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EFFECT OF SOME ORGANIC ACIDS AND ORGANIC SALT BLENDS ON GROWTH PERFORMANCE AND FEED UTILIZATION OF NILE TILAPIA, (*OREOCHROMIS NILOTICUS*)

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SUMMARY

The present study was carried out to study the effect of supplementation of Nile tilapia (*Oreochromis niloticus*) diets by increasing levels (0.5, 1.0 and 1.5%) of two organic acids (malic acid + oxalic acid, 1:1) blend and two organic acid salts (calcium lactate + sodium acetate, 1:1) blend. Therefore 7 diets were formulated (three diets for each blend and the control diet). Growth performance, feed utilization, some hematological parameters and proximate analysis of fish were determined after 90 days. Results could be summarized as follows: Supplementation of the basal diet by each of malic+oxalic acids blend or Na-acetate+Ca-lactate blend significantly improved the final body weight (BW), body length (BL), weight gain (WG) and specific growth rate (SGR) of Nile tilapia compared with the control diet. Fish fed the diet supplemented by 1% malic+oxalic acids blend showed the highest BW, BL, WG and SGR compared with control and the other treated fish groups and the same trend was also observed for feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER). Fish fed the diet D4 (supplemented by 1.5% malic+ oxalic) showed the highest serum protein content while control group showed the highest level of total lipids compared with the other treatments. Fish group fed D5 (0.5% of 1:1 Na-acetate + Ca-lactate blend) showed the highest protein and ash content and the lowest lipid content of the whole fish body, whereas control group showed the lowest protein and the highest fat content.

Keywords: *Organic acids, organic salts, growth performance and Nile tilapia.*

INTRODUCTION

Organic acids are an example of a group of additives which can play an important role in future in aquaculture diets. A number of studies, in cold-water species (Gislason *et al.,* 1994 and 1996) and tropical species (Ramli *et al.,* 2005 and Petkam *et al.,* 2008), indicated a broad range of organic acids, their salts or mixtures can improve growth, feed utilization and disease resistance in fish.

Organic acids in animal feed were initially used in piglets to compliment their limited capacity to maintain a low gastric pH, which linked to problems with digestion (Easter, 1988). Antibiotic inhibit all microbial growth, whereas acidifiers are more selective in their activity (Cromwell, 1990). They can reduce harmful micro-organisms and promote beneficial microflora colonization of the gastrointestinal tract (Mathew *et al.,* 1991).

As reviewed by Baruah *et al.,* (2008), the addition of organic acids in fish feeds may have many advantages; it may reduce the unwanted pathogenic microbial load in feed and the gut of fish; reduce toxic microbial metabolites by reducing the pathogenic microbes; enhance nutrient absorption due to proliferation of mucosal epithelium of the intestine; reduce the discharge of phosphorus in water thereby preventing aquatic pollution; reduce the risk of antibiotic residue in fish and prawns in those regions where antibiotics are used. Mineral absorption may also be enhanced due to more solubilization of Ca, P and Mg etc from animal protein sources, especially in stomach-less fishes.

Some organic acids especially citric, metacetonic and acetic, are also added to pellets for storage effects and/or the improvement of feed utilization (Kumar *et al.,* 1997 and Sugiura *et al.,* 1998).

Generally, the present study was carried out to investigated the effect of some organic acids (1:1 malic+oxalic acids blend) and organic acid salts (1:1 Na-acetate+Ca-lactate blend) at increased levels (0, 0.5, 1.0 or 1.5% of these blends) on the growth performance, feed utilization, proximate analysis and some physiological aspects of *Oreochromis niloticus*.

MATERIALS AND METHODS

The present study was carried out at the Laboratory of Fish Nutrition Faculty of Agriculture Benha University. Fish were obtained from Abbassa hatchery. After acclimatization, the experimental fish were distributed randomly into the experimental aquaria. Fourteen rectangular aquaria 100×40×50 cm were used in the study and the aquaria were supplied with aerated and dechlorinated tap water. Each aquarium was filled with 160 liter and stocked with 15 fish (7.05±0.02 g). One water filter, heater and air pump were used for each aquarium.

