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Evaluation of growth performance and body composition of Oscar fish (*Astronotus ocellatus*) in response to the consumption of dietary intake of garlic (*Allium sativum*)

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Abstract. The aim of this study was to assess the effect of different levels of garlic (*Allium sativum*) on growth performance and body compositions of Oscar fish (*Astronotus ocellatus*). Five isonitrogenic and isolipidic diets were prepared with levels of 0 (control), 5, 10, 20 and 30 g kg^{-1} garlic powder. A total number of 300 fish was used in triplicate groups of Oscar fish with initial weight of 12.43±0.24 g, which were hand-fed to visual satiation at three meals per day for 8 weeks. The results of experiment showed growth performance and feed efficiency were improved in all treatments compared with control group. But according to the results, the best final weight, weight gain rate (WGR%), specific growth rate (SGR) and food conservation ratio (FCR) were observed in the fish fed 10 g kg^{-1} garlic powder in diet. The highest protein content was obtained in the fish fed with dietary with 10 g kg^{-1} garlic powder. Although, fat tissue of fish had decreasing trend but it was not significantly compared with control group. Moisture and ash contents were no significantly affected by garlic powder. Based on the results of growth performance and body composition of fish, it can be concluded that 10 g kg^{-1} of garlic powder have good effect on growth performance and body composition of Oscar fish.
Key Words: medicinal plants, nutrition, Oscar, garlic.

Introduction. Nowadays, ornamental fish industry has grown so much and research projects on these branches are very important. Moreover, the scientific accuracy and compliance issues of the reproduction and rearing ornamental fish are necessary. Nutrition is one of the most important aspects of aquaculture that every grower should be noted that the bulk of the cost of feeding is growing. Aquaculture is the science of nutrition attempts to improve factors such as increased growth rate, increased levels of safety, strength and survival, which is economic benefit. Increase feed efficiency for improve nutrient digestion process is an essential priority for aquaculture (Francis et al 2005). Non-specific immunity of fish is more important than specific immunity of fish (Staeck & Linke 1995). For this reason, the use of stimulants to increase the safety of the fish immune resistance against disease and promote growth factor is increasing. On the other hand, side effects of antibiotic-resistant bacteria and the development of bacterial resistance, problems of environmental degradation, intestinal flora, water, gravity and administrative problems caused more likely to use prescription stimulants as a suitable alternative to the antibiotics (Staeck & Linke 1995; Consoli et al 1992). The use of herbs as natural additives in poultry and fish diets is used to enhance the positive efficiency and safety immune systems. The use of herbs, garlic, due to the structure and composition of it has beneficial role in human nutrition and animal nutrition (Hamail 1992).

Allium is the largest and famous genus in Alliaceae family with about 450 species (Lanzotti 2006). Garlic (*Allium sativum*) contains at least 33 sulfur compounds, several enzymes and the minerals germanium, calcium, copper, iron, potassium, magnesium, selenium and zinc; vitamins A, B1 and C, fiber and water. It also contains 17 amino

acids: lysine, histidine, arginine, aspartic acid, threonine, swine, glutamine, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan and phenylalanine (Josling 2005). One of the most biologically active compounds in garlic is allicin (diallyl thiosulfinate or diallyldisulfide). The most abundant sulfur compound in garlic is alliin (S-allylcysteine sulfoxide), which is present at 10 and 30 mg g^{-1} in fresh and dry garlic, respectively (Lawson 1998). Although allicin is considered the major antioxidant and scavenging compound, recent studies show that other compounds may play stronger roles; such as polar compounds of phenolic and steroidal origin, which offer various pharmacological properties without odor and are also heat stable (Lanzotti 2006; Maniat et al 2014). Garlic is a main vegetable extensively cultivated in many countries. It is used as food for humans as well as some animals and as remedy for several diseases, as reported in folk medicine (Shalaby et al 2006; Gebreyohannes & Gebreyohannes 2013). Nowadays antibiotics are largely used for treatment and control or to reduce harmful bacterial contamination, but there is also a need to replace them with natural substances to avoid their negative effects (Farahi et al 2010).

