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THE IMPACT OF OPTIMAX® ON THE GROWTH, FEED EFFICIENCY, AND BODY CHEMICAL COMPOSITION OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*, L., 1758) FINGERLINGS

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ABSTRACT

This experiment was carried out to evaluate the effects of the graded levels of Optimax® (0, 0.5, 1, and 1.5 g/kg diet) on Nile tilapia (*Oreochromis niloticus*) regarding their growth performance, feed utilization, and chemical composition of their whole bodies for 90 days. Fish with an average initial body weight of 9.56 ± 1.57 g were distributed into four treatments (three replicates per treatment). The obtained results revealed that fish fed with 0.5 g of Optimax®/kg diet showed the highest growth parameters, along with improved feed conversion ratio and protein content in their bodies compared to other levels. Therefore, it could be concluded that the level of 0.5 g/kg diet of Optimax® is useful for enhancing the production performance of *O. niloticus*.

Keywords: Nile tilapia – Organic acids - Growth performance – Feed utilization – Carcass composition

INTRODUCTION

An increased global population resulted in increased aquatic protein due to positive health effects and key food composition aspects, and as a result, global aquaculture has recently increased at an astounding rate (FAO, 2018). According to GAFRD's data, aquaculture is now the country's largest single source of fish supply, accounting for about 80.5 percent of total fish production in Egypt (GAFRD, 2019). Tilapias are highly significant species in aquaculture around the world, ranking second only to carp. Nile tilapia (*Oreochromis niloticus*) is the most widely distributed fish species in aquaculture, with an annual growth rate of 8.0 percent (FAO, 2020). The capacity to feed on a variety of foods, fast growth rates, high conversion ratios, and the ability to spawn in captivity are all factors that contribute to tilapia's worldwide and Egyptian popularity (El-Sayed, 2006).

A nutritionally balanced diet and minimal production costs are essential for successful aquaculture. Feed nutritional quality and cost are determined by the cost and quality of feed ingredients and additives (Yousefi *et al.,* 2018). One of the most important aspects of aquaculture is proper nutrition, which accounts for 50–80% of the total cost of output in aquaculture. Feed firms have turned to the use of functional feed additives to combat rising prices. Antibiotics and chemotherapeutics have been replaced by these useful feed additives. In comparison to conventional feed additives, functional feed additives boost fish growth, immunological response, physiological functions, and health performance (Alemayehu *et al.*, 2018). The usage of feed additives has expanded in recent years due to the various benefits of feed additives, such as hunger stimulants, digestive regulators, and supporting effects to improve fish development performance. The goal of using feed additives in aquaculture is to improve efficiency, quality, and profitability (Ebru and Cengiz, 2016). They can positively improve technological properties and product quality.

Dietary organic acids, such as formic, lactic, malic, citric, propionic, and butyric acids, as well as their sodium and potassium salts, play an important role in increasing aquaculture output efficiency. These compounds have increased production performance in several aquaculture species (De Wet, 2005; Abu Elala and Ragaa, 2014; Khajepour and Hosseini, 2012)**.** One promising method for hydrolyzing phytate is the addition of organic acids to fish feed (Hossain *et al.,* 2007; Luckstadt and Kuhlmann, 2011). Organic acids reduce stomach pH, which boosts pepsin activity and stimulates the digestibility of phosphorus, nitrogen, and minerals (Afzal *et al.,* 2019)**.** They protect the feed and elementary canals of fish from microbial pathogens by suppressing their activities and toxic metabolites such as ammonia. In addition, they minimize the discharge of phosphorus into water bodies and reduce the chances of eutrophication (Baruah *et al.*, 2008; Chowdhury *et al.*, 2009; Christian and

Mellor, 2011). Therefore, this experiment evaluated the impact of different Optimax® levels (as a feed additive) on growth, feed efficiency, and body chemical composition of Nile tilapia, *Oreochromis niloticus.*

MATERIALS AND METHODS

Experimental facilities:

