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The Potential Effect of Dietary Supplementation of Bergapur with and without Choline Chloride on Growth Performance, Survival, Biochemical and Hematological Variables of Juvenile Nile tilapia (*Oreochromis niloticus*)

Asmaa M. A. Mostafa[1]*, Asem A. Amer[2], Ibrahim A. Abu El-Naser[1] and Ahmed F. Fath El-Bab[1]

1- Fish Production Department, Faculty of Agriculture, Damietta University, Egypt.

2-Department of Fish Nutrition and Feed Technology, Central Laboratory for Aquaculture Research, Agricultural Research Center, Abbassa - Egypt.

Email address: ahfarouk74@gmail.com Mobile No: +20 1155302017

Email address: asemamer77@yahoo.com Mobile No: +20 1061750881

Email address: Atta19812000@yahoo.com Mobile No: +20 1097635376

Corresponding author*: asmaaaabed4@gmail.com Mobile No: +20 0115815855

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ABSTRACT:

The aim of the present study was to examine the effects of dietary supplementation of Bergapur (BR) with and without choline chloride (CH) on growth performance, feed utilization, serum biochemical and hematological indices of Oreochromis niloticus. Nile tilapia juvenile fed five treatments (A control diet and four other diets were formulated to include the fine powder and Bergapur (BR) with and without choline chloride (CH) as a follows: {T1(Control), T2 (0.01 BR), T3 (0.02 BR), T4 (0.01 BR + 0.04 CH), and (0.02 BR + 0.04 CH)} of a Bergapur (BR) a commercial product containing Deoiled lecithin, 97% (pure lecithin) and Highest phospholipid with and without choline chloride (CH) for 84 days. After the experimental period, statistical analyses of the obtained results showed that the highest significant higher FBW, WG%, DWG, FI, FE and SGR ($P<0.05$) in fish feed T5 (0.02BR+0.04CH/kg) diet, compared with the control. In addition to that the feed conversion ratio was significantly decreased in fish fed T4 (0.01BR+0.04CH/kg) and T5 (0.02BR+0.04CH/kg) ($P<0.05$). The hematological indices, specifically Hb, PCV, RBCs, and WBCs ($p \leq 0.05$) were significantly improved for Nile tilapia fish fed diet a blend of Bergapur (BR) and choline chloride (CH). Whereas, no marked effects of using Bergapur (BR) and choline chloride (CH) on the blood biochemical traits of Nile tilapia juvenile. Moreover, Fish fed higher dietary inclusion of Bergapur (BR) and choline chloride (CH) significantly increased serum biochemical blood of Nile tilapia juvenile compared to other experimental groups. Consequently, Bergapur (BR) and choline chloride (CH) is recommended at a level of T5 (0.02BR+0.04CH/ kg^{-1}) diet, to improve the growth performance, feed utilization and blood health of Nile tilapia fish.

Key words: feed additives, Bergapur (BR), choline chloride (CH), Nile tilapia juvenile, blood indices, growth performance.

INTRODUCTION

Aquaculture has seen continuous global expansion and is a significant player in food production **(FAO, 2020)**. It offers an alternative means to address food security and meet the demand for protein **(El-Mokhlesany *et al*., 2023)**. However, the rapid growth of intensive aquaculture has presented challenges that hinder its expansion **(Dawood, 2021; El-Mokhlesany *et al*., 2023)**. Aquaculture farms need to optimize feed components to improve digestibility, strengthen immune systems, reduce FCR, enhance microbiota, and lower fish production costs **(Gaballah *et al*., 2021; Emam *et al*., 2024)**. Freshwater fish farming contributes significantly to over two-thirds of global aquaculture production **(Bastos Gomes *et al*., 2017)**.

After carps, Nile tilapia is one of the most farmed fish species worldwide, accounting for 8.3% of global fish production in 2018 **(FAO, 2020)**. The Middle East and Sub-Saharan Africa are home to the robust, hardy tropical fish known as tilapia, which is farmed professionally worldwide. It is the most farmed fish in the world, grows well in fresh and brackish environments, and is prized for its high-end market appeal and sustainable farming practices **(FAO, 2019)**. Its hardiness adds to its popularity. This is the fish that is farmed most extensively in Africa. The rise in tilapia output corresponds with the country's efforts to support aquaculture as well as the population growth **(Niyibizi, 2023)**. Warm water (26–30°C) is the ideal temperature range for tropical fish, such as Nile tilapia, while cold water is less than ideal.