Oscar (*Astronotus ocellatus*) is one of the most important and beautiful ornamental fish in Cichlidae family. Also, Oscar is one of the most popular ornamental fish in the world. Oscar fish has become center of interest for the aquarists because of its unique appearance and movement, fighting behaviour and their colors (Yilmaz & Arslan 2013). Ornamental fish industry has many problems such as high cost of feed, slow growth and bacterial diseases in the period of rearing. One of the best solutions for overcome this problems is use of immune and growth stimulants. Therefore, this study was designed to investigate the effects of garlic as a growth stimulant-free diet compared with garlic powder on the Oscar fish.

Material and Method

Diet preparation. This study was conducted In June 2014. Fresh garlic bulbs were purchased from a local market (Abadan, Khouzestan, Iran). After peeling garlic was cut into small pieces and dried in air for five days. Ingredients and nutrient contents of the experimental diets are presented in Table 1. Five diets were formulated to contain 0, 5, 10, 20 and 30 g kg^{-1} garlic powder as the control (T1, T2, T3 and T4). All ingredients were thoroughly mixed with 300 cc kg^{-1} distilled water, and pellets were prepared using a moist pelleting machine. The pellets were dried at room temperature for 24 h and ground into desirable particle sizes. The dried diet was packaged into plastic bag and stored frozen at -20°C until use (Maniat et al 2014).

Table 1

Formulation and proximate composition of experimental diets (g kg^{-1})

Dietary composition	*Experimental diets (g kg^{-1})*				
	Control	*5*	*10*	*20*	*30*
Fish meal	47	47	47	47	47
Wheat flour	23	23	23	23	23
Soybean meal	12	12	12	12	12
Corn gluten meal	7	7	7	7	7
Fish oil	2	2	2	2	2
Soybean oil	3	3	3	3	3
Vitamin premix[a]	1.5	1.5	1.5	1.5	1.5
Mineral premix[b]	1.5	1.5	1.5	1.5	1.5
Filler	3	2.5	2	1	0
Garlic powder	0	0.5	1	2	3
Proximate analyses (%, DM)*					
Dry matter	85.5	85.8	86.1	86	85.9
Crude protein	45.7	45.9	46.5	46.1	46
Crude fat	10.3	10.5	10.6	10.8	10.9
Ash	9.6	9.7	9.1	9.5	9.3

[a]Vitamin premix (composition per 1 kg): A = 1600000 IU, D3 = 400000 IU, E = 40000 mg, K3 = 2000 mg, B1 = 6000 mg, B2 = 8000 mg, B3 = 12000 mg, B5 = 40000 mg, B6 = 4000 mg, B9 = 2000 mg, B12 = 8 mg, H2 = 40 mg, C = 60000 mg, Inositol = 20000 mg; [b]Mineral premix (composition per 1 kg): Iron: 6000 mg, Zinc: 10000 mg, Selenium: 20 mg, Cobalt: 100 mg, Copper: 6000 mg, Manganese: 5000 mg, Iodine: 600 mg, $CoCl_2$: 6000 mg; *DM, dry matter.

Growth experiment. A total number of 300 Oscar fish were obtained from a local commercial aquarium and transported to the Ornamental Fish Unit of Zist Pazhohan Arvand Company (Khorramshahr, Khouzestan, Iran). Oscar fish (with average initial weight 12.43±0.24 g) were randomly distributed among 15 tanks (120 L each tank) at a density of 20 fish per tank with three replicate tanks for each dietary treatment. Experimental groups were fed three times daily (08:30, 11:30 and 16:30) by hand to visual satiation. Water temperature was maintained at 26.16±1.14°C, dissolved oxygen at 7.69±0.71 mg L^{-1} and pH at 7.97±0.23. The system was housed in a climate-controlled laboratory with controlled photoperiod (12 h light:12 h dark). At the end of experiment, Oscar fish in each tank were collectively weighed after anesthetizing with Carnation powder at a concentration of 30 mg L^{-1} after starvation for 24 h.