At stocking, body weight and body length of fingerlings for each aquarium were individually recorded. Water filters were cleaned and about 10% of the water was daily renewed. Dissolved oxygen was maintained at 4-6 mg\l by continuous aeration and water temperature at 28ºC.

Diets were prepared to confirm the control diet, organic acids (malic acid and oxalic acid blend 1:1) and organic salts (calcium lactate and sodium acetate blend 1:1) were incorporated in three different doses, 0.5, 1.0 and 1.5% (for each blend) therefore seven experimental diets were formulated (three diets for each blend and control diet). Diets were prepared by thoroughly mixing the ingredients (table 1). Water was added to the ingredients of each diet for mixing these ingredients and then dried. After drying, the diets were broken up and sieved into the convenient pellet size.

Fish were given the diets 6 day/week at daily rate of 3% (twice daily at 9.00 am and 3.00 pm). Every two weeks, total fish for each aquarium was weighted and the amount of feed was adjusted according to the changes in body weight through the experimental period. Growth performance parameters were measured by using the following equations:

Weight gain (WG) = final weight (g) – initial weight (g).

Specific growth rate (SGR) = LnW2 – LnW1/t (days), Where, Ln=the natural log; W_1=first fish weight, W_2 = the following fish weight in grams and t =period in days.

Feed conversion ratio (FCR) = Feed intake (g)/weight gain (g).

Protein efficiency ratio (PER) = Weight gain (g)/protein ingested (g).

Blood samples were collected from caudal vein of non-anesthetized fish using plastic syringe containing heparin. Hemoglobin (g/dl) was estimated spectrophotometrically by hemoglobin kits and the Haematocrit (Ht) was determined according to Stoskopf (1993) and reported as percentage packed cell volume (% PCV).

Another blood samples were collected in clean Eppendrof tubes. The plasma was obtained by centrifugation at 3,000 rpm for 15 min, and plasma was stored at −20°C for further assays. Total lipids and total protein contents of plasma were determined colorimetrically according to Joseph *et al.* (1972) and Henry (1964), respectively. Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) spectrophotametrically determined according to Reitman and Frankel (1957).

At the end of the experiment, two fish were randomly sampled from each aquarium and subjected to the chemical analysis of whole fish body according to the methods described in AOAC (1990): dry matter after drying in an oven at 105ºC until constant weight; ash content by incineration in a muffle furnace at 600ºC for 12 hrs; crude protein (N×6.25) by the kjeldhal method after acid digestion; and ether extract by petroleum ether (60-80ºC) extraction.

Statistical analysis of the obtained data was analyzed according to SAS (1996). Differences between means were tested for significance according to Duncan's multiple rang test (Duncan, 1955).

RESULTS AND DISCUSSION

1. Growth performance:

At experiment termination results showed that, supplementation of the basal diet by each of malic+oxalic acids blend or Na-acetate+Ca-lactate blend significantly improved the final BW, BL, WG and SGR of Nile tilapia compared with the control group (Table 2). Also, fish fed the diet supplemented by 1% malic+oxalic acids blend showed the highest BW (25.45 g); the longest BL (12.20 cm); the best WG (18.45 g) and SGR (1.40%) while control group showed the lowest BW (21.85 g); shortest BL (9.95 cm), the worst WG (14.85 g) and SGR (1.33%). Differences among the different treatments in BW, BL, WG and SGR were significant ($P<0.05$).

The obtained results for BW were parallel to those obtained for BL, WG and SGR (table 2) indicating that the acidification of *O. niloticus* diets significantly improved growth performance.