Fats provide the nutritional energy that aquatic organisms need, and they may also improve the efficiency of protein. Aquaculture has long relied on high-fat diets (HFD) to augment protein or supply other energy sources. **(Naiel *et al*., 2023)**. In specific orders, increasing the amounts of fat and lipid in fish meals, like tilapia **(Chou and Shiau, 1996)** and snakehead **(Zhang *et al*., 2017)**. PL is concentrated in eggs, animal brain, and processed soy (lecithin). A combination of various PL, triglycerides, and glycolipids makes up soybean lecithin. Fish have benefited most from the high PC and phosphatidylinositol concentrations found in soy lecithin **(Coutteau *et al*., 1997; Sink and Lochmann, 2014)**.

According to **Soaudy et al. (2024)**, feeding Nile tilapia with supplements containing 4 gkg^{-1} Arabic gum and 10 gkg^{-1} lecithin may enhance growth performance, improve fish physiological state, lower mortality, and increase resistance to the cold throughout the winter.

One phospholipid that is frequently utilized in aquaculture feeds is soy lecithin. All things considered, soy lecithin is known to possess chemo-attractant and antioxidant qualities **(Hertrampf & Piedad-Pascual, 2000)**. In salmonids (rainbow trout and Atlantic salmon), feeding diets containing soy lecithin was linked to high survival and growth performance during the early life periods **(Poston, 1990, Sivaramakrishnan *et al*., 2021)**. The emulsifying qualities of soybean lecithin, as well as its capacity to improve nutritional quality and digestibility, determine how it functions in aquafeed. Growth performance, lipid and carbohydrate metabolism, nutrition utilization, antioxidant activities, and stress tolerance are all significantly impacted by it **Maleki Moghaddam *et al*. (2021).** Due to its involvement in a number of metabolic pathways and regulatory processes that improve the feed utilization and growth performance of larval and juvenile fish species like red sea bream, *Pagrus major* **(Kanazawa *et al*., 1983)**, rainbow trout, *Oncorhynchus mykiss* **(Poston, 1990)**, Atlantic salmon, *Salmo salar* **(Poston, 1990; De Santis *et al*., 2015)**, common carp, *Cyprinus carpio* **(Geurden *et al*., 1997)**, seabass, *Dicentrarchus labrax* **(Cahu *et al*., 2003)**, gilthead seabream, *Sparus aurata* **(Saleh *et al*., 2015 and 2022)**, Nile tilapia, *Oreochromis niloticus* **(El-Naggar *et al*., 2021)**. Additionally, although feed was improved, the 4% soybean lecithin supplemented diet had minimal effects on the channel catfish, *Ictalurus punctatus*, innate immune system and total body composition.

Vitamins that are needed in trace amounts are essential for fish performance measures and for enhancing many metabolic processes **(Sousa *et al*., 2020)**. One of the B-complex vitamins needed for animal development is choline. It prevents fat storage by transferring fat from the liver to other tissues and synthesising methionine **(Devlin, 2000)**. Choline is typically present in animal diets in the form of choline chloride. According to **Sousa *et al*. (2020)**, phosphatidylcholine is a very recent addition to aquafeeds. The vitamin-like substance choline is essential for complex lipids and the phospholipid lecithin. It supplies methyl groups needed for the production of metabolites and acetylcholine precursors. Choline, however, was found to be necessary for the greatest amount of weight increase in the fish investigations **(Craig and Gatlin, 1996; Shiau and Lo, 1999).** The choline requirement of fingerling Atlantic salmon was met with 880 mg kg^{-1}, with choline being replaced with 30 g kg^{-1} lecithin. Furthermore, as demonstrated in larger (100-g) fish, lecithin appeared to improve digestibility **(Hung *et al*., 1997)**. Thus, the current study set out to investigate the effects of dietary supplementation Bergapur (soy lecithin) with and without choline chloride on fish Nile tilapia *(O. niloticus)* juveniles raised in aquariums in terms of growth performance, survivability, nutrient utilization, body composition, and hematological-biochemical blood parameters.

