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Effect of fresh or dried garlic as a natural feed supplement on growth performance and nutrients utilization of the Nile Tilapia *(Oreochromis niloticas)*

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ABSTRACT

The present investigation aimed to study the effect of dietary fresh or dried garlic (*Allium sativum*) supplementation in the Nile tilapia (*Oreochromis niloticus*) diets at different levels, on growth performance, nutrients utilization, carcass traits and whole bodies' chemical composition. The study was performed in four concrete ponds (7.5 × 2.25 × 0.70 m). All experimental ponds were divided into four partitions with a water volume of each partition of 3 m^3 (1.875 × 2.25 × 0.70 m). The experiment included five dietary treatments i.e the control (C); treatment 2 fed on the basal diet supplemented with 5g. fresh garlic/kg diet (FG5); treatment 3 supplemented with fresh garlic at 3g/kg (FG3) and treatments 4 and 5 supplemented with dried garlic at levels of 5 and 3g/kg (DG5) and (DG3), respectively. Fresh and dried garlic were supplemented to the basal diet and mixed with the basal diet thoroughly. Each dietary treatment was applied in triplicates and stocked with healthy mono-sex Nile tilapia fry (0.26g initial weight) at a rate of 60 fry each replicate i.e 20 fry / m^3. The basal diet was formulated to contain about 33% crud protein and 4500 kcal gross energy. The experimental diets were fed at daily rates of 30; 10; 6 and 4% of the fish biomass for fish weights from 0.26 to 1g; 1-5g; 5-20g and 20g till the end of the experiment after 22 weeks, respectively. The experimental diets were offered daily in equal parts at 9am; 11am; 1pm and 3pm, respectively.

Results obtained are summarized in the following:

1- The highest ($P<0.05$) final weights (90.02g); total weight gain (89.76g); daily weight gain (0.58g); specific growth rate (3.81) and survival rate 93.89% were recorded with the group fed on the basal diet supplemented with fresh garlic at 3g/kg level, while the lowest value ($P<0.05$) was recorded by the control un-supplemented group. All garlic supplemented groups recorded significantly higher condition factor compared to the control group.

2- The group fed on the diet supplemented with dried garlic (5g/kg) recorded significantly the best feed conversion ratio; protein efficiency ratio and protein productive value; while the control group recorded the worst value of the tested feed utilization parameters.

3- Garlic supplementation of Nile tilapia diets released significant effects on dressing percentages for the favor of dried garlic at levels 5 and 3g/kg while the control group recorded the lowest (P<0.05) value, garlic supplementation showed significant effects on by-products; flesh percentages and hepato somatic index.

4- Supplementation of Nile tilapia diets with fresh or dried garlic had no significant effects on moisture; dry matter and ash contents of fish whole bodies, while it released significant effects on the whole body protein and fat compared to the control group.

5- Dietary fresh or dried garlic supplementation showed significant effects on tilapia serum total protein; total albumen; total globulin and total lipids.

6- Supplementing Nile tilapia diets with fresh garlic at levels of 5 or 3g/kg and dried garlic at levels of 5 or 3g/kg reduced the costs of production one kg of fish gain by 6.39; 6.02; 9.72 and 6.05% compared to the control group, respectively.

Based on the present results, supplementation of growing Nile tilapia diets with dried garlic at 5g/kg diet level is recommended to achieve better growth performance; feed utilization and to reduce the costs of production of one kg/gain in weight.

Key words: Nile tilapia, natural feed additives, tank culture, garlic.

INTRODUCTION

Recently, the use of antibiotic growth promotors in animal and fish feeds has been seriously criticized by governmental policy makers and consumers because of the development of microbial resistance to these products and the potential harmful effects on human health (Botsoglu and Fletouris, 2001; Williams and Losa, 2001; McCartney, 2002). There is increasing public and government pressure in several countries of EU and some non-EU to search for natural alternative to antibiotics (Williams and Losa, 2001; McCartney, 2002). Probiotic, prebiotic and medicinal plants as natural feed additives are recently used in poultry and fish diets to enhance the performance and the immune response of birds and fish. In this connection, the garlic plant contains many important components and nutrients beneficial to human and animal nutrition (Hamail, 1992). Many beneficial health properties of garlic are attributed to organosulphur compounds, particularly to thiosulfinates (Block, 1992). Allicin (diallythiosulfinate) is the most abundant compound representing about 70% of all thiosulfinates present, or formed in crushed garlic (Block, 1992; Han *et al*., 1995). Garlic has proved to be hypolipidemic (Sumiyoshi, 1997), antimicrobial (Kumar and Berwal, 1999), antihypertensive (Suetsuna, 1998), hepatoprotective (Wang *et al.*, 1998) and insecticidal (Wang *et al.*, 1998). Garlic extract has also been shown to reduce serum cholesterol levels (Bordia *et al*., 1975; Augusti 1977) and increase blood coagulation time (Bordia *et al.*, 1975). AL-Salahy, (2002) reported that oral administration of garlic juice to *Clarias lazera* (African catfish) every 24 hours for 5 days increased serum albumin to 6.03 mg/dl compared to the control unsupplemented group (5.46 mg/dl). Diab *et al.* (2002)

reported that incorporation of *Allium sativum* in tilapia diets improved feed intake and feed conversion ratio. They added that incorporation of garlic or fennel in Nile tilapia diets improved feed conversion ratio and protein efficiency ratio significantly compared to the control unsupplemented group. Shalaby *et al.* (2006) reported that incorporation of garlic in Nile tilapia diets at 10; 20; 30 and 40g/kg diet increased significantly final weights and specific growth rate and the increase was more pronounced at higher incorporation levels. Mesalhy *et al.* (2008) fed Nile tilapia on diets containing 10 or 20 g/kg diet garlic for one month or for two months after that fish were fed on diets free of garlic until 8 months after start. They reported that groups fed on diets with 10 or 20g garlic for two months or 20g garlic/kg diet for one month showed significant increase in the final body weight after 8 months compared to the control group. The present study was conducted to evaluate the effect of garlic supplementation of mono-sex Nile tilapia diets on growth performance, nutrients utilization, carcass traits, whole body composition and some blood serum parameters.