Ramli *et al.* (2005) concluded that K-diformate (0.2, 0.3 or 0.5%) significantly (P<0.05) improved BW and WG of *O. niloticus.* Petkam *et al.,* (2008) found that, 1.5% of Ca-formate, Ca-propionate, Ca-lactate, and citric acid blend resulted in a numerical increase in WG of 11% versus negative control. In recent study, Mogheth (2012) showed that supplementation of the basal diet by 1% Ca-lactate significantly (P<0.001) improved BW, BL, WG and SGR of Nile tilapia, *O. niloticus*. In another study, Eid (2012) reported that, the organic acid blend (0.3% acitic acid + 0.3 formic acid and 0.3 benzoic acid) and organic acid salts blends (0.3% sodium benzoate+0.3% potassium sorbate) significantly enhanced WG and SGR of *O. niloticus* compared to controld group.

For other fish species, de Wet (2005) described that, after 3 months final BW and SGR of rainbow trout fingerlings, *Oncorhynchus mykiss* were significantly improved with increasing acid blend (formic acid and its salts+sorbic acid) inclusion (from 0.5 to 1.0 or 1.5%) versus control (P<0.05).

Ringø, (1991) and Gislason *et al.,* (1996) found that Arctic charr, *Salvelinus alpinus* fed the diets supplemented by each of 1% Na-lactate or 1% Na-propionate significantly (P<0.05) improved SGR. In another study Ringø *et al.,* (1994) found that supplementation of Arctic charr diets by 1% Na-acetate significantly (P<0.05) improved SGR compared with control fish group. For sea bream (*Pagrus major*), Hossain *et al.,* (2007) used 1% each of citric acid, malic acid and lactic acid in three different dietary groups. They showed a significant improvement for WG in the citric acid group versus negative control, but malic or lactic acid did not improve SGR.

2. Feed intake and feed utilization:

During the entire experimental period (90 days), supplementation of tilapia diets by the two blends of organic acids and organic salts significantly (P<0.05) increased feed intake (table 3). Ramli *et al.,* (2005) found that from day 1 to day 85, K- diformate significantly (P<0.01) improved feed intake and the improvement was greater for 0.2 and 0.5% K-formate addition. Mogheth (2012) indicated that, supplementation of tilapia diets by Ca-propionate and Ca-lactate significantly (P<0.05) increased feed intake.

Citric and lactic acids have been reported to be effective in stimulating or enhancing feeding behavior when applied individually or together with other extractive compounds in *Tilapia zilli* (Adams *et al.,* 1988). If the stimulatory effect on fish is confirmed, it could improve fish feed quality regarding both storage and feeding stimulation.

Supplementation of the basal diets by blends of malic+oxalic acid or Na-acetate+Ca-lactate significantly (P<0.05) improved FCR of *O. niloticus* and D3 (the diet supplemented with 1% of malic+oxalic blend) showed the best FCR (table 3). Mogheth (2012) showed that during 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.

For other fish species, de Wet (2005), noticed an improvement in FCR for rainbow trout fingerlings, *Oncorhynchus mykiss* fed a diet supplemented by 1.5% blend of formic acid and its salts plus sorbic acid. Ringø (1992) found that, supplementation of Arctic charr, *Salvelinus alpinus* diets by each of 1% Na-formate or 1% Na-acetate improved FCR. In another study for the same fish specie, Ringø *et al.,* (1994) found that supplementation of fish diets by 1% Na-lactate improved FCR.

Fish group fed D3 (1.5% malic+oxalic acids blend) showed the highest protein efficency ratio, PER (table 3) which was significantly higher than that obtained for the other treated fish groups indicating the superiority of supplementation of this organic acid blend with this dose (1%). Similar results were also obtained by Ramli *et al.,* (2005). The authors found that, from day 1 to day 85, PER of Nile tilapia *O. niloticus* was significantly (P<0.01) improved due to the addition of 0.2 and 0.5% formate. Mogheth (2012) indicated that from 1 day to 12 week the basal diet supplemented with 1.5% Ca-lactate showed the highest PER (1.93) which was significantly higher than obtained for fish fed the control (1.65) diet.

