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Water Quality Effects On Growth Performance And Physiological Indices Of Common Carp Fingerling Fed On *Moringa Oleifera* Leaf

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Abstract

The current study was carried out to investigate water quality effects on common Carp Fingerling Fed on dietary supplementation of *Moringa oleifera* leaf on growth performance, approximate carcass compositions and haematological and biochemical parameters in common carp, *Cyprinus carpio* fingerlings (average weight 27.31 ± 0.04 g) for 12 weeks. Four experimental diets were prepared with supplemented with MOLP at levels of 0 (control diet), T1 (1%MOLP/Kg), (2%MOLP/Kg) and (4%MOLP/Kg). The results showed that all supplemented groups had promising growth, in which significantly improved ($P<0.05$) in final weight (FW), weight gain (WG), specific growth rate (SGR), feed conversion rate (FCR), feed conversion efficiency (FCE), and protein efficiency rate (PER). Whoever, the dietary treatments had no significant impact ($p<0.05$) on ether extract, crude protein, crude ash, moisture, energy, and crude fiber content of the fish. The result of this study had a significant effect on some biochemical blood parameters including CHOL, TG, HDL, LDL, VLDL, TP and globulin but there was no significant difference in ALB. Complete blood count of the fish showed a significant ($P > 0.05$) increase in WBC and RBC, HGB and HCT levels with MOLP varying levels. The MCV of the fish fed 1%MOLP was significantly lower compared to control group, MCHC levels of fish fed 1%MOLP diet were significantly higher than fish fed on the control diet ($P > 0.05$). The MCH and MPV levels of MOLP diets had no significant difference with the control group ($P > 0.05$). The PLT levels of fish fed with 2 and 4%MOLP were significantly ($P > 0.05$) higher than fish fed the control diet. LPCR levels in fish fed with 4% MOLP decreased significantly compared to the control diet ($P > 0.05$). The study examined the impact of different concentrations of Moringa oleifera leaf powder (MOLP) on water quality parameters. Results showed temperature variations (31.24°C to 33.50°C) and pH changes (8.20 to 10.30). MOLP changed electrical conductivity (550.12 to 566.10 μS/cm) and total dissolved solids (288.20 to 306.30 mg/L). Dissolved oxygen remained stable at around 8.00 mg/L, while turbidity decreased (6.67±0.84 to 2.08±0.85 NTU). Ion concentrations (Cl, Na, K, Ca, Mg, SO4) fluctuated across MOLP levels. Total alkalinity ranged from 138.76 to 144.62 mg/L. Nitrate levels varied (13.32 to 13.80 mg/L), while nitrite and ammonia levels were low (0.00 to 0.02 mg/L and ~0.05

CC License CC-BY-NC-SA 4.0	mg/L, respectively). Total hardness increased (155.05 to 173.71 mg/L) with MOLP, notably at 2% concentration. These findings suggest MOLP's potential in water treatment, warranting further investigation for environmental applications. ***Keywords: Common carp fingerlings, Growth parameters, Haematology and biochemical parameters, Moringa oleifera leaf powder, Proximate body composition, water quality parameters***

Introduction

Aquaculture is an industrial process of raising aquatic organisms up to final commercial production within properly partitioned aquatic areas, controlling the environmental factors and administering the life history of the organism positively. It has to be considered as an independent industry from the fisheries hitherto (Dalkiran, 2020). The significance of aquaculture in global development has become increasingly important due to the rising demand for seafood protein, which is driven by population growth, higher incomes, and urbanization, Naylor (2016).

In fish production systems, good nutrition is a crucial aspect of producing a healthy, high-quality product in an economically feasible manner. This is particularly important in fish farming, as feed typically accounts for around 50 per cent of the variable production cost. In recent years, fish nutrition has advanced significantly with the development of new, balanced commercial diets that promote optimal growth and health (Craig *et al*., 2017). The development of species-specific diet formulations has also helped support the aquaculture industry as it seeks to meet the increasing demand for affordable, safe, high-quality fish and seafood products. Artificial feeds can be either complete or supplemental, with complete diets providing all the essential ingredients (protein, carbohydrates, fats, vitamins, and minerals) necessary for optimal growth and health of the fish. The nutritional composition of the feed depends on the species of fish being cultured and at what life stage (Prabu *et al.*, 2017).

One potential solution to malnutrition is *Moringa oleifera*, a plant belonging to the Moringaceae family. Moringa is rich in essential phytochemicals found in its leaves, pods, and seeds, making it an effective remedy for malnutrition (Gopalakrishnan *et al*., 2016), presence of bioactive compounds such as polyphenols, flavonoids, and vitamins in Moringa oleifera leaves and seeds (Abu Hafsa et al., 2020), Given that moringa is a high source of both macronutrients, such as proteins, lipids, and crude fibers, its ability to promote growth can be explained (Francis et al., 2001), microelements; potassium, phosphorus, sodium, magnesium, calcium, zinc, copper, manganese and iron (Biel et al., 2017). Moringa leaf has a significant amount of crude protein, 260 g/kg leaf, of which 87% is true protein (Makkar & Becker, 1996). In addition, moringa is a rich source of vital fatty acids and amino acids, which support the health and growth of fish (Ozcan, 2020).

In recent years, there has been a focus on using MOLP for different fish species. Nile tilapia fed dietary supplementation with 1.5% Moringa oleifera leaf meal has significantly enhanced specific growth rates, weight gain, and feed conversion ratio, (Elabd et al., 2019). Similarly, dietary supplementation with 5% MOLP noticeably improved the FCR and final body weight (FBW) of Nile tilapia (El-Kassas et al., 2020). Furthermore, *Moringa oleifera* leaf extract fed to *Oreochromis niloticus* exhibits significantly higher growth rates than the control fish fed, and the feed intake and feed conversion efficiency among the fish fed with *Moringa oleifera* leaf extract increases (Dongmeza *et al*., 2006). On the other hand, Juvenile gibel carp fed on dietary Moringa oleifera leaf meal have significantly higher growth rates and survival rates compared to the control group, and an increase was observed in the protein content of the fish fed with Moringa oleifera leaf meal, indicating improved nutritional quality (Zhang et al., 2020). A recent study investigating the effects of MOLP on the blood parameters of Nile tilapia fish found that the fish fed with MOLP had significantly higher levels of hemoglobin and red blood cell counts than the control group. The researchers also observed an increase in the number of white blood cells in the fish fed with *Moringa oleifera* leaf powder, indicating improved immune function (Ahmed *et al*., 2020).