MATERIAL AND METHODS

The present study was carried out in Water Resources Research Station belonging to the National Institute of Oceanography and Fisheries at Baltim region, Kafr El-Sheikh governorate, A.R.E. The study started from 4th of June and lasted till 5th of November 2005 for 22 weeks.

Preparation of garlic forms:

Garlic (*Allium sativum*) was used in this study in fresh and dried forms.

1-Fresh form: Garlic was peeled and crushed by electrical grinder then stored frozen in poly-ethylene jar until composing of the experimental diets.

2-Dried form: After peeling garlic was cut into small pieces and dried in air for five days. The dried material was grinded in electric mill then stored in poly ethylene jar until composing of the experimental diets.

Experimental design:

The present experiment was designed to study the effect of garlic as growth promoter in the Nile tilapia diet in fresh or dried forms at two levels of supplementation from each form at 5 and 3g/kg diet, respectively. The experiment included five treatment groups; the first group served as a control unsupplemented group C; the second and third groups were fed on the control diet supplemented with 5g fresh garlic/kg diet (group FG5) and with 3g fresh garlic/kg diet (group FG3), respectively. Groups 4 and 5 were fed on the control diet supplemented with dried garlic at levels of 5g/kg (DG5 group) or 3g/kg (DG3 group) respectively. The composition of the control diet is presented in Table (1). The control diet was formulated to contain about 33% crude protein and 4500 Kcal gross energy (GE)/kg diet. The energy to protein ratio of the control diet was 136.6 kcal GE to 1g protein.

Experimental ponds and water source:

Four rectangular concrete ponds with diameters of 7.5 × 2.25 × 0.7m each, were used in the present study. The four experimental ponds (tanks) were divided into four divisions with screen sheets have fine mesh size with diameters of 1.875 × 2.25 × 0.7m and water volume of about $3m^3$ for each division. During the experimental period, ponds water was exchanged with new water at a rate of 20% of the water column daily to keep the water quality suitable for the experimental fish. Ponds water was drained completely every two weeks and all ponds were cleaned and fish wastes were removed, after that ponds were filled with new water. Water source of the present study was ground water pumped into the ponds through electrical pump and pipelines connected to the experimental ponds. All ponds were supplied with air through a central lobe blower and plastic pipes laid 50 cm below the water level. Water quality parameter including water temperature (C°), dissolved oxygen (DO) concentration (mg / l), water transparency (cm), pH (degrees), ammonia (NH_3) (mg / l) and total dissolved salts (T.D.S) (mg / l) are presented in Table (2). Water quality parameter were measured every two weeks during June, July, August, September and October, the course of both experiments. As presented in this table, water temperature ranged between 24.5 to 31.5 C°, DO concentration ranged between 6.3 and 9 mg / l, transparency 32 to 55 cm, pH 7.5 to 7.9 degrees, NH_3 0.021 to 0.039 mg /l and TDS between 8080 and 9310 mg / l and all tested water quality parameter were within the optimal levels required for growth and development of Nile tilapia and were in accordance with the figures of APHA (1985)

Table 1: Composition and proximate chemical analysis of experimental diet

Ingredient	**%**
Fish meal (72%)	25
Yellow corn	30
Soybean meal (44 %)	25
Rice bran	12
Vegetable oil	6
Vitamin mixture *	1
Mineral premix **	1
Total	100
Chemical analysis of diet ***	
Moisture	8.54
crude protein	32.96
crude fat	11.13
crude fiber	2.91
Ash	7.64
Gross energy (kcal) ****	4503
Energy to protein ratio	136.6 : 1

*Each gram of vitamin mixture contains 20.00 IU vit A 200 IU vit ,.De, 400 vit E, 20mg Niacin 4.5 mg riboflavin, 3 mg pyridoxine , 0.013 mg vit B12, 100 mg cholin chloride and 2 mg vit k.

** Each gram contains 0.83 Ca, 0.63 P .078Na. 0.018Mn , 0.011Zn and 0.001 Cu The Mixture was prepared by mixing 35 parts of dicalcium phosphate , 3 parts of mineral premix and 2 part of common salt.

*** According to AOAC, (1989)

**** Based upon the factor 5.65, 9.45, 4.0 and 4.0 Kcal/g of protein, ether extract, crude fiber and nitrogen free extract (Jobling, 1983)

Table 2: Monthly average water quality parameter during the experimental period in the cement ponds

month	Parameters					
	Temperature (°C)	DO. (mg/l)	Transp. (Cm)	pH	NH3 (mg/l)	TDS (mg/l)
June	24.5	9	55	7.9	0.021	8080
July	29.5	8.2	50	7.7	0.025	8560
August	31.5	7.5	40	7.9	0.032	8320
September	30	6.8	35	7.6	0.039	9310
October	25	6.3	32	7.5	0.038	9100

Experimental fish and stocking density:

A total number of 900 apparently healthy mono-sex Nile tilapia (*Oreochromis niloticus*) fry (sex reversed into males with hormone treatment) were purchased from a commercial private fish hatchery located at Kafr El-Sheikh Governorate, were used as experimental fish in the present study. Fish were acclimated to the experimental water for 7 days before starting the experiment in four fiberglass tank (1 m^3) with small aeration pump. After acclimation the fish were randomly distributed and stocked in the experimental replicates. The initial weight of fish was 0.26 g and chemical composition of fish whole body at the start of experiments is presented in Table (3). The experimental fish were divided into 5 treatment groups each 180 fry represented in three replicates (60 fry / replicate) where the fish were stocked at a rate of 20 fry/ m^3. The three replicates were represented in three divisions of the ponds each of a total water volume of about 3 m^3. The total number of the replicates of the five treatments was 15 represented in 15 divisions.