MATERIALS AND METHODS

In cooperation with the Department of Animal, Poultry, and Fish Production, Faculty of Agriculture, Damietta University, Egypt, this work was carried out at the Department of Fish Nutrition, Sakha Research Unit, Central Laboratory for Aquaculture Research, Abbassa, Agriculture Research Center, Ministry of

Agriculture, Egypt. An investigation into the effects of dietary amounts of Bergapur (BR) with and without choline chloride (CH) on Nile tilapia (Oreochromis niloticus) growth performance, feed utilization, body composition, and preliminary economical evaluation was carried out using a feeding experiment

Experimental fish

The juvenile *Oreochromis niloticus* fish used in the experiment were collected from a private farm in EL-Riyadh, Kafr El-Sheikh governorate. August 2022 marked the beginning of the experiment, and it ended in October 2022. Before the experiment began, the fish were put in a fiberglass tank and divided at random into the experimental aquaria for two weeks of acclimatization to the experimental circumstances. For two weeks, the fish were given the basal diet; in this time, healthy fish of the same weight replaced the dead ones.

Experimental design of rearing fish:

In 15 glass aquariums of 60x30x40 centimeters, 225 Nile Tilapia (*O. niloticus*) fish with an average weight of 10.97±0.03 grams were randomly assigned to 5 treatments. Three aquaria received in each treatment. In fiberglass tanks, fresh tap water was kept for 24 hours with air circulation. Fresh, dechlorinated water from a reservoir tank maintained at the same temperature in the same lab was added to one-third of the culture water each day and the entire amount once a week after the wastes were removed. The water in the aquarium was aerated using nine air stones. The temperature of the water varied from 27.04 to 27.68 °C. 14 hours a day under fluorescent light was the photoperiod. Every day, fish waste and feed residue were extracted using siphoning.

Experimental diets and feeding regime

During the acclimatization period, the fish were fed a basic commercial diet consisting of 32% crude protein, fish meal, soybean meal, yellow maize, wheat bran, rice bran, sunflower oil, and vit. & min. combination.

A commercial product called Bergapur (BR) has the highest phospholipid content, 97% pure lecithin, and deoiled lecithin. The source of this item is the International Free Trade Company (IFT), located at Street No. 9 in front of the Al-Moqttam Sporting Club in Al-Moqttam, Cairo, Egypt. Bergapur (BR) with and without choline chloride (CH) was included in the formulation of four different diets, along with a control diet, which were titled {T1 (Control), T2 (0.01 BR), T3 (0.02 BR), T4 (0.01 BR + 0.04 CH), and (0.02 BR + 0.04 CH)}.

To satisfy Nile Tilapia's (*O. niloticus*) requirements, all materials were well combined. Table 1 displays the formulation and composition of the experimental diets, which were pelleted using a pelleting machine. Every two weeks, the necessary amount of the diet was prepared and refrigerated until the trial started. Before being used, the pellets were dried for 24 hours at room temperature.

Fish in every treatment had two feedings per day, at 8 a.m. and 2 p.m., for 84 days, at a rate of 3% of their body weight in the corresponding test diets. Every two weeks, the weight of the fish was measured, and the meal amounts were modified accordingly.

Water quality analysis:

Water quality samples from every aquarium were examined. Throughout the trial, daily monitoring of the water quality measures was done. A thermometer, a portable digital pH meter (Martini Instruments Model 201/digital), and a waterproof portable dissolved oxygen meter (Hanna, IP67 waterproof rating) were used to measure the water's temperature, pH, and dissolved oxygen (DO). Calorimetric measurement was used to determine the total nitrogen and ammonia.

Proximate analysis of the experimental diets and fish body:

Determination of DM, CP, EE, CF and ash in the basal diet, experimental diets and in fish body at the start and end of the experiment for different groups was also confirmed by following **AOAC (2012).**

At the end of the experimental period, four fish were derived from each treatment for drying at 60°C for 2 days and then ground through electrical mill and stored until analysis in deep freezer.

Table 1: Shown the composition of the experimental diets.