Generally the obtained results of the present study indicated that, supplementation of Nile tilapia diets by organic salts (malic+oxalic acids blend and Na-acetate+Ca-lactate blend) significantly improved BW, BL, WG and SGR, feed intake, FCR and PER.

The improvement in growth performance and feed utilization due to acidification may be due to increasing the absorbance and availability of different minerals and increasing secretion of some enzymes such as proteases. Vielma *et al.,* (1999) reported that dietary acidification by citric acid significantly increased whole body iron in fish. Sugiura, *et al.,* (1998) also observed an increase in the apparent availability of Ca, P, Mg, Mn and Fe in rainbow trout fed fish meal-based diets supplemented with citric acid.

Li *et al.,* (2009) indicated that, supplementation of the diets of hybrid tilapia *(O. niloticus × O. aureus)* by citric acid (10 g kg^{-1}) increased the activities of protease in stomach by 29.6%, but reduced the activities of protease in the intestine by 35.1%. Citric acid increased the activities of amylase in the hepatopancreas and intestine by 30.7% and 29.4% and they concluded that, it is possible that trace elements released by citric acid may have contributed to the increase on protease activity.

3. Some blood parameters and liver fucntions:

The average values of hemoglobin (Hb) ranged between 7.95 to 8.80 u/ml and values of hematocrit (Ht) ranged between 24.00 and 9.50 (PCV %) and the differences between Hb or Ht values were significant (Table 4).

Total protein and total lipids ranged between 4.85 to 6.35 and 98.00 to 117.5 g/dl, respectively. Fish fed the diet D4 (supplemented by 1.5% malic+ oxalic) showed the highest total protein content and the control group showed the lowest total protein content. Total lipids in control group showed the highest value (117.5 g/dl) compared with the other treatments. In the same trend values of ALT and AST ranged between 10.50 to 13.00 u/ml with insignificant differences between these means for ALT and between 13.00 to 16.00 u/ml with significant differences for AST (Table 4).

Hematology is an important factor that could be considered for the fish diet quality assessment. Hari *et al.,* (2004) reported that ichthohematology would be useful for the assessment of suitability of diets and feed mixtures, evaluation of fish conditions, determination of toxic effect of substances, as well as the diagnosis of disease. Avnimelech *et al*., (1994) reported that one of the most common blood variables consistently influenced by diet is the Hb and Ht levels.

Serum total protein is used as a basic index for health status of fish (Mulcahy, 1971), which plays a significant role in the immune response. The estimations of serum enzyme activities of ALT and AST are taken as an indication of the amount of liver damage as the elevated serum enzyme levels might be related to the degree of liver injury. Liver disease causes an increase in some serum enzymes by locking their elimination into the blood (Barraze *et al* 1991).

4. Proximate analysis of whole fish:

Chemical analysis at the end of a feeding trial is frequently used to determine the influence of feed on fish composition. According to Hepher (1990), endogenous factors (size, sex and stage of life cycle) and exogenous factors (diet composition, feeding frequency, temperature etc.) affect the body composition of fish. It should be noted that within endogenous factors, feed composition is only factor, which could have influenced the chemical composition of fish, as other endogenous factors were maintained uniform during the study.

Dry matter in the whole fish body ranged between 26.30 and 27.15%. Control fish group showed the significant ($P<0.05$) highest dry matter content while fish fed the diet D2(supplemented by 0.5% of 1:1 malic+oxalic blend) showed the lowest dry matter content (Table 4). Protein content of the whole fish ranged from 68.00% for control group to 69.60% for fish fed the diet D5 (supplemented by 0.5% of 1:1 Na-acetate+Ca-lactate blend) and the opposite trend was observed for fat content.