Table 3: chemical composition of fish at the start on dry matter basis

Item	Moisture	Protein	Fat	Ash
%	73.1	66.1	15.1	18.8

Feeding rates: The daily feed amount was distributed daily by hand in four equal portions at 9am, 11am, 1pm and 3pm according to Kubaryk, (1980) (table 4). The feeding rates were readjusted after recording the fish weights every two weeks.

Table 4: Feeding rate of Nile tilapia throughout the experimental period

Weight (g)	start – 1	1 - 5	5 - 20	20 - end
Feeding rate (% of b. wt.)	30	10	6	4
Daily feeding times	Four meals(9 am, 11 am, 1pm, 3 pm)			

Growth performance:

1- Body weight gain = W2 – W1

Where: W2 = Final body weight; W1= Initial body weight

2- Average daily gain = (W2 – W1) / period in day

3- Specific growth rate SGR = (Ln W2- Ln W1) x100/ period in day.

Where: Ln = (log l0x) $^{3.303}$
4- Condition factor (K) = [weight (g) / length^3 (cm)] xl00
5- Survival Rate (%) = N1 /N0 x 100
Where: N1 = Total number of fish survival in pond at end of experiments.
N0 = Total number of fish in tank at the beginning of experiments.

Feed utilization:

1- Food conversion ratio (FCR) = total feed consumption (g) / (W2 – W1)
2- Protein efficiency ratio (PER) = (W2 – W1) / protein intake (g)
3- Protein productive value (PPV) = Protein retained in tissue (g) / protein intake (g) ×100

Carcass characteristics

After harvesting five fish were taken from each replicate (15 for each treatment) at random for carcass traits. Body weight of each fish in the sample were recorded at first, then the scales and viscera were removed, also head and fins were cut then skin was removed, bones were obtained by dipping rest of the body in boiling water. All parts were weighted and recorded to calculate the following.

1-Dressing percentage = ((body weight – {head + fins + viscera + scales}) / body weight) ×100
2-By-product percentage = ({head + fins + viscera + scales + skin + bones} / body weight) ×100
3-Flesh percentage = ({body weight – by-product} / body weight) ×100
4-Hepato somatic index: Liver was weighted to calculate (HSI) by using the following formula: HSI = (liver wet weight (g)/ weight of fish (g)) × 100

Chemical analysis of whole fish body and the diet:

Proximate chemical analysis (moisture, dry matter, protein, fat and ash) of fish and diet were determined according to the methods described by AOAC (1989).

Blood serum analysis:

At the end of the experimental period approximately 2 ml blood sample were collected from the different groups via the caudal vein from the fish using a disposable tuberculin syringe. Serum of blood was isolated by electrical centrifuge. The following analysis was conducted on serum blood:

1- Determination of serum total protein: Serum total proteins determined according to the colorimetric method described by Henry (1964) using commercial Kits "DIALAB diagnostics protein Kits, Wien".
2- Determination of serum total albumin: Serum albumin determined by colorimetric method described by Doumas and Biggs (1972) by using commercial Kits "ELITECH diagnostics albumin Kit, France".
3- Determination of serum total globulin: It was calculated by subtract serum total protein from total serum albumin according to Coles (1974).
4- Determination of (A/G): Moreover albumin/globulin ratio (A/G) was calculated

5- Determination of serum total lipids: Total lipids were determined calorimetrically using a kit supplied by El Nasr pharmaceutical chemical Co., according to Knight *et al*. (1972).

Water quality:

Quality of ponds water was checked once per two weeks to determine temperature (°C), dissolved oxygen (DO), transparency Secchi disk visibility (SD), hydrogen ions concentration (pH), Ammonia (NH_3) and Total dissolved salt (T.D.S). All measurements were carried out according to the standard methods of American Public Health Association (APHA 1985) and Boyd (1992)

1- Water temperature (°C) and dissolved oxygen(DO): According to Boyd (1992), tests of temperature and dissolved oxygen were taken between 7 am and 8 am by inserting the probe of the oxygen meter (YSI 57, USA) by dripping it few centimeters below the water surface (approximately 5 cm)

2- Secchi disk visibility (S.D) (cm): Estimates of Secchi disk visibility were made on each sampling date. Measurements were made at the same location in each pond according to Boyd (1992).

3-Hydrogen ions (pH): According to Boyd (1992), pH value was measured by using pH meter (Coming Co. pH meter model 345) as soon as samples of water were collected.

4- Ammonia (NH_3): Ammonia (mg/l) was calculated from the results of total ammonia according to the following equation:

Ammonia concentration (mg/l as NH_3) = A/ 100 x 1.2 x total ammonia.

Where: A is a coefficient related to water pH and temperature at the time of testing (Boyd, 1992).

5- Total dissolved salt (T.D.S): Total dissolved salt was measured by using refractometer (Abbe Model AR-001).

Statistical analysis:

Statistical analysis was performed using the one-way analysis of variance (ANOVA) and Dauncan (1955). Multiple Range Test was done to determine differences between treatment (mean at significance level of $P<0.05$). Standard errors were also estimated. All analysis was run on the computer using the SPSS program (SPSS 13) under windows XP.

Economic efficiency:

The Economic efficiency for the experiments was done to determine the cost of feed required to produce one Kg of fish weight gain. The cost of the experimental diets has been done in L.E. for market price in 2005. Accordingly, the cost of producing one Kg gain = amount of feed used to produce 1 Kg fish gain × cost of one Kg feed.