Consequently, this study has aimed to advance knowledge of the effect of *M. oleifera* leaf powder as a dietary supplement on growth, water quality and hematological aspects.

2. Materials and Method

2.1 Preparation of experimental diets

Preparation of *Moringa oleifera* leaf powder (MOLP)

Dry *Moringa oleifera* leaf powder (MOLP) was obtained from the research centre of Sulaymaniyah. The leaves were kept in a plastic bag and transferred to the laboratory. Then, they were cleaned and ground to a powder using the grinder and were sieved using a household sifter then MOLP was stored in plastic bag at room temperature until use.

Diet formulation: A basal diet and three experimental diets were prepared to supplement 1%, 2% and 4% MOLP/kg diet. Diets were formulated isonitrogenous 32% and isolipidic 7% (Table 1). All ingredients were homogenized and mixed by a commercial food mixer and then blended with oil, and water was added until a solid dough was formed. Diet pellets were extruded Using a cold press extruder (SUNRRY, model: SYMM12, China) with a 2-mm aperture die and then air-dried at room temperature, stored in plastic pack for each separate diet until use.

Table1. Formulation of experimental diets and proximate composition of diets and Moringa oleifera leaf powder (MOLP)

		Basic diet	Experimental diets		
Ingredients					
Soybean meal (g) [a]		570	570	570	570
Corn (g) [b]		130	130	130	130
Fishmeal (g) [c]		100	100	100	100
Soya oil (g) [d]		45	45	45	45
Wheat flour (g) [e]		100	90	80	60
Wheat bran (g) [f]		10	10	10	10
PREMIX (g) [g]		45	45	45	45
Moringa oleifera leaf powder (MOLP) (g) [h]		0	10	20	40
Feed Ratio formulation (g)		1000	1000	1000	1000
Proximate analysis					
	MOLP				
Dry matter %	95.10	93.64	93.79	93.82	93.91
Crude protein %	24.79	31.04	30.86	30.68	30.32
Crude lipid %	7.29	6.74	5.90	5.84	5.72
Crude fiber %	23.93	3.06	3.28	3.73	4.26
Crude ash %	15.34	6.80	6.89	7.00	7.15
Metabolic Energy (kcal/kg)	2139	3271	3222	3200	3170

[a] Soybean was obtained from Kosar Local Company and originally sourced in BAF in Turkey and consists of (Dry mater=89%, MEn=2,230 kcal/kg, protein=44%, crude lipid=0.8%, crude fiber=7%, total phosphorus=0.65%). [b] Corn: (Dry matter=92%, MEn=1,525 kcal/kg, protein=19.2%, crude lipid=2.1%, crude fiber=14.4%, total phosphorus=0.65%). [c] Fis8 meal: (Dry matter =0%, protein=65%). [d] Soya oil. [e] Wheat flour: (Dry matter=87%, MEn=2,900 kcal/kg, protein=14.1%, crude lipid=2.5%, crude fiber=3%, total phosphorus=0.37%). [f] Wheat bran: (Dry matter=89%, MEn=1,300 kcal/kg, protein=15.7%, crude lipid=3% crude fiber=11%, total phosphorus=1.15%). [g] Vitamin Premix sourced in Kosar Company and originally sourced in BAF in Turkey and consists of Vitamin D3 (300,000 IU/kg), Vitamin A (200,0000 IU/kg), Vitamin K3 (1,600 mg/kg), Vitamin E (40,000 mg/kg), Vitamin C (150,000 mg/kg), Vitamin B6 (2,000 mg/kg), Vitamin B2 (3,000 mg/kg), Vitamin B1 (2,000 mg/kg), Pantothenic acid B5 (20,000 mg/kg), Niacin B3 (8,000 mg/kg), Folic acid (800 mg/kg), Cholin (45,000 mg/kg), Biotin (2,000 mg/kg). Mineral Premix consists of 1- trace minerals consisting of selenium (60 mg/kg), manganese (3,000 mg/kg), Cobalt (20 mg/kg), Iodine (200 mg/kg), Zinc (6,000 mg/kg), Copper (30,000 mg/kg)2- calcium carbonate 41% 3- salt 1g/kg limestone 14g/kg. [h] Moringa oleifera leaf powder: obtained from Sulaymaniyah Agriculture research center, Sulaymaniyah Kurdistan Region, Iraq

2.2 Experimental fish and design

Juvenile common carp (*Cyprinus carpio L.*) were obtained from a private fish farm in Erbil, Kurdistan Region of Iraq. Fish were transported to the aquaculture unit, Grdarasha station, College of Agriculture Engineering Sciences, Salahaddin University- Erbil, Kurdistan Region -Iraq. The fish were stocked into 12 cement ponds (2 m^3) (length 2m, width 1m, depth 1m), Fish were acclimatized to the pond system for 2 weeks and fed commercial diets. A total of 180 fish were distributed into 12 cement ponds (15 fish in a pond, with an initial mean weight of 27.31 ± 0.04 g). Each diet was fed to triplicate rectangular cement ponds for 12 weeks, the diets were hand fed to the fish twice a day at 9:00 am and 5:00 pm, at 3% of live fish body weight. Fish biomass was weighed weekly and daily feeding of each experimental group was adjusted weekly. Flow-through aeration was provided by an electrical aerator. Two-thirds of water was exchanged twice a week to maintain the water quality.

2.3 Water quality

Water samples were collected from cement ponds for evaluation of physical and chemical properties of water according to standard procedures of APHA (1998) and Maiti (2004). Water samples were collected for 12 weeks from May to the end of July 2022 daily for the evaluation of (PH, EC, TDS, Temperature, DO) and weekly for analyzing (Turbidity, Chloride, Sodium, Potassium, Calcium, Magnesium, Total Alkalinity, Nitrate, Sulphate, Ammonia, Total Hardness) tests.

