameters were found, Although there was an increase in growth and survival rates in groups A and B it was not significant. In consonance with our outcome, Adloo *et al.*(2015) found that the long-term effect of dietary administration of different ratios of β-glucan had no significant effect on the growth and survival indexes in striped catfish *Pangasianodon hypophthalmus*. Di Domenico *et al*. (2017) found that the addition of (0.01 and 0.1%) of β-glucan to silver

catfish *Rhamdia quelen* diet for 42 days, had no effect on its growth performance. Nieves-Rodriguez *et al*. (2018) Study on Tropical Gar (*Atractosteus tropicus*) Juveniles found no significant differences in growth performance after 62 days of cultivation on β-glucan administrated diets.

In contrast, numerous research papers showed that β-glucan enhanced growth performance in fish significantly. Khanjani *et al*. (2022) study presented that the β-glucan added to diets in different concentrations led to a significant increment in growth performance and survival rates in rainbow trout *Oncorhynchus mykiss* from the control group. Likewise, the same results on different types of fish were investigated (Ghaedi *et al*., 2015; Guzman-Villanueva *et al*., 2013; Chiu *et al*., 2010; Garcia & Villarroel, 2009; Welker *et al*., 2007; Whittington *et al*., 2005). The use of 1% and 2% of the commercial β-glucan "MacroGard" in diets of mirror carp led to an improvement in growth performance factors WI, SGR, and FCR from 0.1% β-glucan and the control diets (Kuhlwein *et al*., 2013).

On the other hand, this study realized a significant improvement in the physiological performance of common carp *C. carpio* fish fed the diet of fungal β-glucan from baker's yeast (A group), followed by the diet of vegetal β-glucan from brown barley bran (B group). All the physiological factors selected in this study are closely related to stress, as they are good indicators for detecting the state of stress occurring in fish (Alkatrani, 2017; Alkatrani *et al*., 2018). The lower their levels, especially when long-term exposure, is an indication of the good health of the fish (Alkatrani *et al*., 2014). The blood parameters PCV, OP, TP, GLU and ALP, AST, and ALT enzymes activity in fishes from group A were significantly lower ($P < 0.05$) from the control fish (C group), while just GLU content and ALP activity in fishes from group B were non-significantly lower ($P > 0.05$) than the control fish. This indicates that the fish in groups A and B are less stressed than the fish in group C. The results also presented that the diets added with fungal β-glucan were more effective than the diets with vegetal β-glucan in stress-reducing and immunostimulation of common carp fish. Many studies are in agreement with these results. fingerlings of *Labeo rohita* showed an improvement in growth performance, survival rate, and immune response when fed on β-glucan additive diets (Misra *et al*.,2006).A study of Adloo *et al*. (2015) noticed a significant rise in the serum lysozyme action and total protein of *P. hypophthalmus* fed on various concentrations of added β-glucan. Lopes *et al*. (2022) results in evaluating the short-term effect (15 days) of the diets additive β-glucan derived from baker's yeast on metabolic responses, innate immunity, and stress in juveniles of *Piaractus mesopotamicus* found an increase in the respiratory activity of leukocytes (RAL), hemolytic activity and lysozyme activity in fish serum as immunostimulation indicators, and a reduction of plasma glucose and cortisol as a stress biomarkers. Reis *et al*. (2021) found an improvement in anti-oxidant status in liver oxidative stress biomarkers: total glutathione, SOD, CAT, and LPO in juveniles of *Sparus aurata* fed of diets added with two sources of β-glucan from *Saccharomyces cerevisiae*, the baker's yeast, and *Phaeodactylum tricornutum* a microalga at periods of 2 and 8 weeks. A study by Soltanian *et al*. (2014) evaluated the influences of β-glucan in diets of striped catfish (*Pangasianodon hypophthalmus*) on fish responses to cold stress, and found no significant alterations in glucose and cortisol among treatments and control fish. But, the death rate was depressed significantly. Results of Dawood *et al*. (2017) found an improvement in red sea bream *Pagrus major* growth performance factors, impedance to stress of salinity, and immune reaction which fed on three percentages of added β-glucan [250, 500, and 1000 mg /kg] to artificial diets after 56 days of cultivation.

Sado *et al*. (2016) announced that the intraperitoneal injection of β-glucan was better in immunostimulation for juvenile Nile tilapia *Oreochromis niloticus* than oral and immersion of β-glucan after 15 days of study. Correspondingly, many researchers have stated an improvement in enzymes activity after supplementation of β-glucan in diverse quantities (Lauridsen & Buchmann, 2010; Siwicki *et al*. 2009; Misra *et al*. 2006; Bagni *et al*. 2005; Ortuno *et al*. 2002).