RESULTS AND DISCUSSION

1- Growth performance: As presented in Table (5), averages of initial weights of mono-sex Nile tilapia at the experimental start were found to be 0.26 g. for all experimental groups indicating the complete random distribution of the experimental fish into the experimental groups. Averages of final weights (i.e. 22 weeks after start) for the control (C), fresh garlic 5g/kg (FG5), fresh garlic 3g/kg (FG3), dried garlic 5g/kg (DG5) and dried garlic 3g/kg (DG3) were 80.35; 84.99; 90.02; 86.01 and 82.11g, respectively. Analysis of variance for final weights indicate that the FG3 group had significantly ($p<0.05$) the highest final weights followed in a significantly decreasing order by the DG5 group and by the FG5; DG3 and the C groups, respectively. As presented in the same table, averages of total weight gain for groups C; FG5; FG3; DG5; and DG3 were 80.09; 84.74; 89.76; 85.75 and 81.85g respectively. The analysis of variance for total gain in weight (TGW) showed that the group FG3 had the highest TGW with a significant difference with the DG5 groups and the other treatment groups where the C group showed the lower TGW. The same trend was observed with the daily gain in weight (DGW) where the FG3 group recorded the highest ($p<0.05$) values and the DG3 and C recorded the lowest (DGW) $p<0.05$ values. Concerning SGR for groups C; FG5; FG3; DG5 and DG3, averages were found to be 3.73; 3.77; 3.81; 3.77 and 3.75, respectively (Table 5). Results revealed that the highest SGR value ($p<0.05$) was recorded by the FG3 group and the lowest ($p<0.05$) was recorded by the C group. Results of SGR show also that differences among groups FG5; DG5 and DG3 were insignificant. Results of Table (5) show that averages of condition factor (K) for the C; FG5; FG3; DG5; and DG3 were 1.79; 1.82; 1.84; 1.84; and 1.82, respectively. The analysis of variance of results indicate that groups FG3; DG5; DG3; and FG5 recorded the highest K values followed compared to C. Results of K values indicate that the groups FG3; DG5; DG3 and FG5 grow more in weight rather in length compared to C group. In general results of table indicate that incorporation of fresh garlic at 3g/kg level or dried garlic at 5g/kg into growing mono sex Nile tilapia diets improved growth performance of the fish.

Table 5: Growth performance of Nile tilapia fed Garlic as feed additives in diet

Items	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Initial weight (g)	$0.26^{a} \pm 0.00$	$0.26^{a} \pm 0.00$	$0.26^{a} \pm 0.00$	$0.26^{a} \pm 0.00$	$0.26^{a} \pm 0.00$
Final weight (g)	$80.35^{d} \pm 0.89$	$84.99^{bc} \pm 1.13$	$90.02^{a} \pm 1.82$	$86.01^{b} \pm 0.96$	$82.11^{cd} \pm 0.82$
Total weight gain (g)	$80.09^{d} \pm 0.89$	$84.74^{bc} \pm 1.13$	$89.76^{a} \pm 1.82$	$85.75^{b} \pm 0.96$	$81.85^{cd} \pm 0.82$
Daily weight gain (g)	$0.52^{d} \pm 0.01$	$0.55^{bc} \pm 0.01$	$0.58^{a} \pm 0.01$	$0.56^{b} \pm 0.01$	$0.53^{cd} \pm 0.01$
SGR	$3.73^{c} \pm 0.01$	$3.77^{b} \pm 0.01$	$3.81^{a} \pm 0.01$	$3.77^{b} \pm 0.01$	$3.75^{bc} \pm 0.01$
Condition factor	$1.79^{b} \pm 0.01$	$1.82^{a} \pm 0.01$	$1.84^{a} \pm 0$	$1.84^{a} \pm 0.01$	$1.82^{a} \pm 0.01$
Survival Rat %	$85.19^{c} \pm 0.67$	$92.78^{ab} \pm 0.85$	$93.89^{a} \pm 0.85$	$90.37^{b} \pm 1.03$	$91.85^{ab} \pm 0.67$

a, b, c…etc.: Means within row with different superscripts are significantly different ($P < 0.05$)

These results are in accordance with the finding of Diab *et al*. (2002), who reported that incorporation of garlic (*Allium sativum*) in Nile tilapia diets increased gain in body weight. Also, shalaby *et al*. (2006) reported that incorporation of garlic in Nile tilapia diets at 10; 20; 30 and 40g/kg diet increased significantly final weights and specific growth rate and the increase was more pronounced at higher incorporation levels. Furthermore, Mesalhy *et* *al*. (2008) fed Nile tilapia on diets contained 10 or 20 g/kg diet garlic for one month or for two months after that fish were fed on diets free of garlic until 8 months after start. They reported that groups fed on diets contained 10 or 20 g/garlic for two months or 20g garlic/kg diet for one months showed significant increase in final body weight after 8 months compared to the control group. Result in Table (5) is in agreement with that reported by Soltan and El-Laithy (2008) who reported that incorporation of garlic in growing Nile tilapia diets improved significantly final weights; final body length, weight gain and specific growth rate. The growth promoting effect of garlic may be due to the increase of glucose inflow into tissues and its thyroid like activity (EL-Nawawy, 1991). Sulfur compounds in garlic are considered as active antimicrobial agents and improve immunity and therefore stimulate growth (EL-Afify, 1997) and have a mode of action similar to antibiotics (Ibrahim *et al*., 2004). As presented in Table (5) averages of survival rate (%) for the C; FG5; FG3; DG5; and DG3 groups were 85.19; 92.78; 93.89; 90.37 and 91.85 %, respectively The statistical evaluation of results indicate that groups FG3; FG5 and DG3 had significantly ($p<0.05$) higher survival rates followed in a significant decreasing order by DG5 and the C (control group). In general results revealed that garlic incorporation in Nile tilapia diet improved the tilapia survival. In this connection, Shalaby *et al*. (2006) recommended the incorporation of 3% garlic in tilapia diets for growth promotion total bacterial reduction and improving fish health. Results of Soltan and El-Laithy, (2008) are in agreement with the results of the present study. They reported that incorporation of garlic into Nile tilapia diets at 1% level improved survival rate. The improvements due to garlic may due to its antimicrobial, antioxidant, and antihypertensive properties (Konjufca *et al*. 1997; Sivam, 2001). Previous research suggested that those functions are mainly attributed to the bioactive components of garlic including sulphur containing compounds, such as allin, diallylsulphides and allicin (Amagase and Milner, 1993). Many beneficial health properties of garlic are attributed to organosulphur compounds, particularly to thiosulfinates (Block, 1992). Allicin (dially thiosulfinate) is the most abundant compound representing about 70% of all thiosulfinates present, or formed in crushed garlic (Block, 1992; Han *et al*., 1995). Garlic has proved to be hypolipidemic (Sumiyoshi, 1997), antimicrobial (Kumar and Berwal, 1999) antihypertensive (Suetsuna, 1998), hepato protective (Wang *et al*., 1998) and insecticidal (Wang *et al*., 1998). In the literature garlic extract has also been shown to reduce serum cholesterol levels (Augusti, 1977) and increase blood coagulation time (Bordia *et al*., 1975). An antifungal activity has been identified in garlic bulbs (Fromthing and Bulmer, 1978). S-allyl cysteine, present in the crushed garlic, was found to inhibit tumor metabolism and enhance the immune response (Sumiyoshi, 1997). The allyl sulfides enhance the glutathione s-transferase enzyme system, which through their dependent biochemical pathway enhance the liver's detoxification of carcinogenic substances. The *allium* species show immune enhancing activities that include promotion of lymphocyte synthesis, cytokine release, phagocytosis and natural killer cell activity (Kyo *et al*., 1998).