Water pH, EC, temperature and TDS parameters were measured directly in the field by portable device (Hanna, HI98129, CE; Made in Mauritius), dissolved oxygen by portable DO-meter model (AZ 8403) (electrometric method). Turbidity was measured with a HACH. 2100N Turbidimeter, chloride by argentometric method. Sodium, Calcium and Potassium were determined by (Jenway PFP7, Flame Photometer).

2.4 Assessment of Growth Performance and Feed Utilization

After 12 week feeding period, the following growth performance and feed utilization were measured:

- Weight gain (g/fish) = Final Wt (W2)-Initial Wt (W1).
- Specific growth rate (SGR %) was calculated as follows:

SGR % = (Final body weight-Initial body weight) /T (experimental period) x100

- Feed conversion ratio (FCR) = (Total feed intake, g)/ (Total wet weight gain, g).
- Total feed intake (TFI, g)
- Protein efficiency ratio (PER) was calculated as follows:

PER = (Total weight in wet, g/ fish) / (administered protein amount, g/ fish).

2.5 Proximate composition analyses

Analyses for test diets and fish samples were performed, three initial fish were dried and ground into powder. After 12 weeks, three fish from each pond (nine fish per treatment) were dehydrated in a fan assisted oven at 105°C for 48 hours until a constant weight was achieved, then the fish was ground into powder and moisture content was determined. Protein was measured using the Kjeldal method, involving digestion, distillation, and titration. Fat was separated using the flying droplet siphon method and measured accordingly. The Ash level of the samples was measured by incineration in a muffle furnace at 550°C for a period of 24h. Fibre analysis involved the addition of diluted sulfuric acid, boiling, filtration, the addition of NOH, then boiling, and filtration again to obtain the residue as fibre content. These tests were conducted at the Barash feed factory lab in Erbil, Kurdistan Region of Iraq.

2.6 Hematological tests

At the end of the experiment, blood was obtained from the caudal vein of six fish from each treatment by the needle from the ventral body wall, fish were not fed for 24h before sampling. The blood sample was carefully transferred into a Vacuum k3 EDTA tube and immediately the tubes were inverted 8-10 times to ensure adequate anticoagulation of the sample then placed in a box full of ice and was taken to the laboratory for CBC test including white blood cell (WBC), red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), concentration of hemoglobin in a RBC relative to the size of the cell (MCHC), red cell distribution (RDW), number of platelets (PLT), mean platelet volume (MPV), Platelet-large cell ratio (LPCR), cholesterol (CHOL), triglycerides (TG), high density lipoprotein (HDL), low density lipoprotein (LDL) total protein (TP), albumin (ALB), Globulin, very low density lipoprotein (VLDL).

2.7Statistical analysis

The results of this study are displayed as mean ± standard deviations (SD). The hypothesis of normality and homogeneity for data was confirmed. Various parameters including growth performance, body composition, feed efficiency, hematological indices, and serum biochemical parameters were subjected to analysis of oneway (ANOVA) using SPSS software (version 26) to investigate the impact of MOLP levels. significant differences among the treatments were identified using Duncan's test with a significance level set at 0.05.

3. Results

3.1water quality parameters

The mean temperatures of studied water samples were 31.24 °C, 33.50 °C, 31.22 °C and 31.20 °C, while mean PH values recorded were 10.30, 8.20, 8.30 and 8.23, Regarding mean EC 550.12 µS/cm, 558.60 µS/cm, 566.10 µS/cm and 563.00 µS/cm, however, the mean values for TDS were 288.20 mg/L, 289.40 mg/L, 306.30 mg/L and 291.23 mg/L, Furthermore, the DO mean values remained relatively constant during the study period, with values of 7.86 mg/L, 8.12 mg/L, 7.93 mg/L and 7.84 mg/L during the study period for 0%MOLP, 1%MOLP, 2%MOLP and 4%MOLP groups respectively. Turbidity reduced in MOLP treatment levels compared to the control with values of 6.67±0.84, 2.37±0.73, 3.47±1.06, 2.08±0.85 for 0%MOLP, 1%MOLP, 2%MOLP and 4%MOLP groups respectively. fluctuations observed in ion concentrations (Cl, Na, K, Ca, Mg, SO4) with values of Cl 160.98±11.17, 151.06±15.05, 159.35±14.34, 155.82±13.40, Na mean values were 65.75±5.28, 66.60±4.41, 68.96±6.93, 69.11±3.52, with mean values of K 4.69±1.03, 5.44±1.33, 5.25±1.50, 4.93±1.16, Ca mean values were 78.65±36.22, 79.80±28.78, 81.57±33.69, 86.24±29.75, Where the mean values of Mg were 5.27±12.44, 3.45±9.08, 4.83±10.76, 3.02±7.50 and SO4 mean values 90.99±13.58, 85.72±14.34, 93.35±10.53, 88.22±9.46 for 0%MOLP, 1%MOLP, 2%MOLP and 4%MOLP groups respectively. Mean values of total alkalinity 138.76±26.53, 139.48±19.98, 142±24.89, 144.62±20.99 for 0%MOLP, 1%MOLP, 2%MOLP and 4%MOLP groups respectively. The mean nitrate levels were found to be 13.58 ± 0.67 mg/L for the control group, 13.80 ± 0.88 mg/L for 1% MOLP, 13.32 ± 0.92 mg/L for 2% MOLP, and 13.69 ± 0.82 mg/L for 4% MOLP.

Table 2: Water quality parameter for common carp fingerlings cultured in cement pond system fed with various levels of Moringa oleifera leaf powder for 12 weeks

Parameters	**Control**	**MOLP 1%**	**MOLP 2%**	**MOLP 4%**
Temperature	31.24±4.25	33.50±27.00	31.22±4.35	31.20±4.40
PH	10.30±27.50	8.20±0.50	8.30±0.50	8.23±0.50
EC	550.12±131.20	558.60±136.00	566.10±136.84	563.00±130.00
TDS	288.20±73.00	289.40±71.21	306.30±74.80	291.23±72.20
DO	7.86±0.22	8.12±0.72	7.93±0.27	7.84±0.14
Turbidity	6.67±0.84	2.37±0.73	3.47±1.06	2.08±0.85
Cl	160.98±11.17	151.06±15.05	159.35±14.34	155.82±13.40
Na	65.75±5.28	66.60±4.41	68.96±6.93	69.11±3.52
K	4.69±1.03	5.44±1.33	5.25±1.50	4.93±1.16
Ca	78.65±36.22	79.80±28.78	81.57±33.69	86.24±29.75
Mg	5.27±12.44	3.45±9.08	4.83±10.76	3.02±7.50
Total alkalinity	138.76±26.53	139.48±19.98	142±24.89	144.62±20.99
NO3	13.58±0.67	13.80±0.88	13.32±0.92	13.69±0.82
NO2	0.05±0.06	0.00 ±0.00	0.02±0.02	0.01±0.02
NH3	0.05±0.06	0.05±0.06	0.04±0.06	0.04±0.05
SO4	90.99±13.58	85.72±14.34	93.35±10.53	88.22±9.46
Total hardness	153.71±35.89	155.05±35.98	173.71±31.37	170.86±34.07

Data are expressed as mean ± SD.