The experiment was conducted in the Central Laboratory of Aquaculture Research (CLAR), Abbasa, Abou-Hammad, El- Sharkia government, Egypt. Two hundred and forty Nile tilapia (*O. niloticus*) fingerlings with an average initial body weight of 9.56 ± 1.57 g were obtained from the fish hatchery of CLAR, Egypt. Under experimental conditions, fingerlings were acclimated for two weeks and fed an experimental diet containing 30% crude protein. Fish were randomly distributed into four experimental treatments (three glass aquaria for each treatment). The aquarium (dimensions of 60 (L) x 75 (W) x 45 (D) cm; total volume 200 L) was supplied with compressed air via air-stones using aquarium air pumps. Settled fish wastes with one-half of the aquarium's water were removed daily by siphoning, and water volumes were replaced by dechlorinated aerated tap water from the storage tank. The water temperature ranged between 26 and 28 °C.

Optimax® was produced by Optivite International Company, UK. The components of Optimax® are present in Table (1). The diet proximate chemical analysis was conducted according to AOAC (2004), as shown in Table (2). The ingredients were minced, then Optimax® was added at levels of 0, 0.5, 1, and 1.5 g/kg diet. The experimental diets were offered twice a day, at 9 a.m. and 2 p.m. with equal meals. Fish were fed at a rate of 5% of their body weight for 90 days. Every two weeks, the fish in each aquarium were weighed, and the required feed amounts were recalculated based on the actual body weight.

Table 1: Components of Optimax® used as an additive in this experiment.

Composition	Percentage (%)
Formic acid (85%)	13.9
Ammonium formate (100%)	17.4
Propionic acid (99%)	5.0
Colloidal silica	63.7

Table 2: Composition (g/kg) and chemical analysis (% dry matter basis) of the experimental diets.

Ingredients	Optimax® levels (gram/1000 g diet)			
	0	0.5	1	1.5
Fish meal (65% CP)	100	100	100	100
Soybean meal (48% CP)	440	440	440	440
Wheat milling by product	150	150	150	150
Yellow corn	210	210	210	210
Corn starch	20	20	20	20
Oil mixture [1]	50	50	50	50
Vitamin premix[2]	10	10	10	10
Mineral premix[3]	20	20	20	20
Optimax®	0	0.5	1	1.5
Total	1000	1000	1000	1000
Nutrient composition (% on dry matter basis)				
Dry matter (DM, %)	92.55	92.55	92.55	92.55
Crude protein (CP, %)	30.00	30.00	30.00	30.00
Crude fat (CF, %)	5.99	5.99	5.99	5.99
Crude fiber (%)	2.15	2.15	2.15	2.15
Ash (%)	4.95	4.95	4.95	4.95
Nitrogen free extract[4] (%)	56.91	56.91	56.91	56.91
Gross energy[5] (MJ/g)	1983.6	1983.6	1983.6	1983.6

[1] Sunflower oil: cod liver oil with a ratio of 1:1.

[2-3] Minerals and vitamins premix each one kg contain Vit. A,15000 IU; Vit. D_3, 15000 IU; Vit. E, 2 mg; Vit. K_3, 2 mg; Vit. B_1, 2 mg; Vit. B_2, 2.5 mg; Nicotine amide, 10 mg; Vit. B_6, 3 mg; Vit. B_{12}, 5 mg; Folic acid, 2 mg; Ca – d –Pantothenate, 5.5 mg; Calcium, 200 g; Phosphate, 90 g; Sodium, 40 g; Cupper, 2.5 g; Magnesium, 48 g; Manganese, 3.6 g; Zinc, 23.5 g; Iron, 8 g; Cobalt, 450 mg; Iodine, 200 mg; Selenium, 20 mg.

[4] Nitrogen free extract was calculated as follows = 100 – (CP% + CF% + crude fiber% + Ash%).

[5] Calculated by using factors of 23.64, 39.54, and 17.57 MJ/g for CP, EE, and nitrogen-free extract (NFE, %), respectively (NRC, 1994).