2- Nutrients utilization: Averages of total feed intake (g/fish) and total weight gain (g/fish) during the whole experimental period for the treatment groups are presented in Table (6). Averages of feed conversion ratio (FCR) for the C; FG5; FG3; DG5; and DG3 were 2.47; 2.30; 2.31; 2.19; and 2.30 kg of diet required for each kg gain in weight respectively. Analysis of variance for FCR revealed that the DG5 group had significantly ($p<0.05$) the lowest (best) FCR records followed in a significant decreasing order by the three groups FG5; FG3 and DG3 and the highest (worst) value was recorded by the control group C. The same trend was observed with protein efficiency ratio (PER) where the DG5 group recorded the highest ($p<0.05$) value and the C group recorded the lowest ($p<0.05$) value.

Table 6: Feed utilization of the Nile tilapia fed on Garlic as feed additives in the diet

Items	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Total feed intake g/fish	198.054	194.793	207.738	187.624	187.891
Total weight gain g/fish	80.09	84.74	89.76	85.75	81.85
FCR	$2.47^{a} \pm 0.03$	$2.30^{b} \pm 0.04$	$2.31^{b} \pm 0.03$	$2.19^{c} \pm 0.03$	$2.30^{b} \pm 0.03$
PER	$1.23^{c} \pm 0.01$	$1.32^{b} \pm 0.02$	$1.31^{b} \pm 0.02$	$1.39^{a} \pm 0.02$	$1.32^{b} \pm 0.02$
PPV	$20.91^{d} \pm 0.25$	$24.55^{bc} \pm 0.43$	$23.60^{c} \pm 0.3$	$26.32^{a} \pm 0.36$	$25.45^{ab} \pm 0.38$

a, b, c…etc.: Means within row with different superscripts are significantly different ($P < 0.05$)

Concerning the protein productive value (PPV) averages of this trait for the C; FG5; FG3; DG5; and DG3 groups were found to be 20.91; 24.55; 23.60; 26.32 and 25.45, respectively. Results of PPV revealed that DG5 group recorded the highest ($p<0.05$) value and the C group recorded the lowest PPV value. There results are in accordance with the findings of Diab *et al.* (2002) who reported that incorporation of *Allium sativum* in tilapia diets improved feed intake and feed conversion ratio. Also, Shalaby *et al.* (2006) reported that incorporation of garlic (*Allium sativum*) at 10; 20; 30 and 40 g/kg. Diet improved the feed conversion ratio and the improvement was more pronounced at 30 g/kg diet g garlic. The same authors added that incorporation of garlic seemed to have no significant effects on PER. Results in Table (6) are also in agreement with those obtained by Khattab *et al.* (2004) who found that the dietary of Biogen (containing garlic) increased feed intake, FCR, PER and body composition (crude protein, ether extract, ash, and moisture) in fish. In the study of Shalaby *et al*. (2006) apparent protein Digestibility was improved with increasing levels of garlic (from 85.68% to 93.70%). Similar results were obtained by Gomes *et al*. (1993) in rainbow trout (from 85.02% to 92.43%); Degani *et al.* (1997) in hybrid tilapia (from 85.79% to 90.87%); Goddard and Mclean, (2001) in *Oreochromis aureus* (from 76.8% to 90.8%) and Khattab (2001) in the Nile tilapia (from 85.65% to 92.25%). Also Soltan and El-Laithy (2008) reported that incorporation of garlic or fennel in Nile tilapia diets improved feed conversion ratio and protein efficiency ratio significantly, compared to the control unsupplemented group. In this connection, El-Afify, (1997) reported that sulfur compounds in garlic are considered as active antimicrobial agents and improve immunity and therefore stimulate growth and improve Nutrients utilization and have mode of action similar to antibiotics (Ibrahim *et al.*, 2004).