Actually, several limitations such as time and duration of management, different manufacturing processes of β-glucan, type and source, and concentration added of β-glucan, in addition to environmental factors, may be affect results obtained from different experiments, This explains the difference in results among different studies (Del Rio-Zaragoza *et al*. 2011; Mohammad *et al*. 2011; Bridle *et al*. 2005; Couso *et al*. 2003).

5. Conclusion

We infer from this study that the addition of fungal and vegetal sources of β-glucan to common carp diets conducted to a non-significant rise in growth performance parameters and survival rates, while it guided to a significant improvement in the physiological functioning of the stress indicators PCV, OP, TP, GLU, ALP, AST, and ALT in the blood of common carp fish. Also, the fungal β-glucan was more effective than the vegetal β-glucan in stress-reducing of common carp fish.

The study encourages the addition of the fungal source of β-glucan derived from baker's yeast *S. cerevisiae* to the artificial diets of common carp as an Immunostimulator for its health enhancement.

Acknowledgments

The authors would like to extend their thanks and gratitude to all the employees of the vertebrate department in the Marine Science Center, where the study was carried out in the Laboratory of Aquaculture and the Laboratory of Fish Physiology. The authors confirm that there were no competing interests with others. This research did not obtain any special funds from funding organizations in the communal, commercial, or not-for-profit sectors.

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تأثير التناول الغذائي لمصدرين بيتا جلوكان على النمو والنشاط الفسيولوجي لأسماك الكارب الشائع

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المستخلص. تم إجراء تجربة نمو لتقدير تأثير مصدرين مختلفين من بيتا جلوكان، الفطرية المشتقة من خميرة الخبز *Saccharomyces cerevisiae* والنباتية المشتقة من نخالة الشعير *Hordeum vulgare* كتأثير طويل الأمد على أداء النمو ومعدل البقاء والحالة الفسيولوجية. في إصبعيات أسماك الكارب الشائع (*Cyprinus carpio*) بعد 60 يومًا من التغذية على علائق صناعية تحتوي على 3٪ بيتا جلوكان فطري (المجموعة أ)، و3٪ بيتا جلوكان نباتي (المجموعة ب)، بالإضافة إلى 0٪ بيتا جلوكان (المجموعة ج) كمجموعة سيطرة وبواقع مكررين لكل مجموعة. تم تقدير بعض مؤشرات الدم مثل حجم الخلية المرصوصة PCV، والضغط الأزموزي OP، ومحتوى البروتين الكلي TP، ومحتوى الجلوكوز GLU، وإنزيمات ALP، AST، وALT. أظهرت نتائج أداء النمو بما في ذلك زيادة الوزن ومعدلات النمو ومعدلات النمو النسبي ومعدلات النمو النوعية، وكذلك معدلات البقاء عدم وجود فروق معنوية ($P > 0.05$) بين المجموعات الثلاث، على الرغم من وجود ارتفاعات في هذه القيم في المجموعة الفطرية (A) والمجموعة النباتية (B) لمضافات البيتا جلوكان مقارنة بالمجموعة الضابطة C. وعلى العكس من ذلك، أظهرت معظم القياسات الفسيولوجية المقدرة في دم الأسماك تحسنا ملحوظا في الأداء في المجموعة A ثم المجموعة B، حيث أظهرت قيم PCV، OP، TP، GLU، ALP، AST وALT انخفاضًا معنويًا ($P <0.05$) للمجموعة A والمجموعة B من المجموعة الضابطة C. وأكدت الدراسة أن إضافة البيتا جلوكان إلى علائق الأسماك، وخاصة المشتقة من المصدر الفطري، أدى إلى زيادة غير معنوية في معدلات النمو والبقاء، في حين أدى إلى تحسن كبير في الأنشطة الفسيولوجية للمعاملات PCV، OP، TP، GLU، ALP، AST، وALT في دم الأسماك. تشجع الدراسة على إضافة المصدر الفطري للبيتا جلوكان إلى العلائق الصناعية لسمك الكارب الشائع كعامل محفز مناعي لتعزيز صحته.

الكلمات المفتاحية: بيتا جلوكان، مصدر فطري، مصدر نباتي، الكارب الشائع، النمو، المؤشرات الفسيولوجية.