Experimental measurements:

Fish performance parameters:

Growth performance parameters of fish such as total weight gain (TWG, g), average daily gain (ADG, g/fish/day), relative growth rate (RGR, %), the specific growth rate (SGR, %/day), and Survival rate (SR, %). These parameters were calculated as follows:

TWG = Final weight – initial weight.

ADG = TWG / period of experiment (days).

RGR = (TWG / initial weight) × 100.

SGR = 100 × [(ln final weight- ln initial weight) ⁄ period of experiment (days)].

SR (%) = (No. of fish at the end of the study / No. of fish initially stocked) × 100.

Feed efficiency parameters:

Feed efficiency parameters were computed, such as feed intake (FI, g), feed conversion ratio (FCR), feed efficiency ratio (FER, %) and protein efficiency ratio (PER). These parameters were calculated per tank as follows:

FCR = Dry feed intake (g)/ fish live weight gain (g).

FER = (Fish live weight gain (g)/ dry feed intake (g))/100.

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

The chemical compostion of the fish body:

At the end of the experiment, six fish from each treatment were collected and kept frozen (-20 °C) until the proximate analysis of the whole fish body was done according to AOAC (2004). The proximate analysis of the whole fish body included moisture, crude protein (CP), and crude fat (CF). The energy content (EC) of the fish body was calculated according to NRC (1994).

Statistical analysis:

Data were subjected to one-way analysis of variance (ANOVA) using the SAS (2009) procedure of the statistical analysis system (version 9.1.3). The normality and homogeneity of variance of data were tested by the Shapiro-Wilk and Levene tests, respectively. The differences between the means of treatments were compared using Tukey's *post hoc* significant test, and the differences were considered statistically significant at $P \leq 0.05$.

RESULTS

Fish growth performance:

The data in Figure 1A-F showed that Nile tilapia fingerlings fed on 0.5 g of Optimax®/kg diet gave the highest growth performance parameters compared to other experimental treatments ($P \leq 0.05$). However, there is no significance among experimental treatments of SR compared to the other treatments ($P > 0.05$).