Ash content ranged between 13.7% (D6) to 15.10% (D5). Incorporation of organic acids or their salts in *O. niloticus* diets significantly affected proximate analysis of the treated fish. Vielma *et al.,* (1999) found that acidification of rainbow trout diets by citric acid increased whole-body ash content. Baruah *et al.,* (2007) indicated that, whole-body ash content of rohu, *Labeo rohita* juveniles was not significantly ($P>0.05$) affected by citric acid. Similar results were also reported by Van Weerd *et al.,* (1999) in *Clarias gariepinus* and Vielma *et al.,* (1998) in rainbow trout.

Proximate analysis of the present study showed that fish group fed D5 (the basal diet supplemented by 0.5% of 1:1 Na-acetate+Ca-lactate blend) showed the highest protein and ash content and the lowest lipid content of the whole fish body while control group showed the lowest protein and the highest fat content. Therefore a negative relationship was observed between protein and fat content of the whole fish body and these results are in agreement with those obtained by Goda (2002) and Mogheth (2012) who found a negative correlation between protein and fat content of Nile tilapia. On the other hand, El-Saidy *et al.,* (1999) found that there was a positive correlation between crude protein and fat content of *O. niloticus*.

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Table (1). Composition and chemical analysis of the experimental diets.

Feed ingredients	Experimental diets						
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Fish meal (65%)	16	16	16	16	16	16	16
Yellow corn	28	28	28	28	28	28	28
Soybean meal (40%)	40	40	40	40	40	40	40
Wheat bran	10.5	10	9.5	9	10	9.5	9
Soybean oil	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Vit. &Min. mixture[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Oxalic+ malic acid blend (1:1)	0	0.5	1.0	1.5	0	0	0
Ca lactate + Na acetate blend (1:1)	0	0	0	0	0.5	1.0	1.5
sum	100	100	100	100	100	100	100
Chemical analysis (on dry matter basis)							
Dry matter (Dm) %	92.56	92.79	93	93.45	93.88	92.85	94.11
Crude protein (CP) %	30.18	30.20	30.45	30.66	30.71	30.80	30.91
Ether extract(EE) %	4.44	4.34	4.22	4.23	4.87	4.20	4.36
Crude fiber (CF) %	9,33	9.65	9.82	10.22	10.10	10.24	10.66
Ash %	10.12	10.12	10.14	10.14	10.33	10.45	10.15
NFE[2] %	45.93	45.69	45.37	44.75	43.99	44.31	43.92
Me (Kcal/Kg diet)[3]	2610	2611	2612	2609	2607	2600	2595
P/E ratio[4]	115.6	115.7	116.6	117.5	117.8	118.5	119.1

[1]*Vitamin & mineral mixture/ kg premix: vitamin D3, 0.8 million IU; A, 4.8million IU; E, 4g; K, 0.8g; BI, 0.4g; Riboflavin, 1.6g; B6,0.6g; B12, 4mg; pantothenic acid, 4g; Nicotinic acid, 8g; Folic acid, 0.4g Biotin, 20 mg, Mn, 22g; Zn, 22g; Fe, 12g; Cu, 4g; I, 0.4g; Selenium, 0.4g and Co, 4.8 mg.*
[2]*Nitrogen free extract (NFE) = 100 – (CP+EE+CF+Ash).*
[3]*Metabolizable energy was calculated from ingredients based on NRC (1993) values for tilapia.*
[4]*Protein to energy ration in mg protein /Kcal ME.*

Table (2). Effect of organic acids and organic salts on growth performance of Nile tilapia *O. niloticus*.