Minimal variability was observed in nitrite levels across the different MOLP concentrations. The control group exhibited a mean nitrite concentration of 0.05 ± 0.06 mg/L, while the concentrations of nitrite in MOLP-treated groups remained relatively low, ranging from 0.00 ± 0.00 mg/L to 0.02 ± 0.02 mg/L. Similar to nitrite, ammonia concentrations showed negligible changes across the MOLP-treated groups compared to the control. The control group recorded a mean ammonia concentration of 0.05 ± 0.06 mg/L, with MOLP-treated groups maintaining levels within the same range. Analysis of total hardness indicated notable changes across the MOLP-treated groups. The control group had a mean total hardness of 153.71 ± 35.89 mg/L, while MOLP-treated groups demonstrated varying degrees of alteration, ranging from 155.05 ± 35.98 mg/L to 173.71 ± 31.37 mg/L. Notably, the 2% MOLP concentration showed the highest increase in total hardness compared to the control (Table 2).

3.1 Growth performance and feed utilization

The growth parameters of *C. carpio* are detailed in Table 3. The findings of growth performance revealed that all experimental groups exhibited substantial growth over the 12-week nutritional trial, evidenced by an increase in body weight. Notably, the mean values of the groups administered *M. oleifera* based diets exhibited a significant difference in the final weight, weight gain, specific growth rate, feed conversion ratio, feed conversion efficiency, and protein efficiency rate in comparison to the control group. Regarding to FI, PI, and survival rate there was no significant difference between groups, while for FW, WG and SGR the highest mean value was 1%MOLP group. The best FCR mean value was observed in the control group. The lowest mean value of PER is in the control group and the groups fed with MOLP were significantly different with the control group.

Table 3: Growth response, nutrient utilization and survival rate of *C. carpio* fed with various levels of MOLP for 12 weeks.

Parameters	Control	**MOLP** 1%	**MOLP** 2%	**MOLP** 4%
IW	27.33±0.07	27.29±0.03	27.31±0.03	27.29±0.03
FW	49.40±0.53^{c}	53.65±1.24^{a}	52.64±0.62^{ab}	51.96±0.48^{b}
WG	22.07±0.47^{c}	26.36±1.20^{a}	25.33±0.64^{ab}	24.67±0.52^{b}
SGR	0.82±0.01^{c}	0.94±0.03^{a}	0.91±0.02^{ab}	0.89±0.01^{b}
FI	88.14± 1.22	92.86±2.54	91.44±2.30	90.57±3.51
FCR	4.12±0.17^{b}	3.61±0.09^{a}	3.61±0.05^{a}	3.67±0.14^{a}
FCE	24.30±1.01^{b}	27.70±0.67^{a}	27.71±0.40^{a}	27.26±1.10^{a}
PI	27.36±0.38	28.99±0.79	28.06±0.70	27.46±1.06
PER	0.783±0.032^{b}	0.898±0.022^{a}	0.903±0.013^{a}	0.899±0.036^{a}
Survival rate	97.78±3.85	97.78±3.85	100.00±0.00	100.00±0.00

Data in the same row with different subscripts are significantly different (P≤0.05).
Data are expressed as mean ± SD.

3.2Proximate analyses of fish

In the comprehensive proximate analysis of whole dried fish, the influence of the various feed treatments exhibited no statistically significant difference concerning ether extract, crude protein, crude ash, moisture content, energy, and crude fibre, as presented in Table 4.

Table 4: Effects of supplementation of MOLP levels on Whole body percentage of common carp (*Cyprinus carpio*) fingerlings.

Parameters	Control	**MOLP** 1%	**MOLP** 2%	**MOLP** 4%
Moisture	**74.00±2.00**	**76.00±1.50**	**74.22±2.00**	**74.40±2.00**
Protein *	**54.55±2.23**	**56.18±1.53**	**54.56±3.23**	**54.62±2.11**
Fat *	**31.15±2.01**	**27.84±2.24**	**31.22±3.15**	**31.21±2.62**
Ash *	**8.53±0.75**	**9.50±1.05**	**7.98±0.82**	**8.75±0.13**
Fiber *	**0.58±0.28**	**0.68±0.11**	**0.84±0.17**	**0.83±0.02**
Energy	**4645.33±125.30**	**4434.33±155.22**	**4649.33±186.38**	**4628.00±131.67**

Data in the same row with different subscripts are significantly different (P≤0.05).
Data are expressed as mean ± SD.
*Dry matter basis

3.3Blood parameters

The hematology indices result of C. carpio juveniles are shown in Table 5. Dietary supplementation of MOLP persuaded a significant (P > 0.05) increase in differential WBC and RBC, HGB and HCT levels compared to the control diet. The MCV of the fish fed 1%MOLP was significantly lower than that of fish fed on a control diet. However, MCHC levels of fish fed 1%MOLP dietary treatment were significantly higher than in fish fed the control diet (P > 0.05). The MCH and MPV levels of fish fed the dietary treatment did not differ significantly from those of fish fed the control diet (P > 0.05). The PLT levels of fish fed with 2 and 4%MOLP were significantly (P > 0.05) higher than fish fed the control diet. LPCR levels in fish fed with 4% MOLP decreased significantly when compared to the control diet (P > 0.05).