3- Carcass traits: Results of carcass traits including dressing; by-products (head, fins, scales, skin, bones and viscera) and flesh without bones are presented in Table (7). Averages of dressing percentages (as % of fish weight) for the C; FG5: FG3; DG5; and DG3 were found to be 59.47; 60.98; 61.07; 62.44 and 62.41 percent, respectively. Analysis of variance for dressing percentage show that groups fed on experimental diets DG5 and DG3 had significantly ($p<0.05$) higher dressing percentages followed in a significant ($p<0.05$) decreasing order by both FG3 and FG5 and C respectively. These results are in partial agreement with the finding of Rahmatnejad *et al.* (2009) who reported that incorporation of prebiotic Biolex-MB and garlic powder in broiler chick rations increased carcass percent than the control or turmeric groups. In this connection, Abdel-Latif *et al*. (2001) reported that supplementing broiler diets with a mixture of dried onion and garlic (1:1) at 2% level improved significantly dressing and edible parts significantly compared to birds fed on diets containing dried onion or garlic alone at the same level. Furthermore, El-Nawawi (1991) reported that feeding dietary garlic to broilers increased carcass weight, but dressing and giblets percentages were not significantly affected.

Table 7: Carcass parameter of Nile tilapia fed Garlic as feed additives in diet

Items	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Dressing %	59.47 ^{c} ±0.407	60.98 ^{b} ±0.17	61.07 ^{b} ±0.27	62.44 ^{a} ±0.53	62.41 ^{a} ±0.5
By-product %	49.32 ^{a} ±0.4	47.08 ^{bc} ±0.17	47.31 ^{b} ±0.56	46.05 ^{bc} ±0.48	45.89 ^{c} ±0.38
Flesh %	50.68 ^{c} ±0.4	52.92 ^{ab} ±0.17	52.69 ^{b} ±0.56	53.95 ^{ab} ±0.48	54.11 ^{a} ±0.38
HSI %	1.85 ^{a} ±0.06	1.73 ^{ab} ±0.05	1.79 ^{ab} ±0.04	1.71 ^{ab} ±0.05	1.67 ^{b} ±0.04

a, b, c…etc.: Means within row with different superscripts are significantly different ($P < 0.05$)

Averages of by-products percentages (head, fins, viscera, scales, skin and bones) were found to be 49.32; 47.08; 47.31; 47.31; 46.05 and 45.89% for the C; FG5; FG3; DG5 and DG3 groups respectively. Results revealed that the C (control) group showed the highest ($p<0.05$) by-products percentages while the DG3 showed the lowest one. In this respect Bayoumi (2004) reported that feeding Nile tilapia on diets supplemented with Biogen probiotic containing garlic) or Bio-Most probiotics had no significant effects on dressing and by-products percentages. The same trend was observed with results obtained by El-katcha (1996) who reported that supplementing Nile tilapia diets with methionine and lysine amino acids had no effects on dressing as well as by-products percentages. As presented in Table (7) averages of flesh (with out bones) percentages for the same dietary treatment groups cited before were 50.68; 52.92; 52.69; 53.95 and 54.11% respectively. Results revealed that groups DG3; DG5 and FG5 had significantly higher flesh percentages compared to the control group; however differences in this trait among DG5; FG5 and FG3 groups were insignificant. There results are in agreement with the findings of El-saidy and Gaber (1997) who supplemented diets of growing Nile tilapia fish (8.90 g initial weight) with dried garlic meal at 2; 4; 6 and 8% levels for 20 weeks and reported that supplementation of dried garlic at 4% level reduced fish flesh and whole fish fat at the end of the experiment with differences reaching statistical significance among groups fed different levels of garlic meal and the control. Results of Table (7) show that averages of hepato somatic indices (HSI) were found to be 1.85; 1.73; 1.79; 1.71 and 1.67%, for the C; FG5; FG3; DG5 and DG3 groups, respectively. Results revealed that DG3 had significantly lower (HSI %) than the control group, however differences among C and FG5; FG3; and DG5 in this trait were insignificant. There results are in partial agreement with the finding of Shalaby *et al.* (2006) who reported that supplementing Nile tilapia diets with *Allium sativum* at 10; 20; 30 or 40 g. /kg diet had no significant effects on HSI %. In this respect Metwally, (2009) fed Nile tilapia fingerling on diets containing different forms of garlic, natural garlic (40 g/kg diet), garlic oil capsules (250 mg. /kg diet) and garlic powder (32g. /kg diet) for three months. He reported that all forms of garlic tested decreased significantly the HSI %of tilapia.

4- Whole body chemical composition: Results of Table (8) illustrate the whole body chemical composition including moisture, dry matter (DM); crude protein (CP), fat (EE) and ash as percentages of dry matter as affected with the dietary treatments. Results of this table reveal that moisture contents ranged between 70.12 and 72.05%, DM contents ranged between 27.95 and 29.88% and ash contents between 16.67 to 17.86% with insignificant differences among the dietary treatment groups. As presented in the same table, averages of CP% for the C; FG5; FG3; DG5; and DG3 groups were 61.03; 63.33; 62.54; 63.61 and 64.47%, respectively, where groups DG5; DG3; and FG5 had significantly ($p<0.0$) higher CP contents in whole body DM compared to the control group. The opposite trend was observed in EE percentage, where the control group recorded the highest EE ($p<0.05$) contents (21.11%) and the DG3 group recorded the lowest ($p<0.05$) value (18.12%). These results may indicate clearly that as the CP contents in the DM of tilapia whole bodies increased the EE contents decreased. These results may lead us to believe that, the increase in body protein contents are on the costs of EE contents.

There results are in accordance with the findings of Soltan and El-Laithy (2008) who reported that incorporation of garlic (1% g the diet) or (1% S. subtilis + 1% garlic) into Nile tilapia diets resulted in significant effects in DM; CP and EE contents of Nile tilapia, while ash contents show some insignificant variations. In this respect Barros *et al.* (2000) and Yildirim *et al*. (2003) reported that body fat content is closely related to weight gain and inversely related to body moisture content and this agreed with the obtained results of the present study.