Diets	Body weight (g)		Body length (cm)		WG (g/fish)	SGR
	Initial BW	Final BW	Initial BL	Final BL		
D1 (Control)	7.00	21.85[c]	6.65	9.95[d]	14.85[b]	1.33[b]
D2 (malic + oxalic 1:1) 0.5%	7.10	24.55[a]	6.75	10.95[bc]	17.45[a]	1.38[a]
D3 (malic + oxalic 1:1) 1.0%	7.00	25.45[a]	6.70	12.20[a]	18.45[a]	1.40[a]
D4 (malic + oxalic 1:1) 1.5%	7.15	24.40[a]	6.90	10.50[cd]	17.25[a]	1.38[a]
D5 (Ca-lactate+Na-acetate 1:1) 0.5%	6.90	22.85[b]	6.70	11.70[ab]	15.95[ab]	1.35[b]
D6 (Ca-lactate+Na-acetate 1:1) 1.0%	7.05	23.65[b]	6.75	10.95[bc]	16.60[ab]	1.37[ab]
D7 (Ca-lactate+Na-acetate 1:1) 1.5%	7.20	24.55[a]	6.85	11.00[bc]	17.35[a]	1.38[ab]
Standard error (SE)	0.014	0.249	0.009	0.096	0.204	0.0009

**Means followed by different letters in each column are significantly (P<0.05) different*.

Table (3). Effect of organic acids and organic salts on feed intake and feed utilization of Nile tilapia *O. niloticus.*

Diets	Feed intake (g/fish)	Feed conversion ratio (FCR)	Protein efficeny ratio (PER)
D1 (Control)	31.35[b]	2.11[a]	1.85[d]
D2 (malic + oxalic 1:1) 0.5%	32.25[ab]	1.85[cd]	1.81[ab]
D3 (malic + oxalic 1:1) 1.0%	33.08[a]	1.79[d]	1.87[a]
D4 (malic + oxalic 1:1) 1.5%	32.43[ab]	1.88[cb]	1.78[bc]
D5 (Ca-lactate+Na-acetate 1:1) 0.5%	31.26[b]	1.96[b]	1.70[c]
D6 (Ca-lactate+Na-acetate 1:1) 1.0%	32.01[ab]	1.93[cb]	1.73[bc]
D7 (Ca-lactate+Na-acetate 1:1) 1.5%	32.54[ab]	1.88[cb]	1.78[bc]
Standard error (SE)	0.295	0.001	0.001

**Means followed by different letters in each column are significantly (P<0.05) different.*

Table (4). Effect of organic acids and organic salts on blood of Nile tilapia *O. niloticus.*

Diets	Hb g/dl	Ht or (PCV %)	Total protein g/dl	Total lipids g/dl	ALT µ/ml	AST u/ml
D1 (Control)	8.00[c]	29.50[a]	5.45[bc]	117.5[a]	11.50	14.5[ab]
D2 (malic + oxalic 1:1) 0.5%	8.35[abc]	26.50[ab]	5.50[bc]	103.0[cb]	10.50	13.0[b]
D3 (malic + oxalic 1:1) 1.0%	8.80[ab]	29.0[a]	5.95[ab]	104.5[cb]	12.50	13.5[ab]
D4 (malic + oxalic 1:1) 1.5%	7.95[c]	26.0[ab]	6.35[a]	100.5[cb]	12.00	14.5[ab]
D5 (Ca-lactate+Na-acetate 1:1) 0.5%	8.15[bc]	25.5[ab]	4.85[c]	106.0[b]	10.50	13.5[ab]
D6 (Ca-lactate+Na-acetate 1:1) 1.0%	8.50[abc]	24.0[b]	5.45[bc]	98.0[c]	12.00	13.5[ab]
D7 (Ca-lactate+Na-acetate 1:1) 1.5%	8.00[c]	25.5[ab]	4.85[c]	101.0[cb]	13.00	16[a]
Standard error (SE)	0.088	2.476	0.133	7.751	2.071	0.833

**Means followed by different letters in each column are significantly (P<0.05) different*.

Table (5). Effect of organic acids and organic salts blends on proximate chemical analysis of Nile tilapia *O. niloticus.*