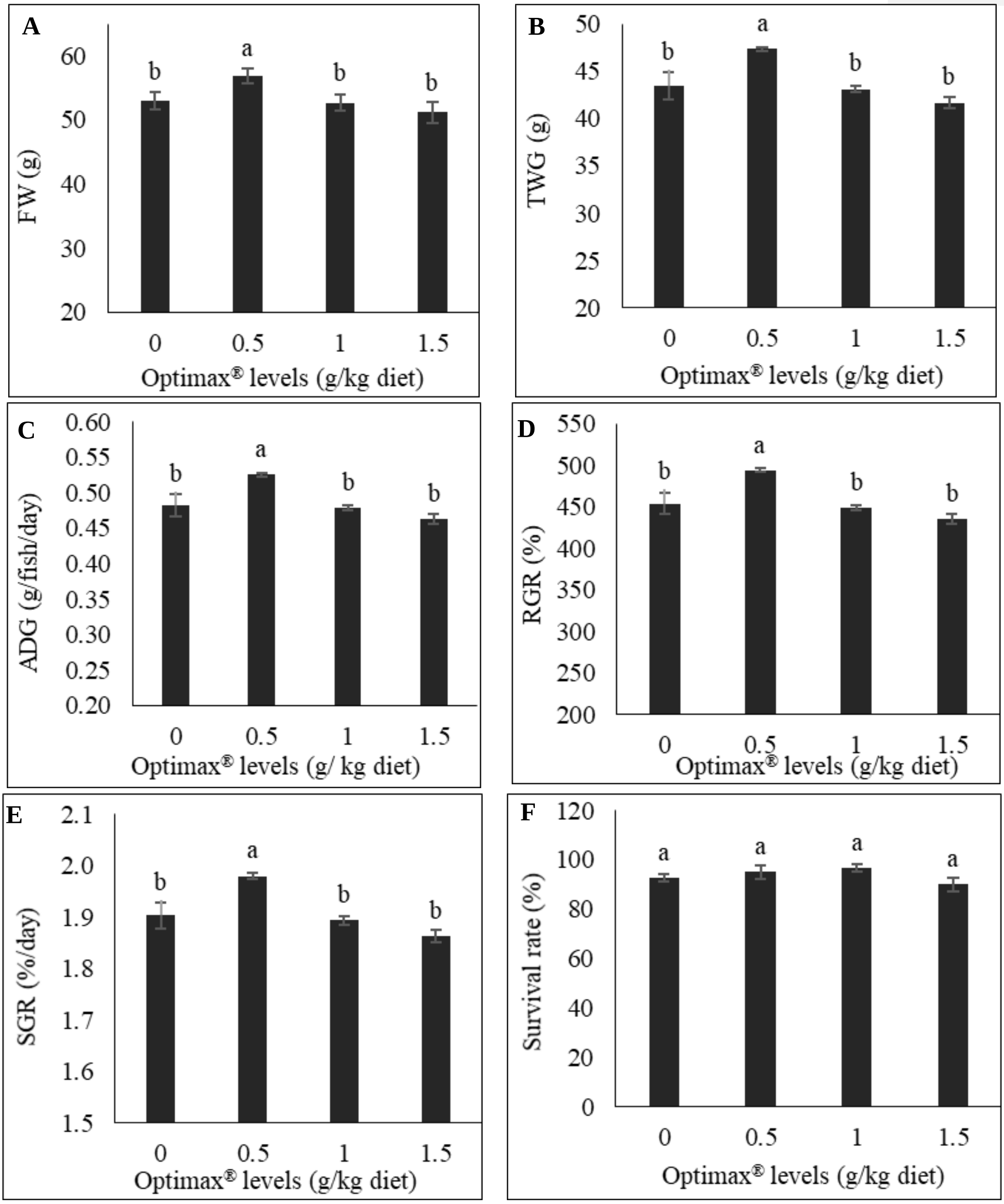

Figure 1 A-F: Effect of Optimax® levels on growth parameters (A) FW (P = 0.006), (B) TWG (P = 0.005), (C) ADG (P = 0.005), (D) RGR (P = 0.003), (E) SGR (P = 0.003), and (F) survival rate (P = 0.273) of Nile tilapia. Vertical bars indicate the standard error; means with an asterisk indicate a significant difference among levels of Optimax® ($P \leq 0.05$).

Feed efficiency parameters:

The effect of Optimax® levels on the feed efficiency parameters of Nile tilapia is present in Table 3. Fish fed on 0.5 g Optimax® / kg diet exhibited the best values of FCR, FE, and PER compared to other levels ($P \leq 0.05$). However, there was no significant difference among the other levels of Optimax® in FI ($P > 0.05$).

Table 3: Effect of Optimax® levels on feed efficiency parameters of Nile tilapia

Parameters	Optimax® levels (g/kg diet)				*P-value*
	0	0.5	1	1.5	
Feed intake (g)	90.20± 2.24	90.86±1.86	89.00±1.77	85.76±2.36	0.371
Feed conversion ratio	2.08±0.01^{a}	1.92±0.04^{b}	2.06±0.04^{a}	2.06±0.06^{a}	0.040
Feed efficiency (%)	48.15±0.35^{b}	52.13±1.17^{a}	48.47±0.97^{b}	48.64±1.36^{b}	0.041
Protein efficiency rate (%)	1.59±0.01^{b}	1.72±0.04^{a}	1.60±0.03^{b}	1.61±0.04^{b}	0.025

Means in the same row of each parameter having different letters are significantly differ ($P < 0.05$).

The chemical composition of the fish body:

The chemical composition of the fish body is presented in Figures 2A-E. Fish fed on 0.5 g of Optimax®/kg diet significantly increased DM and CP while decreasing CF and ash compared to other different levels ($P \leq 0.05$). However, there were no significant differences among the other levels of Optimax® in EC ($P > 0.05$).