Table 8: Chemical composition of the Nile tilapia fed on Garlic as feed additives in the diet

Items	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Moisture	72.05 ^{a} ±1.08	70.63 ^{a} ±0.51	71.22 ^{a} ±0.73	70.14 ^{a} ±0.47	70.12 ^{a} ±0.23
Dry matter	27.95 ^{a} ±1.08	29.37 ^{a} ±0.51	28.78 ^{a} ±0.73	29.86 ^{a} ±0.47	29.88 ^{a} ±0.23
Protein	61.03 ^{b} ±0.37	63.33 ^{a} ±0.51	62.54 ^{ab} ±0.88	63.61 ^{a} ±0.66	64.47^{a} ±0.6
Fat	21.11^{a} ±0.52	19.63 ^{b} ±0.28	20.34 ^{ab} ±0.43	19.72 ^{b} ±0.43	18.12 ^{c} ±0.33
Ash	17.86 ^{a} ±0.22	17.04 ^{a} ±0.57	17.12 ^{a} ±0.56	16.67 ^{a} ±1.07	17.41 ^{a} ±0.85

a, b, c…etc.: Means within row with different superscripts are significantly different (P < 0.05)

In this connection Shalaby *et al.* (2006) incorporated *Allium sativum* in Nile tilapia diets at 0; 10; 20; 30 and 40g/kg diet. They reported that protein content in fish body was significantly higher in the group fed on diet containing 30g/kg diet of *Allium sativum* (60.92%) than in all other groups of *Allium sativum*. The same authors added that contrarily, total lipids content in fish body decreased significantly (18.35%, p<0.05) in fish fed on 30g *Allium sativum*; while in all other groups of *Allium sativum* it was similar to control. They continued that moisture contents in fish body was not significantly affected with garlic levels, while Ash content was significantly higher (20.23%; p<0.05) in fish fed on 30g *Allium* / kg diet, and the lowest values were obtained with 20g/kg *Allium sativum* and control. Results presented in Table (8) are in complete agreement with the finding of Metwally, (2009) who reported that incorporation of pure garlic capsules (250 mg/kg diet) or garlic powder tablets (32g.kg diet) or natural garlic (40g/kg diet) in Nile tilapia diets (20-21g. initial weight) for three months had insignificant effects on whole body DM, while the garlic treatments increased significantly protein contents and decreased whole body fat contents compared to the garlic free control group. The same author added that garlic supplementation decreased ash contents from 19.90% to 17.31%.

5- Blood serum analysis: Averages of total portion (g/dl); total albumin (g/dl); total globulin (g/dl); albumin to globulin ratio A/G and total lipids (g/dl) in Nile tilapia blood serum as affected with garlic dietary treatments are presented in table (9). Results of the same table show that total serum protein (g/dl) for the C; FG5; FG3; DG5; and DG3 groups were found to be 3.18; 3.92; 3.87; 3.28 and 3.19 g/dl on the average, respectively. The analysis of variance of results indicate that FG5 and FG3 groups had significantly (p<0.05) higher total serum protein followed in a significant (p<0.05) order by the DG5 group then by both DG3 and the control group (C), respectively. There results are in partial agreement with the finding of Al-Salahy, (2002) who reported that oral administration of garlic juice to African cat fish for 5 days (1 dose every 24 h) caused insignificant increase in total serum protein from 5.46 mg/dl (control) to

6.03 mg/dl (garlic group). Furthermore, Metwally (2009) fed Nile tilapia on diets supplemented with pure garlic oil capsules (250 mg/kg diet) or natural garlic (40 g/kg diet) and garlic powder tablets (32 g/kg diet) for three Months. He reported that fish fed on diets containing pure garlic oil had significantly higher total serum protein (3.71 g/dl) followed in a decreasing order by fish fed on diets containing garlic powder, natural garlic and the lowest value was recorded by the control unsupplemented group on the other hand results of Shalaby *et al.* (2006) showed that incorporation of garlic at 10: 20: 30 and 40 g/kg diet in Nile tilapia diets decreased total blood plasma protein.

Table 9: Blood serum analysis of the Nile tilapia fed on Garlic as feed additives in the diet

Items	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Total Protein g/dl	3.18 ^{c} ±0.02	3.92 ^{a} ±0.02	3.87 ^{a} ±0.02	3.28 ^{b} ±0.02	3.19 ^{c} ±0.02
Total Albumin g/dl	1.15 ^{c} ±0.01	1.58 ^{a} ±0.02	1.56 ^{ab} ±0.02	1.54 ^{ab} ±0.02	1.53 ^{b} ±0.01
Total Globulin g/dl	1.55 ^{b} ±0.02	1.99 ^{a} ±0.02	1.98 ^{a} ±0.02	1.94 ^{a} ±0.03	1.97 ^{a} ±0.02
A/G ratio	0.74 ^{b} ±0.01	0.79 ^{a} ±0	0.79 ^{a} ±0	0.8 ^{a} ±0.02	0.78 ^{a} ±0.01
Total Lipids g/dl	10.02 ^{a} ±0.01	8.7 ^{d} ±0.01	8.89 ^{c} ±0.02	9.6 ^{b} ±0.02	9.59 ^{b} ±0.02

a, b, c…etc.: Means within row with different superscripts are significantly different ($P < 0.05$)