Table 5: Blood profile of *C. carpio* fed with various levels of MOLP for 12 weeks

Parameters	Control	MOLP 1%	MOLP 2%	MOLP 4%
WBC	**95.05±0.36^{c}**	**98.07±0.46^{a}**	**98.17±0.52^{a}**	**96.60±0.35^{b}**
RBC	**1.50±0.04^{d}**	**1.90±0.04^{b}**	**2.05±0.86^{a}**	**1.81±0.04^{c}**
HGB	**11.42±0.15^{c}**	**15.10±0.60^{a}**	**15.90±0.63^{a}**	**14.27±1.03^{b}**
HCT	**25.88±0.47^{c}**	**30.52±1.20^{b}**	**34.58±1.62^{a}**	**31.95±1.37^{b}**
MCV	**172.60±5.67^{ab}**	**161.48±4.11^{c}**	**169.02±4.64^{b}**	**178.12±6.71^{a}**
MCH	**77.18±3.11**	**79.52±2.59**	**77.92±5.36**	**78.72±6.92**
MCHC	**44.12±0.86^{b}**	**49.52±2.11^{a}**	**45.26±4.08^{b}**	**44.71±3.65^{b}**
RDW	**8.43±0.24^{d}**	**10.85±0.77^{c}**	**13.02±0.48^{b}**	**14.17±0.68^{a}**
PLT	**4.80±0.67^{c}**	**5.37±0.62^{c}**	**6.77±0.49^{b}**	**8.17±0.98^{a}**
MPV	**14.37±0.81**	**14.40±0.50**	**14.40±0.33**	**14.55±1.40**
LPCR	**71.85±2.01^{a}**	**71.37±4.79^{a}**	**69.65±4.60^{ab}**	**66.78±1.22^{b}**

Data in the same row with different subscripts are significantly different ($P \leq 0.05$).
Data are expressed as mean ± SD.

The serum biochemical indices of *C. carpio* juveniles fed on different levels of MOLP are presented in Table 6. The fish fed with a control diet had significantly higher levels of CHOL and TG than the fish fed dietary treatments of MOLP ($P > 0.05$). The HDL and LDL levels of fish fed with MOLP supplementation diets were significantly lower than those of fish fed on a control diet ($P > 0.05$). TP levels had a decreasing trend with increasing MOLP, and significant differences were obtained in the fish fed with 4%MOLP when compared to the control diet ($P > 0.05$). The fish fed 4%MOLP had the lowest levels of globulin which were significantly ($P > 0.05$) lower than fish fed the control diet. However, no significant differences in the albumin levels were noticed between the dietary treatments.

Table 6: Biochemistry parameters of *C. carpio* fed with various levels of MOLP for 12 weeks

Parameters	Control	MOLP 1%	MOLP 2%	MOLP 4%
CHOL	**135.67±3.98^{a}**	**117.83±3.25^{b}**	**114.33±3.72^{b}**	**106.33±3.01c**
TG	**562.00±31.39^{a}**	**327.50±6.98^{c}**	**578.83±6.97^{a}**	**469.50±8.60^{b}**
HDL	**36.77±1.66^{a}**	**31.87±1.05^{b}**	**23.00±7.21^{c}**	**26.07±2.02^{c}**
LDL	**24.05±1.01^{a}**	**19.58±0.68^{b}**	**16.78±1.77^{c}**	**15.70±1.08^{c}**
VLDL	**67.00±2.28^{c}**	**107.33±6.50^{a}**	**113.50±6.92^{a}**	**96.17±8.01^{b}**
TP	**2.61±0.31^{a}**	**2.41±0.26^{ab}**	**2.42±0.19^{ab}**	**2.22±0.16^{b}**
ALB	**2.01±0.32**	**1.98±0.37**	**1.84±0.17**	**2.02±0.15**
Globulin	**0.60±0.08^{a}**	**0.43±0.17^{a}**	**0.58±0.23^{a}**	**0.20±0.11^{b}**

Data in the same row with different subscripts are significantly different ($P \leq 0.05$).
Data are expressed as mean ± SD.

4. DISCUSSION

The temperature of water stands out as a crucial element influencing pond dynamics, with the water temperature in fishponds being linked to the surrounding environmental temperature (Všetičková *et al*., 2012). In the present study, Overall, there is no variation in temperature across the different MOLP fed concentrations. The values remain relatively stable, where results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 31.24±4.25, 33.50±27.00, 31.22±4.35 and 31.20±4.40 respectively. the ideal range (24-30°C) recommended for the optimal growth of common carp (Santhosh *et al*., 2007). A slight decrease in pH is observed in the MOLP fed group compared to the control, where results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 10.30±27.50, 8.20±0.50, 8.30±0.50 and 8.23±0.50 respectively. The values for dissolved oxygen remain consistent across all groups where results for control, 1%MOLP, 2%MOLP and 4%MOLP showed /;16.00±5.00, 16.25±15.3, 16.00±7.00 and 16.00±6.00 respectively. the recommended range is a minimum DO of less than 5 ppm, with pH maintained between 6 and 9 (Billard *et al*., 1995). The electrical conductivity (EC) shows an increase in the group fed with MOLP concentration compared to control, where results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 550.12±131.20, 558.60±136.00, 566.10±136.84 and 563.00±130.00 respectively. Similar to EC, there's a modest increase in TDS with higher MOLP concentrations, where results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 288.20±73.00, 289.40±71.21, 306.30±74.80 and 291.23±72.20 respectively. A substantial decrease in turbidity is observed with MOLP groups. were results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 6.67±0.84, 2.37±0.73, 3.47±1.06 and 2.08±0.85 respectively. The EC, TDS and turbidity were within a suitable range of common carp culture (Ayroza *et al*., 2013). There's a slight decrease in chloride levels with MOLP concertation groups compared to the control. were results for control, 1%MOLP, 2%MOLP and 4%MOLP showed 160.98±11.17, 151.06±15.05, 159.35±14.34 and 155.82±13.40 respectively. The concentrations of sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg) show minor fluctuations, but no clear trend is apparent with increasing MOLP concentrations. were results of (Na) for control, 1%MOLP, 2%MOLP and 4%MOLP showed 65.75±5.28, 66.60±4.41, 68.96±6.93 and 69.11±3.52 respectively. And results of (K) for control, 1%MOLP, 2%MOLP and 4%MOLP showed 4.69±1.03, 5.44±1.33, 5.25±1.50 and 4.93±1.16 respectively. And results of (Ca) for control, 1%MOLP, 2%MOLP and 4%MOLP showed 78.65±36.22, 79.80±28.78, 81.57±33.69 and 86.24±29.75 respectively. And results of (Mg) for control, 1%MOLP, 2%MOLP and 4%MOLP showed 5.27±12.44, 3.45±9.08, 4.83±10.76 and 3.02±7.50 respectively which were within the acceptable range suggested in two studies for common carp culture (Boyd *et al*., 1999) (Bhatnagar *et al*., 2013).