Item Feed Ingredients (%)	T1	T2	T3	T4	T5
Fish meal	10	10	10	10	10
Soybean meal	37	37	37	37	37
Yellow corn	15	15	15	15	15
Wheat bran	10	10	10	10	10
Rice bran	10	10	10	10	10
Wheat flour	7.44	7.43	7.42	7.41	7.38
Corn gluten	5	5	5	5	5
Sun flower oil	2.5	2.5	2.5	2.5	2.5
Di-calcium	1	1	1	1	1
Vit. C	0.06	0.06	0.06	0.06	0.06
Vit and mins premix*	10	10	10	10	10
Bergapur (BR) **	0	0.01	0.02	0.01	0.02
Choline chloride**	0	0	0	0.04	0.04
Total (g)	100	100	100	100	100
Chemical composition (g/kg)					
Crud protein (CP)	32.3	32.1	31.8	31.92	32.3
Crud lipid (CL)	7.5	7.1	7.35	7.27	7.41
Ash	8.71	8.82	8.7	8.86	8.84
Fibers	4.17	4.3	4.11	4.1	4.13
NFE***	47.32	47.68	48.04	47.85	47.32
GE****	447.85	444.42	446.57	445.71	447.00

*Vitamins and minerals premix detailed by Dawood et al (2020).,** Bergapur (BR) was bought from the international company (IFT), *** NFE (Nitrogen free extract) calculated by differences [NFE = 100 - (CP+ EE+ CF+ Ash)], **** Gross energy was calculated according to NRC (1993) by using factors of 5.65, 9.45 and 4.22 Kcal per gram of protein, EE and NFE, respectively.

Growth performance and efficiency of feed and protein utilization:

The growth performance and feed utilization parameters were calculated according to the following equations:

- Total weight gain (TWG):

TWG = final weight (g) - initial weight (g)

- Average daily gain (ADG):

ADG (g) = TWG (g) / Time (days)

- Survival rate (SR %):

SR % = Total number of fish at the end of the experimental × 100 / total number of fish at the start of the experiment.

- Specific growth rate (SGR, % / day):

SGR = 100 × [In wt1- In wt0/T]

Whereas:

In: Natural log. Wt1: Final weight (g), Wt0: Initial weight (g), T: Time in days

- Feed conversion ratio (FCR):

FCR = Total feed consumption (g) /Weight gain (g)

- **Feed efficiency** (**FE**):

FE= Body weight gain (g) / Feed intake (g)

- Protein efficiency ratio (PER):

PER = Body weight gain (g) / protein intake (g)

Blood sampling and analysis

After putting the fish to sleep with 100 mg/L of tricaine methane sulfonate, three fish per group had their blood drawn from the caudal vein using 5-milliliter gauge syringes. After the blood was divided into two parts, the first half was kept for hematological analysis in tubes that had been heparinized with EDTA. Blood samples were centrifuged at 3000 rpm/15 min at 4ºC after 2 hours; serum was collected and kept at −20ºC for subsequent analysis. For serum collection, the second half was kept in nonheparinized tubes.

Hemoglobin concentration (Hb), red blood cell (RBC), and white blood cell (WBC) counts were carried out in compliance with recognized protocols (Houston, 1990). On Giemsa-stained blood smears, differential WBC and RBC counts were carried out. The packed cell volume (PCV,%) was estimated using the micro haematocrit method, and the hemoglobin (Hb) concentration was identified using the **Blaxhall and Daisley (1973)** method with a spectrophotometer (Model RA 1000, Technicon Corporation, USA) at 540 nm.

While the concentration of globulins was computed mathematically, serum total proteins and albumins were measured in accordance with **Doumas *et al*. (1981) and Dumas and Biggs (1972)**.

Statistical model and analysis procedure:

Data were edited in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). A MIXED method (PROC Mixed; **SPSS, 2006**) was used to examine Nile tilapia growth performance, feed consumption, haemato-biochemical blood parameters. The statistical analyses were performed with SPSS Ver. 15. The data (n = 3) are shown as the mean ± standard error. All variables were computed using one-way analysis of variance (ANOVA), followed by Duncan's multiple range tests, in order to examine differences across individual means at a significance level of $P < 0.05$.

RESULTS:

Water quality parameters

The most important physico-chemical parameters of tap water used in this experiment are shown in table 2. Data showed that all tested water quality criteria were suitable for rearing Nile tilapia *(O. niloticus)* and the differences between all treatments were in- significant.

Growth, and Fish survival ratem

The growth performance characteristics (Control-T1, T2, T3, T4, and T5) of Nile tilapia (Oreochromis niloticus) given diets supplemented with dietary amounts Bergapur (BR) with and without choline chloride (CH) are displayed in Table 3. When Nile tilapia juveniles fed the experimental diets at the beginning, their initial body weight did not change, suggesting that the groups were identical.

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Table 2: shown average of some physicochemical parameters of water.