As presented in Table (9), averages of blood serum albumin g/dl for Nile tilapia groups C; FG5; FG3; DG5; and DG3 were 1.15; 1.58; 1.56; 1.54 and 1.53 g/dl, respectively. Results indicate that the FG5 group had significantly ($p<0.05$) the highest total serum albumin followed in an insignificant decreasing order by the FG3 and DG5 groups and in a significant ($p<0.05$) order by the DG3 and the control (C), groups, respectively. In general results reveal that incorporation of garlic in Nile tilapia diets increased total serum albumin and the increase was more pronounced at incorporation level of 5g/kg fresh garlic. There results are in agreement with the finding of AL-Salahy, (2002) who reported that oral administration of garlic juice to *clarias lasera* (African catfish) every 24 hours for 5 days increased serum albumin to 6.03 mg/dl compared to the control unsupplemented group (5.46 mg/dl). Results of present study are in partial agreement with the findings of Bayoumi (2004) who reported that supplementing Nile tilapia diet with Biogen (probiotic containing garlic) at 0.01; 0.02 and 0.03% levels increased significantly serum total albumin compared to the control unsupplemented group. Concerning total serum globulin (g/dl.), averages were found to be 1.55; 1.99; 1.98; 1.94 and 1.97 (g/dl.) for the control (C); FG5; FG3; DG5 and DG3, respectively. The analysis of variance of results indicate that incorporation of garlic in fresh or dried forms increased significantly ($p<0.05$) serum globulin compared to the control group. These results are in partial accordance with the findings of Bayoumi (2004) who reported that supplementing Nile tilapia diets with a probiotic containing garlic (Biogen) at 1; 2 or 3g/kg diet increased serum globulin significantly. Results of Table (9) reveal that the garlic supplemented groups either fresh or dried at both levels showed significantly higher ($p<0.05$) albumin to globulin ratios compared to the control group. In this connection it is worth to mention that many beneficial health properties of garlic are attributed to organosulphur compounds, particulay to thiosulfinates (Block, 1992). Allicin (diallythio sulfinate) is the most abundant compound representing about 70% of all thiosulfinates present, or formed in crushed garlic (Block, 1992; Han *et al*., 1995). As presented In Table (9), averages of serum total lipids (g/dl) for the control; FG5; FG3; DG5 and DG3 groups were 10.02; 8.7; 8.89; 9.6 and 9.59 g/dl, respectively. There results indicate in general that incorporation of garlic into Nile tilapia diets depressed serum total lipids and the depression was more pronounced in the group received 5g fresh garlic /kg diet. All garlic supplemented group showed significantly lower serum total lipids compared to the control group. In this connection garlic has proved to be hypolipidemic (Sumiyoshi, 1997), antimicrobial (Kumar and Berwal, 1999), antihypertensive (Suetsuna, 1998), hepatoprotective (Wang *et al.,* 1998) and insecticidal (Wang *et al.,* 1998) garlic extract has also been shown to reduce serum cholesterol levels (Bordia *et al.,* 1975; Augusti, 1977) and increase blood coagulation time (Bordia *et al.,* 1975). Results of table (9) are in an agreement with those of Shalaby *et al.* (2006) who reported that garlic at 30 or 40 g/kg diet level decreased significantly serum total lipids compared to the control groups, however lower garlic levels had no significant effect on serum total lipids of Nile tilapia. On the other hand Al-Salahy (2002) reported that oral of garlic juice for 5 day had no significant effect on serum total lipids of Nile tilapia.

6- Economic efficiency: Averages of total feed intake g/fish; costs of one kg of diet (LE); total weight gain g/fish; feed costs for each kg gain in weight/fish and the relative gain costs as percentage to the control group one presented in Table (10). The economic efficiency was calculated on the feed and gain costs, thus other costs were equal for the experimental groups. Results of the same table indicate that incorporation of garlic in fresh or dried forms increased the costs of one kg of diet and the increase was more pronounced at higher incorporation level (5%) compared to the lower one (3%). Results of Table (10) reveal also that costs for each kg. gain in weight (LE) for the control; FG5; FG3; DG5 and DG3 groups were 5.935; 5.556; 5.578; 5.358 and 5.576 LE, respectively which indicate incorporation of garlic to growing Nile tilapia diets reduced the gain costs by 9.72 (DG5) and 6.02 (FG3 group) percent compare to the control group. There results indicate that garlic supplementation increased the costs of one kg of diet but this was compensated through the better gain in weight which resulted in reduction of gain costs. In general results of Table (10) indicate that incorporation of dried garlic at 5% level to growing Nile tilapia diets resulted in the highest reduction in gain costs due to diet.

These results are in partial accordance with the findings of Bayoumi (2004) who reported that incorporation of Biogen (containing garlic) to Nile tilapia diets at 1; 2; 3 g/kg diet increased the total feed costs (LE/kg) to 1.54; 1.58 and 1.62 LE compared to 1.50 LE for the control group, respectively. The same author reported that incidence costs (costs of feed consumed) required for one kg of fish produced decreased from 4.43 LE for the control group to 3.983; 2.96 and 4.14 LE for groups fed the biogen containing diets at 1; 2 and 3g/kg diet, respectively. He added also that costs of gain relative to the control group (100%) were 89.91; 66.82 and 93.54 for Biogen levels 1; 2; 3 g/kg diet, respectively. The same author concluded that the incidence cost was lower (2.69) for group 2 and the profit index indicate that these group was more economically profitable. However, the nutritional effects of the feed additive level used must be carefully determined and taken into account when selecting an economic inclusion level. Therefore, the recommended level of the inclusion is 2g Biogen/kg feed and this choice is based on the nutritional parameters and economical analysis.

Table 10: feed cost (L.E) for one Kg weight gain produced by fish fed Garlic as feed additives in diet

Treatment	Control	Fresh Garlic		Dried Garlic	
		FG5	FG3	DG5	DG3
Feed intake g/fish	198.054	194.793	207.738	187.624	187.891
Cost (L.E) of one Kg of feed	2.400	2.417	2.410	2.449	2.429
Total weight gain g/fish	80.09	84.74	89.76	85.75	81.85
Feed cost/Kg gain L.E	5.935	5.556	5.578	5.358	5.576
Percentage decrease in feed cost to produce one Kg fish gain	100	93.61 (-6.39)	93.98 (-6.02)	90.28 (-9.72)	93.95 (-6.05)

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