It has been demonstrated that a variety of medicinal plants with a wide range of health benefits can enhance growth performance and activate fish immunological capabilities against a variety of fish pathogenic microorganisms. Every component of the plant, including the leaves, offers lots of beneficial physiologically active chemicals with growth and health-promoting properties (Ozcan, 2020).

The results showed that all supplemented groups had promising growth, in which was significantly better in final weight, weight gain, specific growth rate, feed conversion rate, feed conversion efficiency, and protein efficiency rate. Similarly, in a study conducted by El-Kassas *et al*., (2020) the effects of dietary *M. oleifera* leaves exposure on the growth parameters of tilapia fish were investigated, and their results revealed significant positive impacts on growth parameters. Also, Ebuka *et al*., (2021) recorded similar results on *Clarias gariepinus* juveniles where it gains weight significantly after feeding with *M. oleifera*. Furthermore, *Pangasius bocourti*, when fed with a diet incorporating moringa leaf at levels of 100 g/kg, 150 g/kg, and 200 g/kg, exhibited no apparent improvement in growth performance (Puycha *et al*., 2017). However, there was no significant difference in FI, survival rate and PI among the groups. This disagrees with Nyerhovwon and O.K.U.K.U., (2017) who recorded that the use of Moringa diets increased protein intake and feed intake of the experimental fish as treatment rate of the moringa constituent increased.

These findings suggest that the inclusion of *M. oleifera* in the diets positively influenced the growth and feed utilization of *C. carpio* fingerlings, leading to enhanced weight gain and improved feed conversion efficiency. The reason behind *M. oleifera* ability to enhance growth can be attributed to its richness of various nutrients. Moringa serves as a significant source of macronutrients like proteins, fats, and crude fibers (Francis *et al*., 2001).

The proximate analysis of whole dried fish aimed to assess the nutritional composition of the fish after being fed diets containing different MOLP levels. The results indicate that the dietary treatments had no significant impact on ether extract, crude protein, crude ash, moisture, energy, and crude fiber content of the fish. Results disagree with Ebuka *et al.,* (2021) who recorded those diets with varying MOLP levels exhibited distinct trends. For instance, 10% MOLP had the highest crude protein content, while 30% and 40% MOLP showed lower values. Additionally, the diets with higher MOLP concentrations (30%MOLP and 40%MOLP) displayed elevated levels of crude fiber, total ash, and a slight decrease in crude lipid content, results also disagree with the report of Dienye and Olumuji (2014), where the increase in fiber, moisture, ash found in the quality of fish carcasses that were fed *M. oleifera*. These findings suggest that the inclusion of MOLP in the diets did not alter the nutritional composition of the fish. This may be indicative of the nutrient-rich nature of MOLP, which may not have caused any negative changes in the fish's proximate composition (Liaqat *et al*., 2016).

It was observed that dietary supplementation of MOLP persuaded a significant increase in WBC, RBC, HGB and HCT levels compared to the control diet. The results agree with Elabd *et al*., (2019), who proposed a notable increase in the haematological parameters (such as RBC, WBC and HGB) in *O. niloticus* fish that were given a diet containing 1.5% moringa supplementation. Also, similar results were recorded by Elgendy *et al*., (2021) who reported a significant increase in the haematological parameters (RBC, Hb and HCT) in fish fed with moringa crude crushed leaves-supplemented diet. The results of the current study are in contrast with the study that noted a decrease in RBC count in African catfish, *Clarias gariepinus* when they were fed diets where *M. oleifera* leaf meal replaced fish meal. This study disagrees with Puycha *et al*., (2017) found that the hematocrit level showed no significant difference in fish that were fed a diet enriched with moringa leaf.

Notably, the MCV of the fish fed 1%MOLP was significantly lower than that of fish fed on the control diet. The present study attributed the decline to the elevated levels of antimetabolites, particularly tannins found in *M. oleifera* leaves (Ozovehe, 2013). MCHC levels of fish fed 1%MOLP dietary treatment were significantly higher than in fish fed the control diet. However, the MCH and MPV levels of fish fed the dietary treatment did not differ significantly from those of fish fed the control diet. This doesn't agree with the finding of Omar, (2023), who recorded decreased MPV and MCH values in common carp fed on rosemary leaf powder. Abdel-Tawwab *et al*., (2020) included varying levels of garlic and chitosan powders in *Dicentrarchus labrax* feed revealed an opposite trend where MCH increased. The PLT levels of fish fed with 2% and 4%MOLP were significantly higher than fish fed the control diet. Similarly, the study by Shahzad *et al*., (2016) stated that the supplement of MOLP increased the PTL of Catla catla. Also, agree with Arsalan *et al*., (2016) results showed an increase in PLT of *Labeo rohita* supplemented with MOLP. In this study, significant improvements were observed in certain haematological indices when dietary supplementation with *M. oleifera* was employed. The study also investigated the effect of MOLP-containing diets on the blood parameters of *C. carpio*. A study conducted by Osuigwe *et al*., (2005) emphasized that haematological indices in fish differ because of several factors, including age, size, physiological reactions, and environmental conditions. This variation indicates that the impacts observed rely on numerous factors such as the type of fish, size, the dose given, time of administration of supplements, and the physiological condition of the fish.

The study further examined various serum biochemistry parameters to evaluate the impact of MOLP supplementation on biochemical profiles. Fish fed with dietary treatments of MOLP had significantly lower levels of TG and CHOL than the fish fed control diet this agrees with Sangkitikomol *et al*., (2014), who recorded that MOLP could prevent the expression of several lipids metabolism genes accordingly reduce the cholesterol and lipid complexes. Younes *et al*., (2021) stated that providing *O. niloticus* with diets enriched by onion (*Allium cepa* L.) enhanced the fish growth performance while showing insignificant changes in triglyceride levels.