Items	Water Parameters			
	Temperature ºC	**pH value**	**DO mg/l**	**NH4 mg/l**
T1 (Control)	27.46±0.64	7.57±0.1	7.00±0.2	0.35±0.02
T2 (0.01BR)	27.68±0.54	7.61±0.05	6.96±0.12	0.33±0.01
T3 (0.02BR)	27.16±0.58	7.60±0.11	6.86±0.29	0.38±0.01
T4 (0.01 BR+0.04CH)	27.04±0.58	7.63±0.11	6.96±0.18	0.40±0.05
T5 (0.02 BR+0.04CH)	27.54±0.60	7.60±0.04	6.94±0.07	0.33±0.03

∗ Values expressed as means ± SE (*n* = 3).

The results showed that adding choline chloride (CH) to the food enhanced the levels of Bergapur (BR) in the final body weight (g/fish), total weight gain (g/fish), daily gain (g/fish/day), and specific growth rate (%) significantly ($p < 0.05$). Furthermore, all indicators showed significantly higher values in the fish fed diet T5 (0.02BR+0.04CH). In contrast to supplemented diets, the control diets (T1) had the lowest values. However, there are no appreciable variations in terms of survival rate percentage. This might be because soy lecithin's capacity to combine with choline chloride improved the ration's nutritional value.

Feed intake and protein utilization

All criteria studied which presented in Table 4 showed that T4 and T5 were improved ($P \le 0.05$) in comparison with the other group concerning FI, FCR, PER, and PPV% in tilapia fish. On the other side, there was no significance difference between T1 and T2 in data of FCR, PER, and PPV%.

Table 3. The effect of Bergapur (BR) and choline chloride (CH), g/kg on the growth performance of Nile tilapia.

Items	(T1)control	(T2) 0.01BR	(T3)0.02BR	(T4) 0.01 BR+0.04CH	(T5)0.02BR +0.04CH
IW	10.95±0.08	10.91±0.08	10.95±0.14	11.06±0.07	11.00±0.07
FW	29.44±0.57[c]	30.88±1.28[c]	32.16±1.16[b]	32.98±1.82[b]	36.70±1.69[a]
WG	18.49±0.58[c]	19.97±1.30[c]	21.20±1.30[b]	21.92±1.87[b]	25.700±1.66[a]
WG (%)	168.84±0.69[c]	183.15±1.26[bc]	193.94±1.45[b]	198.25±1.80[b]	233.57±1.45[a]
DWG	0.22±0.00[b]	0.23±0.01[b]	0.25±0.01[ab]	0.26±0.02[a]	0.30±0.01[a]
SGR	1.37±0.02[b]	1.44±0.06[b]	1.49±0.06[ab]	1.51±0.08[ab]	1.67±0.06[a]
SR	97.77±2.22	95.55±2.22	97.77±2.22	97.77±2.22	97.77±2.22

⁎ Values expressed as means ± SE (*n* = 3). in the same row with different letters differ significantly ($p < 0.05$). IBW: initial body weight, FBW: final body weight, WG: weight gain, SGR: specific growth rate

Haemato-biochemical blood parameters:

Tables 5 and 6 showed that the tilapia fed soy lecithin with or without choline chloride are in a stable health condition ($P > .05$) based on the observed hematological and biochemical blood variables. For healthy Nile tilapia, every value fell within the reference range.

Table 4. Effect of Bergapur (BR) and choline chloride (CH) (g/kg) on Feed intake and conversion as well as protein utilization by Nile tilapia fish.

Items	(T1) control	(T2) 0.01BR	(T3) 0.02BR	(T-4)0.01 BR +0.04CH	(T5) 0.02BR +0.04CH
FI	38.75±1.01[b]	39.33±1.29[b]	43.01±0.68[a]	43.28±1.21[a]	45.77±1.12[a]
FCR	2.09±0.01[a]	1.97±0.07[ab]	2.03±0.09[a]	1.99±0.11[ab]	1.79±0.07[b]
FE	0.47±0.00[b]	0.50±0.02[ab]	0.49±0.02[ab]	0.50±0.03[ab]	0.56±0.02[a]
PI	12.51±0.32[c]	12.62±0.41[bc]	13.67±0.21[ab]	13.81±038[a]	14.78±0.36[a]
PER	1.47±0.01[b]	1.57±0.06[a]	1.54±0.07[ab]	1.58±0.09[a]	1.73±0.07[a]

⁎ Values expressed as means ± SE (n = 3). in the same row with different letters differ significantly ($p < 0.05$). FI: feed intake, FCR: feed conversion ratio, FE: Feed efficiency, PI: protein intake, PER: Protein efficiency ratio.