Diets and whole body chemical analysis. Fifteen fish from each tank were randomly sampled and stored at -20°C in freezer for proximate composition at the end of experiment. Proximate analysis of diets and fish were determined according to the method of AOAC (1995). Crude protein content was determined using the Kjeldahl method using an Auto Kjeldahl System. Crude lipid was analyzed by ether extraction, moisture content by a dry oven drying at 105°C for 24 h and ash by a furnace muffler (550°C for 4 h).

Statistical analysis. Analysis of all the data and the operations were performed by SPSS 19 software. Data collected were analyzed using analysis of variance at p = 0.05 and means were separated by Duncan Multiple Range Test.

Results and Discussion

Growth performance. Growth performances of the fishes after 56 days of feeding are summarized in Table 2; fish group fed on 10 g kg^{-1} of garlic had higher final weight, weight gain, and specific growth rate (SGR) than fish fed on other levels of garlic and control. The results in Table 2 show that food conversion ratio (FCR) decreased significantly to 11.73±0.122 g kg^{-1} garlic diet.

Table 2

Growth performance of Oscar fish (*A. ocellatus*) fed the experimental diets for 8 weeks

Diet	*Experimental diets (g kg^{-1})*				
	Control	*5*	*10*	*20*	*30*
Initial weight (g)	12.42±0.42^{ns}	12.44±0.30	12.39±0.26	12.37±0.25	12.53±0.35
Final weight (g)	26.11±0.97^{a}	29.45±0.81^{bc}	35.11±0.84^{d}	31.36±0.73^{c}	28.42±0.82^{ab}
Weight gain (g $fish^{-1}$)[1]	13.68±0.85^{a}	17.01±0.64^{bc}	22.72±0.69^{d}	18.98±0.59^{c}	15.89±0.63^{b}
Weight gain (%)[2]	110.00±5.77^{a}	136.66±3.73^{b}	183.33±5.50^{d}	153.33±3.33^{c}	126.66±3.33^{b}
SGR(%)[3]	1.32±0.085^{a}	1.53±0.040^{b}	1.86±0.034^{d}	1.66±0.040^{c}	1.46±0.046^{b}
FCR (%)[4]	2.18±0.272^{a}	2.7±0.309^{a}	1.73±0.122^{b}	1.96±0.258^{a}	2.00±0.248^{a}
Survival (%)[5]	93.33±11.54^{ns}	95.00±5.00	96.66±5.77	95.00±8.66	93.33±7.63

Values (means ± SE of three replication) in the same row not sharing a common superscript are significantly different ($p < 0.05$); ns = not significant ($p > 0.05$); [1]Weight gain = final weight-initial weight; [2]Weight gain percent = [(final weight-initial weight)/initial weight] × 100; [3]Specific growth rate (%) = [ln (final fish wt.) - ln (initial fish wt.)] × 100/days of feeding; [4]Food conversion ratio = weight gain/feed intake; [5]Survival = (final fish number/initial fish number) × 100.

Body compositions. The results of the body composition of Oscar fish fed the experimental diets were presented in Table 3. The results showed the highest amount of protein in treatment 2 that was significantly different compared with control group ($p < 0.05$). The use of garlic in the diet of all treatments leads to reduced body fat but it was not significantly different compared with control group ($p > 0.05$). Ash content of fish

had increasing trend but was not significantly different compared with control group ($p > 0.05$). Also, the moisture content of fish was not significantly different compared with control group ($p > 0.05$).