HDL and LDL levels of fish fed with MOLP supplementation diets were significantly lower than those of fish fed on a control diet. Similarly, a study by El-Kassas *et al*., (2020) showed that both HDL and LDL of Nile tilapia fed with MOLP decreased. Moreover, a study by Mahmoud *et al*., (2022) recorded a decrease in HDL and LDL of Nile tilapia fed with an MOLP supplement. TP levels decreased with increasing MOLP, significant differences were obtained in the fish fed with 4%MOLP when compared to the control diet which disagreed with the study of (Omar, 2023) where there was an increase in the total protein of the common carp fed with rosemary. Fish fed 4% MOLP had the lowest levels of globulin which were significantly lower than fish fed the control diet which differed from a study by Zhang *et al*., (2020) where his results showed that globulin increased in juvenile gibel carp fed with MOLP. However, no significant differences in the albumin levels were noticed between the dietary treatments which agreed with the study of (Omar, 2023) where there was no significant change in the albumin levels.

5. Conclusion

In conclusion, the utilization of medicinal plants presents a promising and effective approach for the enhancement of farmed fish health. These plants offer a diverse array of biologically active constituents that exhibit growth-promoting and immunostimulatory properties, rendering them invaluable in aquaculture practices. Amongst the notable medicinal plants renowned for their therapeutic attributes, *M. oleifera* emerges as a particularly noteworthy candidate.

M. oleifera is replete with biologically active compounds characterized by their potent immunostimulatory and antioxidant qualities. The inclusion of *M. oleifera* in the dietary regimen of *C. carpio* (common carp) at a supplementation rate of 10%MO has been demonstrated to yield significant benefits. This inclusion not only fosters improvements in growth performance but also enhances various physiological functions and augments immune competence. Thus, the findings of this study underscore the merit of incorporating *M. oleifera* into the diet of *C. carpio* at the specified ratio of 10%MO. Such an approach represents a judicious strategy for the cultivation of healthier and more robust fish populations, highlighting its potential significance in the context of sustainable aquaculture practices. Further research endeavours in this domain are warranted to explore the full spectrum of benefits and mechanisms underlying the use of medicinal plants like *M. oleifera* in the realm of aquaculture.

6. References

1. Abdel-Tawwab, M., Khalil, R.H., Metwally, A.A., Shakweer, M.S., Khallaf, M.A. and Abdel-Latif, H.M., 2020. Effects of black soldier fly (Hermetia illucens L.) larvae meal on growth performance, organs-somatic indices, body composition, and hemato-biochemical variables of European sea bass, Dicentrarchus labrax. Aquaculture, 522, p.735136.
2. Abu Hafsa, S.H., Ibrahim, S.A., Eid, Y.Z. and Hassan, A.A., 2020. Effect of dietary Moringa oleifera leaves on the performance, ileal microbiota and antioxidative status of broiler chickens. *Journal of animal physiology and animal nutrition*, *104*(2), pp.529-538.
3. Ahmed, N.F., Sadek, K.M., Soliman, M.K., Khalil, R.H., Khafaga, A.F., Ajarem, J.S., Maodaa, S.N. and Allam, A.A., 2020. Moringa oleifera leaf extract repairs the oxidative misbalance following sub-chronic exposure to sodium fluoride in Nile tilapia Oreochromis niloticus. *Animals*, *10*(4), p.626.
4. Arsalan, M.Z.H., Hussain, S.M., Asrar, M., Anwar, H., Rehan, M.M.H., Shahzad, M.M. and Wahab, N., 2016. Effects of Moringa oleifera leaf meal (MOLM) based diets on carcass composition and hematology of Labeo rohita fingerlings. Journal of Biodiversity and Environmental Sciences, 9(1), pp.214-223.
5. Ayroza, D.M.M.R., Nogueira, M.G., da Silva Ayroza, L.M., Carvalho, E.D., Ferraudo, A.S. and Camargo, A.F.M., 2013. Temporal and spatial variability of limnological characteristics in areas under the influence of tilapia cages in the Chavantes Reservoir, Paranapanema River, Brazil. *Journal of the World Aquaculture Society*, *44*(6), pp.814-825.
6. Bhatnagar, A. and Devi, P., 2013. Water quality guidelines for the management of pond fish culture. *International journal of environmental sciences*, *3*(6), pp.1980-2009.
7. Biel, W., Jaroszewska, A. and Łysoń, E., 2017. Nutritional quality and safety of moringa (Moringa oleifera Lam., 1785) leaves as an alternative source of protein and minerals. Journal of Elementology, 22(2), pp.569-579.
8. Billard, R., Cosson, J., Perchec, G. and Linhart, O., 1995. Biology of sperm and artificial reproduction in carp. Aquaculture, 129(1-4), pp.95-112.
9. Boyd, C.E. and Alliance, G.A., 1999. Codes of practice for responsible shrimp farming.
10. Craig, S.R., Helfrich, L.A., Kuhn, D. and Schwarz, M.H., 2017. Understanding fish nutrition, feeds, and feeding.
11. Dalkiran, G., 2020. Can some words in news content create negative perception in terms of Sectoral image? Aquaculture or fish farms. IBAD Sosyal Bilimler Dergisi, pp.639-661.
12. Dienye, H.E. and Olumuji, O.K., 2014. Growth performance and haematological responses of African mud catfish Clarias gariepinus fed dietary levels of Moringa oleifera leaf meal. Net Journal of Agricultural Science, 2(2), pp.79-88.
13. Dongmeza, E., Siddhuraju, P., Francis, G. and Becker, K., 2006. Effects of dehydrated methanol extracts of moringa (Moringa oleifera Lam.) leaves and three of its fractions on growth performance and feed nutrient assimilation in Nile tilapia (Oreochromis niloticus (L.)). *Aquaculture*, *261*(1), pp.407-422.
14. Ebuka, I.A., Adogbeji, E.P., Oghenebrorhie, O., Lydia, A.M., Ejovwokoghene, O.J. and Ufuoma, A.E., 2021. Moringa oleifera leaf meal as partial replacement of soybean meal in diets of Clarias gariepinus juveniles. Livestock Research for Rural Development, 33, p.8.
15. Elabd, H., Soror, E., El-Asely, A., El-Gawad, E., & Abbass, A. (2019). Dietary supplementation of Moringa leaf meal for Nile tilapia Oreochromis niloticus: Effect on growth and stress indices. Egyptian Journal of Aquatic Research, 45, 265–271.
16. Elgendy, M.Y., Awad, E.S., Darwish, D.A., Ibrahim, T.B., Soliman, W.S., Kenawy, A.M., Abumourad, I.M., Abbas, H.H. and Abbas, W.T., 2021. Investigations on the influence of Moringa oleifera on the growth, haematology, immunity and disease resistance in Oreochromis niloticus with special reference to the analysis of antioxidant activities by PAGE electrophoresis. Aquaculture Research, 52(10), pp.4983-4995.
17. El-Kassas, S., Abdo, S.E., Abosheashaa, W., Mohamed, R., Moustafa, E.M., Helal, M.A. and El-Naggar, K., 2020. Growth performance, serum lipid profile, intestinal morphometry, and growth and lipid indicator gene expression analysis of mono-sex Nile tilapia fed Moringa oleifera leaf powder. Aquaculture Reports, 18, p.100422.
18. Francis, G., Makkar, H.P. and Becker, K., 2001. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture*, *199*(3-4), pp.197-227.
19. Gopalakrishnan, L., Doriya, K. and Kumar, D.S., 2016. Moringa oleifera: A review on nutritive importance and its medicinal application. *Food science and human wellness*, *5*(2), pp.49-56.