Hematic test findings showed that young Nile tilapia fish fed diets T4 and T5 had increased Hb, RBCs, and HCT ($p < 0.05$) than the control group (Table 5). WBCs also showed negligible variations between the fish fed different amounts of soy lecithin with or without choline chloride and the control group. On the other hand, fish fed diets T4 and T5 showed a significant increase in plasma total protein (TP) when compared to fish fed the control diet and other

Fish fed diets T4 and T5 showed a significant ($P < 0.05$) increase in plasma albumin (Alb), but fish fed diets T1, T2, and T3 showed a significant decrease in Alb. Between all treatments, there was a negligible ($P < 0.05$) difference in plasma globulin (glu).

Table 5. Hematological indices of Nile tilapia fed levels of Bergapur (BR) and choline chloride (CH) (g/kg).

Item	(T1) control	(T2) 0.01BR	(T3) 0.02BR	(T4) 0.01 BR +0.04CH	(T5) 0.02BR +0.04CH
Hb	7.40±0.20[d]	7.85±0.05[cd]	8.15±0.05[c]	9.30±0.20[b]	9.85±0.05[a]
RBCs	1.39±0.05[c]	1.45±0.00[bc]	1.61±0.02[bc]	1.64±0.09[b]	1.87±0.08[a]
HCT%	21.45±016[b]	22.00±0.50[b]	25.00±1.36[ab]	25.92±1.42[a]	27.56±0.73[a]
WBCs	55.75±2.85	49.50±0.60	51.50±3.90	53.00±0.00	52.25±1.75

⁎ Values expressed as means ± SE (n = 3). in the same row with different letters differ significantly ($p \leq 0.05$). Hb: hemoglobin; RBCs: red blood cells, HCT: hematocrit, WBCs: white blood cells.

Table 6. Blood biochemical indices of Nile tilapia fed levels of Bergapur (BR) and choline chloride (CH) (g/kg).

Item	(T1) control	(T2)0.01BR	(T3) 0.02BR	(T4) 0.01 BR +0.04CH	(T5) 0.02BR +0.04CH
TP (g/dL)	2.25±0.05[c]	2.65±0.05[b]	2.60±0.00[b]	2.75±0.05[a]	2.60±0.20[b]
Alb (g/dL)	0.80±0.005[d]	1.00±0.00[b]	0.90±0.00[c]	1.09±0.00[a]	0.91±0.03[c]
Glu (g/dL)	1.44±0.05	1.65±0.05	1.70±0.00	1.65±0.04	1.68±0.16

⁎ Values expressed as means ± SE (n = 3). in the same row with different letters differ significantly (p ≤ 0.05). TP: Total protein, Alb: Albumin, Glu: Globulin.

DISCUSSION:

The objective of the current study was to ascertain how dietary supplements of soy lecithin (LC) and choline chloride (CH) affected the Nile Tilapia's growth performance, hematological indices, antioxidant activity, and immunological responses. The growth experiment results showed that the fish groups fed with (T5 (0.02BR+0.04CH)) had considerably higher values for all parameters, including final body weight (FBW), weight gain (WG), specific growth rate (SGR), and protein efficiency ratio (PER). Similarly, **Poston (1990a, 1991a)** indicated that incorporating lecithin and choline in the diet may have a good impact on size. Furthermore, fish fed the enhanced meals weighed an average of 13 g at the end of the trial (day 84), compared to fish fed the un supplemented diet, which weighed an average of 6.3 g. The survival rate of fingerlings did not differ amongst the dietary groups, and the specific growth rates (SGR) of fish fed diets supplemented with choline chloride (CH) and lecithin was within the predicted range for fish fed a commercial diet. **(Hung and others, 1997)**. The lack of higher growth rates with choline addition to the lecithin-supplemented diet was likewise consistent with findings in 0.12-g rainbow trout by **Poston (1991a)**.