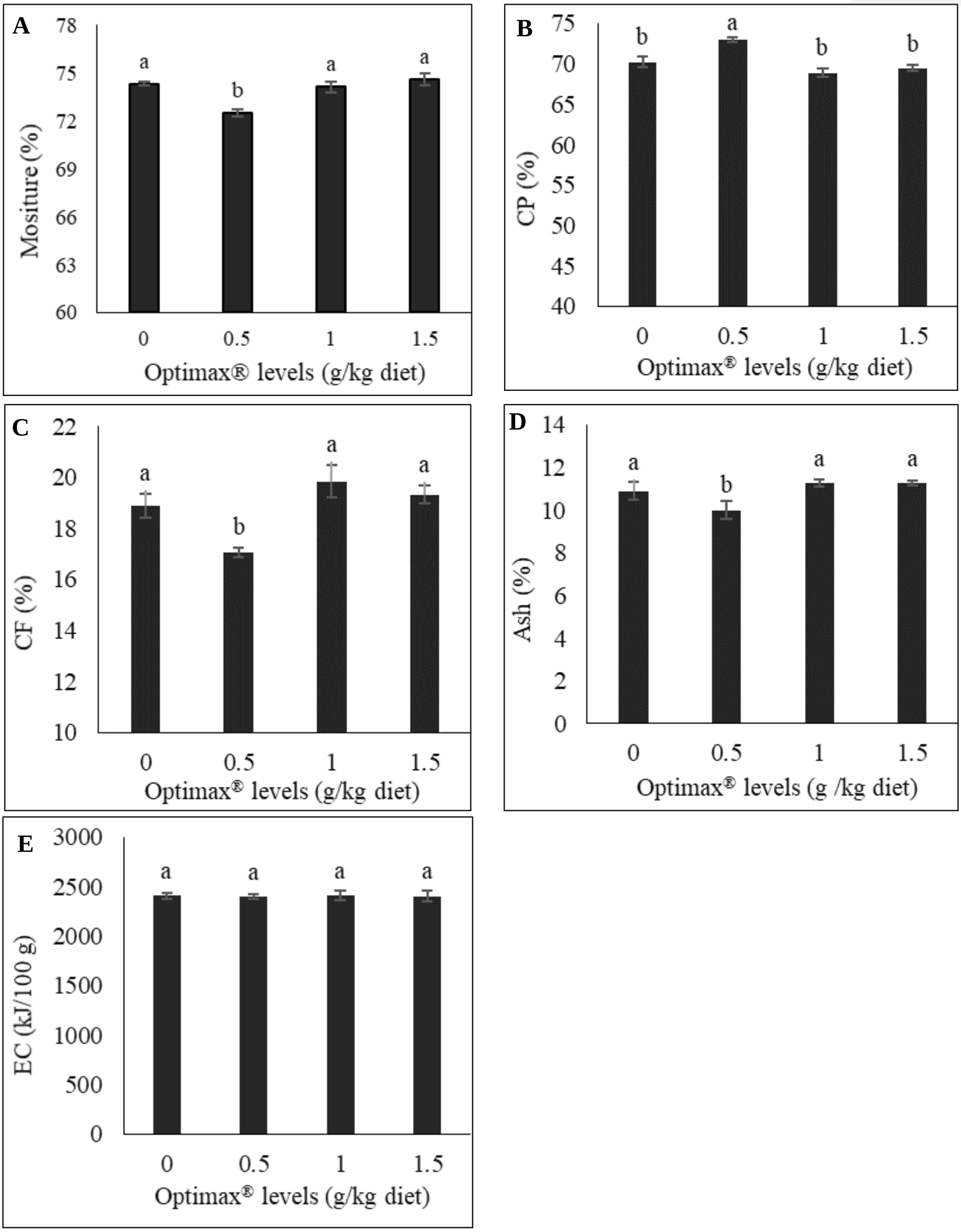

Figure 2 A-E: Effect of Optimax® levels on chemical composition of fish body (A) DM (*P* = 0.003), (B) CP (*P* = 0.001), (C) CF (*P* = 0.009), (D) ash (*P* = 0.051), and (E) EC (*P* = 0.874) of Nile tilapia. Vertical bars indicate the standard error; mean with an asterisk indicate a significant difference among levels of Optimax® (*P* < 0.05).