Diets	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)
Diet 1 (Control)	27.15[a]	68.00[b]	14.00[a]	14.60[ab]
Diet 2 (malic + oxalic 1:1) 0.5%	26.30[c]	68.15[b]	13.25[ab]	14.90[a]
Diet 3 (malic + oxalic 1:1) 1.0%	26.80[b]	68.85[b]	13.15[ab]	14.75[ab]
Diet 4 (malic + oxalic 1:1) 1.5%	27.05[ab]	68.80[b]	13.00[ab]	14.90[a]
Diet 5 (Ca-lactate+Na-acetate 1:1) 0.5%	26.80[b]	69.60[a]	12.85[ab]	15.10[a]
Diet 6 (Ca-lactate+Na-acetate 1:1) 1.0%	26.85[ab]	69.40[a]	13.10[ab]	13.70[c]
Diet 7 (Ca-lactate+Na-acetate 1:1) 1.5%	26.95[ab]	68.80[b]	13.35[ab]	14.05[bc]
Standard error (SE)	0.016	0.106	0.192	0.079

**Means followed by different letters in each column are significantly (P<0.05) different*.

تأثير خلطات بعض الأحماض العضوية وخلطات بعض أملاح الأحماض العضوية على النمو والإستفادة من الغذاء لأسماك البلطى النيلى

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أجريت هذه لدراسة لمعرفة تأثير إضافة مستويات متزايدة (0.5، 1.0، 1.5%) من خليط حمضين عضويين هما حمض الماليك والأوكساليك (بنسبة 1:1) وتأثير إضافة مستويات متزايدة (0.5، 1.0، 1.5%) من خليط ملحين لحمضين عضويين هما خلات الصوديوم ولاكتات الكالسيوم (بنسبة 1:1) فى علائق أسماك البلطى (وزن إبتدائي 7جم) ولذلك تم تكوين 7 علائق (3 علائق لكل خلطة وعليقة الكنترول وكل معاملة تشمل على 2 حوض 15 سمكة/حوض). وتم تغذية الأسماك على العلائق السبعة لمدة 90 يوم وكان من أهم النتائج المتحصل عليها مايلى:

أدت إضافة خلطات الأحماض العضوية (حمض الماليك والأوكساليك) وأملاح الأحماض العضوية (خلات الصوديوم ولاكتات الكالسيوم) إلى تحسين معنوى فى وزن وطول الجسم النهائى، الزيادة فى وزن الجسم، معدل النمو النوعى مقارنة بالأسماك الى تغذت على عليقة المقارنة (بدون إضافات) كما أعطت مجموعة الأسماك التى تغذت على العليقة المحتوية على 1% من خليط حمض الماليك والأوكساليك أعلى مقاييس لهذه الصفات مقارنة بمجموعات الأسماك التى تغذت على المعاملات الأخرى وكذلك مجموعة المقارنة. كما أظهرت نتائج الغذاء المستهلك ومعدل تحويل الغذاء وكفاءة البروتين نتائج مشابهة لنتائج النمو (وزن وطول الجسم النهائى، الزيادة فى وزن الجسم، معدل النمو النوعى).

أظهرت مجموعة الأسماك التى تغذت على العليقة الرابعة (المحتوية على 1.5% حمض الماليك+حمض الأوكساليك) أعلى قيماً للدهون الكلية فى الدم مقارنة بالأسماك التى تغذت على العلائق الأخرى. كما أظهرت مجموعة الأسماك التى تغذت على العليقة الخامسة (المحتوية على 0.5% خلات الصوديوم ولاكتات الكالسيوم) أعلى قيماً للبروتين والرماد وأقل كمية دهون فى جسم السمكة بعد إنتهاء فترة التجربة مقارنة بالأسماك التى تغذت على عليقة المقارنة والتى أظهرت أقل قيماً لمحتوى الجسم من البروتين وأكبر نسبة للدهن.