Purified phosphatidylcholine (PC) is one of the most abundant phospholipid groups in fish tissues and plant components, including soy lecithin. The weight gain and feed efficiency of young Nile tilapia kept at 28 °C were enhanced by graded levels of food supplementation with 15.0 g kg^{-1} phosphatidylcholine (PC) **(Kasper and Brown, 2003)**. Additionally, food therapy had a substantial impact on the growth performance of adult Nile tilapia. Supplementing with 0.3 g/kg of Lysomax increased (p <.05) SGR, FCR, PER, and PPV. Growth performance was still better than the control group at all Lysomax levels (p <.05). On the other hand, the results of the quadratic regression analysis showed that the optimal feed efficiency and fish development happened at roughly 0.44 g Lysomax/kg feed **(El-Sayed *et al*., 2021)**. Additionally, the fish fed a diet containing 10 g/kg lecithin and 4 g/kg Arabic gum had the best FCR and the highest FBW, SGR, WG, and survival rate (SR) **(Soaudy *et al*., 2024)**. According to **Saleh *et al*. (2022)**, the L2C1 group showed the highest somatic growth, proving the benefit of supplementing the fish diet with both 40 g SBL and 500 mg C at the same time as opposed to just one of them. Lastly, when Nile tilapia were bred at suboptimal temperatures (22 °C), the addition of phospholipids in the form of soy lecithin enhanced the weight increase, feed efficiency, and digestibility of lipids. For weight increase, 42.2 g kg^{-1} and 49.8 g, respectively, were judged to be the ideal soy lecithin incorporation levels.

According to **Makled *et al*. (2017)**, hematological analysis is a simple and useful method for keeping an eye on the health of fish. It can offer important and trustworthy details about metabolic disorders, nutrient shortages, stress status, and fish adaptability mechanisms. The current investigation revealed that tilapia fed (BR) with or without CH have significantly higher Hb values and are in a stable health condition (P >.05) than the control diet. Additionally, the results of the hematic test showed that juvenile Nile tilapia fed diets T4 and T5 had higher Hb, RBCs, and HCT (p ≤ 0.05) than the control group. WBCs also showed negligible variations between the fish fed different amounts of soy lecithin with or without choline chloride and the control group. **El-Sayed *et al*. (2021)** observed comparable outcomes: as compared to the control group, Nile tilapia fed Lysomax supplemented meals at the optimal dosages showed significantly better values of hematological parameters for both Hb%, RBC, MCV, and MCH. According to **Jafari *et al*. (2018)**, fish fed diets high in lecithin may have a higher metabolic requirement, which could account for the increase in Hb and RBC levels.

Important indicators of significant physiological reactions are serum biochemical markers **(Hassaan *et al*., 2020)**. Numerous cellular processes, including hormone secretion, enzyme activity, and nutrition metabolism, are influenced by serum protein concentration **(Shi *et al*., 2006)**. Findings from this study demonstrated that, when compared to the control group, *O. niloicus* juveniles fed rations containing choline chloride (CH) and Bergapur (BR) had significantly higher concentrations of serum total protein, albumin, and globulin. Additionally, the results showed that the concentrations of TP, albumin, and globulin were higher in relation to T4 and T5. The acquired results were similar to **El-Sayed *et al*., (2021)**. Researchers discovered that fish fed Lysomax, which included lecithin, had considerably greater values of total blood protein and albumin ($p < 0.05$) than fish fed the control diet. On the other hand, the innate immune system of young channel catfish, *Ictalurus punctatus*, was only slightly affected by a diet supplemented with 4% soybean lecithin **(Sink and Lochmann, 2014).** Moreover, Dietary supplementation of soybean lecithin is also connected with the increase of fish systemic immunity against bacterial illness as stated by **Adel *et al*. (2017)**. Because increased globulin, a protein fraction that contains proteins implicated in the immune response, was present in diet groups containing phosphatidylcholine, total serum protein levels increased as well. Research has shown that elevated blood globulin levels are indicative of a strengthened fish immune system (**Elkamel and Mosaad, 2012; Dorucu *et al*., 2009 and Sousa *et al*., 2020)**. This suggests that when fish are fed 800 mg/kg of phosphatidylcholine, their immune systems are either directly or indirectly stimulated, which is a good indicator of reduced stress. **(Sousa *et al*., 2020; Baldissera *et al*., 2019).**

CONCLUSIONS:

When it comes to fish feeding, Bergapur (BR) and choline chloride (CH) are especially advised since they offer Nile tilapia a nutrient-rich diet that improves their health, growth rate, and feed efficiency. The Nile tilapia T5 (0.02BR+0.04CH/kg diet) can ingest BR and CH with success. Using BR and CH are a profitable strategy for farmers and would help in decreasing the market prices of tilapia fish for consumers.