Table 3

Proximate composition (%) of the whole body of Oscar fish (*A. ocellatus*) fed the experimental diet for 8 weeks

Diet	*Experimental diets (g kg^{-1})*				
	Control	*5*	*10*	*20*	*30*
Crude protein[a]	13.57±0.12[a]	13.84±0.39[ab]	14.97±0.54[d]	14.50±0.48[cd]	13.80±0.47[ab]
Crude lipid[ns]	6.63±0.31	6.15±0.70	5.77±0.66	6.41±0.37	6.27±0.25
Moisture[ns]	72.17±0.77	71.99±0.49	71.6±1.99	71.63±1.68	71.79±0.96
Ash[ns]	4.15±0.71	4.28±0.15	4.37±0.31	4.39±0.23	4.50±0.66

Values (mean ± SE of three replication) in the same row not sharing a common superscript are significantly different ($p < 0.05$); ns = not significant ($p > 0.05$).

The current experiment aimed to study the effects of garlic on the growth performance and body composition of Oscar fish. Garlic was used at the levels 5, 10, 20 and 30 g kg^{-1} diet and their effects are presented in Tables 2 and 3. This indicates that the final weight, weight gain, and SGR increased significantly with all treatments of garlic. The highest growth performance was observed in fish fed on 10 g kg^{-1} of garlic. It agrees with studies of Mesalhy et al (2008), Nya & Austin (2009), Maniat et al (2014).

Also, Shalaby et al (2006) reported significant increased weight gain (%) and SGR in the Nile tilapia (*Oreochromis niloticus*) when fed diet containing 30 g kg^{-1} garlic in diet. Furthermore, the results of Mesalhy Aly et al (2008) confirm the positive effects of garlic on growth performance of Nile tilapia. Also other studies conducted by Nya & Austin (2009) and Farahi et al (2010) on rainbow trout (*Onchorhynchus mykiss*), Lee et al (2012) on sterlet sturgeon (*Acipenser ruthenus*), Guo et al (2012) on *Epinephelus coioides*, Nwabueze (2012) on *Clarias gariepinus*, and Megbowon et al (2013) on cichlid fish (commonly called 'Wesafu' reared in hapa) demonstrate the use of garlic herb improves growth performance in different fish species. Metwally (2009) reported that although growth is enhanced with garlic supplementation but high dose of garlic in fish may reduce feed intake as a result of its unpleasant odour. The result of Platel & Srinivasan (2004), Mesalhy Aly et al (2008) and Maniat et al (2014) demonstrate the use of garlic with high levels of garlic is related to negative effect of smell and pungent taste of garlic that leads to reduce fish feed intake.

In this study, results of Oscar fish body compositions showed that crude protein increased significantly with diets containing 10 g kg^{-1} garlic, and lower fat content was observed in body of Oscar fish.

Farahi et al (2010) and Maniat et al (2014) showed that inclusion of garlic in the diet increased fish protein content and decreased whole body fat in fish. Banerjee & Maulik (2002) reported that compounds in garlic lower the activity of lipogenic and cholestrogenic enzymes in liver. On the other hand, compounds in garlic increase the excretion of acidic and neutral steroids that cause the excretion of cholesterol from the body content. Water-soluble sulfur compounds such as S-alLyl Sulfur Said cysteine (SAC) and Diallyl-di-sulfide (DADS) of garlic extract inhibit the synthesis of cholesterol (Yeh & Liu 2001; Gebhardt & Beck 1996). As well as allicin of garlic causes inhibition of accumulation of fat in body (Elkayam et al 2003).

Conclusions. At the end, garlic meal as feed additives represent alternative solution to thrive aquaculture feeds as growth promoters. From the obtained results it could be recommended that garlic may be used as a growth promoter and antibiotic for the treatment and for enhancing fish tolerance to environmental stress, so garlic should be added to the diets of fish. Generally based on the result of growth performance and body composition it can be recommended 10 g kg^{-1} garlic powder as a natural alternative growth promoters in diet of Oscar fish.

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