DISCUSSION

One of the most important tasks in aquaculture is to improve the fish's growth performance. The results of the present study exhibited an improvement in all growth performance parameters of fish fed on a 0.5 g Optimax®/kg diet compared to other different levels. The positive effects of dietary Optimax® may be due to it containing some organic acids such as formic acid and propionic acid. These components significantly increased amylase and protease activity while decreasing lipase activity. Organic acids may improve digestive enzyme activity by reducing the number of harmful bacteria in the stomach and increasing the number of helpful bacteria like *Lactobacilli* (Luckstadt, 2008). These helpful lactic acid bacteria indirectly help fish digest their food by enhancing the activity of digestive enzymes (Askarian *et al.*, 2011; Suzer *et al.*, 2008). These results agree with the enhancement of FCR and PER and increased crude protein in the chemical composition of the fish body observed in this study. This may be related to the ability of formic and propionic acids to reduce stomach pH, which increases pepsin activity and stimulates the digestibility of phosphorus, nitrogen, and minerals in feed (Afzal *et al.*, 2019). Luqman *et al.* (2021) found that dietary acidification may have suppressed intestinal pathogenic bacteria and reduced their competitive activity with the host for available nutrients, resulting in improved growth of fish. These results agree with the enhancement of feed efficiency and the increase in crude protein obtained in this study. Increasing the concentration of organic acids by more than 0.5 g/kg led to a decrease in all growth performance and feed utilization parameters. This may be due to an increase in organic acids causing a sharp decrease in gastric pH, which leads to an inhibition of the secretion of digestive enzymes.

The positive effect of the addition of organic acids on the growth performance has been observed in several fish species such as *Cirrhinus mrigala* (Luqman *et al.*, 2021), yellow croaker (Zhang *et al.*, 2016), Nile tilapia (Sherif and Doaa, 2013), *Oncorhynchus mykiss* (De Wet, 2005), and red hybrid tilapia (Ng *et al.*, 2009). Conversely, Romano *et al.* (2016) found no significant response in growth parameters, when they fed tilapia on fish diets with different levels (1 to 4%) of sodium citrate acidifier. In the same direction, Omosowone *et al.* (2015) observed that the increasing levels of dietary fumaric acid (1.5–2 g/kg) in the diet of *Clarias gariepinus* significantly reduced growth performance and feed utilization. These differences in the previous results suggest the use of acidifiers in diets may be attributed to some variations among fish species, size, strain, age, nutrient content of the experimental diet, and level of acidifiers and their compositions, in addition to the rearing culture system, water quality, and feeding management.

Many reports have shown that the beneficial effects of organic acids such as formic and propionic acids on feed efficiency in many fish species. This agrees with the results obtained for this study. Fish fed on 0.5 g of Optimax®/kg diet had the best values of FCR, FE, and PER compared to other different levels. This improvement may be related to enhanced digestibility via lowered pH, resulting in a higher dissociation of mineral compounds, a reduced rate of gastric emptying, and the formation of chelated mineral complexes, which are easily absorbed (Hossain *et al.*, 2007). Moreover, Baruah *et al.* (2008) found that the addition of organic acids in fish feeds causes the following: reduction of the pathogenic microbial load in feed and the gut of fish; reduction of toxic microbial metabolites by reducing the pathogenic microbes; enhancement of nutrient absorption due to the proliferation of mucosal epithelium of the intestine Sherif and Doaa (2013) tested cultured *O. niloticus* on different doses of organic acid blend and reported a significant improvement in FCR, SGR, and survival rates by increasing the level of acidifiers compared to the control group. Abu Elala and Ragaa (2014) also observed that graded levels of potassium diformate of 0.2 and 3% significantly improved FCR. Despite the previous results, a study showed that there was no significant difference among different levels of organic acid blend (0.1%, 0.2%), and potassium diformate (0.2%) in red hybrid tilapia (Ng *et al.*, 2009). Mogheth (2012) showed that during the 90-day experimental period, FCR for *O. niloticus* fed the control diet showed the highest (worst) FCR compared to the other experimental diets supplemented with the different doses (0.5, 1.0, or 1.5%) of Ca-propionate and Ca-lactate.