20. Liaqat, S., Mahmood, S., Ahmad, S., Kamran, Z. and Koutoulis, K.C., 2016. Replacement of canola meal with Moringa oleifera leaf powder affects performance and immune response in broilers. Journal of Applied Poultry Research, 25(3), pp.352-358.
21. Mahmoud, H.K., Farag, M.R., Reda, F.M., Alagawany, M. and Abdel-Latif, H.M., 2022. Dietary supplementation with Moringa oleifera leaves extract reduces the impacts of sub-lethal fipronil in Nile tilapia, Oreochromis niloticus. Scientific Reports, 12(1), p.21748.
22. Makkar, H.A. and Becker, K., 1996. Nutrional value and antinutritional components of whole and ethanol extracted Moringa oleifera leaves. Animal feed science and technology, 63(1-4), pp.211-228.
23. Naylor, R.L., 2016. Oil crops, aquaculture, and the rising role of demand: A fresh perspective on food security. Global Food Security, 11, pp.17-25.
24. Nyerhovwon, O.K.U.K.U., 2017. Effect of Moringa olifera and Methionine as Feed Supplement on Growth and Utilization of Clarias gariepinus. Int. J. Innov. Agric. Biol. Res., 5, pp.46-54.
25. Omar, S.S., 2023. Evaluation of dietary rosemary leaf powder on growth, carcass composition and hemato-biochemical profiles of common carp (Cyprinus carpio) reared in cage system. Cellular and Molecular Biology, 69(11), pp.141-148.
26. OSUIGWE, D.I., OBIEKEZIE, A.I. and ONUOHA, G.C., 2005. Some haematological changes in hybrid catfish (Heterobranchus longifilis x Clarias gariepinus) fed different dietary levels of raw and boiled jackbean (Canavalia ensiformis) seed meal. African Journal of Biotechnology, vol. 4, no. 9, pp. 1017-1021.
27. Özcan, M.M., 2020. Moringa spp: Composition and bioactive properties. South African Journal of Botany, 129, pp.25-31.
28. Ozovehe BN (2013) Growth performance, hematological indices and some biochemical enzymes of juveniles Clarias gariepinus [Burchell 1822] fed varying levels of Moringa oleifera leaf meal diet. J Aquat Res Devel 4:166–172
29. Prabu, E., Felix, S., Felix, N., Ahilan, B. and Ruby, P., 2017. An overview on significance of fish nutrition in aquaculture industry. *International Journal of Fisheries and Aquatic Studies*, *5*(6), pp.349-355.
30. Puycha, K., Yuangsoi, B., Charoenwattanasak, S., Wongmaneeprateep, S., Niamphithak, P., & Wiriyapattanasub, P. (2017). Effect of moringa (Moringa oleifera) leaf supplementation on growth performance and feed utilization of Bocourti's catfish (Pangasius bocourti). Agriculture and Natural Resources, 51, 286–291.S0044-8486(01)00526-9
31. Sangkitikomol, W., Rocejanasaroj, A., & Tencomnao, T. (2014). Effect of Moringa oleifera on advanced glycation end-product formation and lipid metabolism gene expression in Hep G2 cells. Genetics and Molecular Research, 13, 723–735.
32. Santhosh, B. and Singh, N.P., 2007. Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Lembucherra-799210, Tripura (west). Publication no. 29, 2007. *publication*, (29).
33. Shahzad, M.M., Hussain, S.M., Jabeen, F., Hussain, A.I., Arsalan, M.Z.H., Ahmad, N., Rehan, M.M.H. and Riaz, D., 2016. Carcass composition and hematological study of Catla catla fingerlings fed on phytase supplemented Moringa oleifera leaf meal (MOLM) based diet. J Biodiv Environ Sci, 9, pp.57-68.
34. Všetičková, L., Adamek, Z., ROZKOŠNÝ, M. and SEDLÁČEK, P., 2012. Effects of semi-intensive carp pond farming on discharged water quality. Acta ichthyologica et piscatoria, 42(3).
35. Younes, A. M., Gaafar, A. Y., Abu-Bryka, A. Z., Awad, E. S., Abo-Aziza, F., Abd El-Aziz, T. H., Darwish, D., Authman, M. M., & Abbas, W. T. (2021). Effects of Onion (Allium cepa) in diets of Oreochromis niloticus: Growth improvement, antioxidant, anti-inflammatory and disease resistance perspectives. Aquaculture Research, under press.
36. Zhang, X., Sun, Z., Cai, J., Wang, J., Wang, G., Zhu, Z. and Cao, F., 2020. Effects of dietary fish meal replacement by fermented moringa (Moringa oleifera Lam.) leaves on growth performance, nonspecific immunity and disease resistance against Aeromonas hydrophila in juvenile gibel carp (Carassius auratus gibelio var. CAS III). *Fish & Shellfish Immunology*, *102*, pp.430-439.