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The authors declare no CONFLICTS OF INTEREST.

AUTHORS CONTRIBUTION

Ahmed F. Fath El-Bab: General supervision, Conceptualization, Investigation, Methodology. Asmaa M. A. Mostafa: Formal analysis, Investigation, Follow-up, Writing - original draft. Asem A. Amer: Formal analysis, Supervision, Writing, Follow-up, Methodology, original draft. Ibrahim A. Abu El-Naser: Formal analysis, Supervision, Writing, Follow-up, Methodology

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الملخص العربى

التأثير المحتمل للمكملات الغذائية من بيرجابور مع أو بدون كلوريد الكولين على أداء النمو والبقاء والمتغيرات البيوكيميائية والدموية لصغار أسماك البلطي النيلي

أسماء محمد عبد الهادى مصطفى[1] – عاصم على عامر[2] - إبراهيم عطا أبو النصر[1] و أحمد فاروق فتح الباب[1]
[1]قسم الانتاج الحيوانى و الداجني و السمكي- كلية الزراعة - جامعة دمياط
[2]قسم تغذية الأسماك وتكنولوجيا الأعلاف، المعمل المركزي لبحوث الاستزراع السمكي، مركز البحوث الزراعية، العباسة - مصر.

الهدف من الدراسة هو فحص آثار الاضافات الغذائية من بيرجابور) مع أو بدون كلوريد الكولين على أداء النمو والاستفادة من الغذاء وصفات الدم في اسماك البلطى . تم تغذية صغار البلطي النيلي على خمس معاملات (الكنترول وأربعة أنظمة غذائية أخرى تم تركيبها لتشمل مسحوق ناعم وبيرجابور مع وبدون كلوريد الكولين على النحو التالي: المعامله الاولى الكنترول, المعامله الثانية (0.01بيرجابور)المعامله الثالثة(0.02 بيرجابور)، المعاملة الرابعة (0.01بيرجابور+ كلوريد الكولين 0.04 ، والمعاملة الخامسة (0.04 كلوريد الكولين + 0.02 بيرجابور) وهو منتج تجاري يحتوي على الليسيثين منزوع الزيت بنسبة 97٪ (ليسيثين نقي) وأعلى فسفوليبيد مع وبدون كلوريد الكولين لمدة 84 يومًا. بعد الفترة التجريبية، أظهرت التحليلات الإحصائية للنتائج التي تم الحصول عليها أن أعلى وزن نهائى للأسماك، والزيادة فى الوزن، ونسبة الزيادة فى وزن الجسم والغذاء المأكول، وكفاءة الغذاء،ومعدل الوزن النوعي (P ≤0.05)في أسماك المعاملة الخامسه (0.04 كلوريد الكولين + 0.02 بيرجابور) كجم) مقارنة بالمجموعة الكنترول بالإضافة إلى أن نسبة تحويل العلف انخفضت بشكل ملحوظ في الأسماك التي تغذت على المعاملة الرابعة (0.01بيرجابور+ كلوريد الكولين 0.04و المعاملة الخامسه (0.04 كلوريد الكولين + 0.02 بيرجابور) كجم) (P ≤0.05). تم تحسين المؤشرات الدموية، وتحديدًا الهيموجلوبين، ، وكريات الدم الحمراء، وكريات الدم البيضاء (P ≤ 0.05؛) بشكل ملحوظ لأسماك البلطي النيلي التي تتغذى على عليقة تحتوي علي مزيج من بيرجابور وكلوريد الكولين . في حين لم يكن هناك تأثيرات ملحوظة لاستخدام بيرجابور وكلوريد الكولين على السمات الكيميائية الحيوية لدم صغار البلطي النيلي. علاوة على ذلك، أدت الأسماك التي تغذت على نظام غذائي يحتوي على نسبة أعلى من بيرجابور وكلوريد الكولين إلى زيادة كبيرة في مصل الدم لصغار البلطي النيلي مقارنة بالمجموعات التجريبية الأخرى. وعليه، يوصى باستخدام المعاملة الخامسة التى تحتوى على بيرجابور وكلوريد الكولين بمستوى 0.04 كلوريد الكولين + 0.02 بيرجابور كجم علف ، لتحسين أداء النمو واستخدام العلف وصحة الدم لأسماك البلطي النيلي.