Environmental and food conditions affect the chemical composition of the fish's body in ways that can be used as good indicators for the physiological situation of fish (Weatherley and Gill, 1987). In the current study, the results exhibited significant enhancement in the chemical composition of the fish body, with an increase in CP and a decrease in CF and EC. This improvement was related to organic acid supplementation, leading to a lower gut pH owing to dietary acidification, which may cause a faster conversion of pepsinogen to pepsin, resulting in increased pepsin activity (Kirchgessner and Roth, 1982; Park *et al.*, 2009). These factors could have played a role in the greater protein digestibility. Higher protein digestibility was also found in yellow catfish (Zhu *et al.*, 2015) and beluga (Khajepour and Hosseini, 2012) with organic acid supplemented diets. However, Luqman *et al.* (2021) indicated that formic acid had no influence on moisture or crude ash. However, it did cause a large increase in CP and a drop in CF. In another study, the protein and moisture content of muscle revealed no significant variations; however, *C. carpio* fed citric acid-supplemented meals had reduced lipid content and increased muscle ash content (Khajepour *et al.*, 2012).

Hassaan *et al.* (2014) found that the highest values of crude protein and ash contents were detected at 1 and 1.5 percent calcium carbonate compared with the basal diet or other tested diets for *O. niloticus.* In the present study, body moisture was mostly not significantly affected by different levels of acidifiers. This result agrees with Ng *et al.* (2009) who tested different levels of dietary potassium diformate and organic acid blends on red hybrid tilapia. They did not find any negative effects on fish body composition or any hazard effects or toxicity on all treated fish, which appeared to be in the same healthy status as that of the control. Romano *et al.* (2015) discovered similar results, finding the highest muscle crude protein levels in shrimp fed on a 2% organic acid blend diet, though there were no significant differences from the control diet. Lim *et al.* (2010) revealed that the benefits of organic acid inclusion in the diet of fish may vary among fish and tend to be inconsistent, depending on the dietary ingredient, culture system, and water quality.

CONCLUSIONS

From the current outcomes, it could be concluded that the use of 0.5 g Optimax®/kg is a promising agent to improve the productive efficiency of Nile tilapia fingerlings through the improvement of growth performance, feed efficiency, and carcass composition. Additionally, further studies regarding the effects of organic acids such as Optimax® on different sizes and ages of fish are needed. Furthermore, the possibility of using organic acids to work on raising the value of non-traditional or low nutritional value (low protein) feed reduces the economic cost.

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الملخـــــص العربــــي

أجريت هذه التجربة لتقدير تأثيرات المستويات المتدرجة من الأوبتاماكس® (٠، ٠,٥، ١، ١,٥ جم / كجم علف) على أصباعيات البلطي النيلي، فيما يتعلق بأداء نموها والاستفادة من الغذاء والتركيب الكيميائي لها لمدة ٩٠ يوما. وزعت الأسماك التي يبلغ متوسط وزنها الأولي ٩,٥٦ ± ١,٥٧ جرام على أربع معاملات (ثلاث مكررات لكل معاملة). أوضحت النتائج المتحصل عليها أن الأسماك التي تم تغذيتها بـــ ٠,٥ جم الأوبتاماكس® / كجم علف لها أعلى قيم لمقاييس أداء النمو وتحسن نسبة تحويل العلف ومحتوى البروتين في التركيب الكيميائي للجسم مقارنة بالمستويات الأخرى. لذلك، يمكن التوصية بأن مستوى ٠,٥ جم الأوبتاماكس®/ كجم علق مفيد في تحسين أداء إنتاج أصباعيات البلطي النيلى.