# 4. RESULTS AND DISCUSSION

## 4.1. First experiment

### 4.1.1. Body weight (BW):

Average body weight (BW) of Nile tilapia as affected by increasing levels of biogen are presented in Table (3). The initial body weight for fish received the increased levels of biogen ranged between 2.18 and 2.25 g with insignificant differences in BW indicating the random distribution of fish around the different experimental treatments. At experiment termination (after 90 days from the experimental start) the highest significant (table, 4) average BW (13.11 g) was recorded for fish group 3 which fed on diet supplemented with 2 g of biogen/kg feed followed in descending order by those in groups 4 (12.49 g), 2 (11.58 g), 5 (10.39 g) and control group 1 (9.46 g).

Analysis of variance (table, 4) indicated that final average BW of Nile tilapia significantly ($P<0.001$) affected by the biogen concentration in the experimental diets. The present results are in accordance with those of **Bayoumi (2004)** who found that biogen at level of (2 kg/ton diet) can be recommended in fish farming to improve production since it enhances the growth rate of tilapia. Also, **Khattab *et al.*, (2004)** demonstrated that, final body weight of Nile tilapia *O. niloticus* was significantly ($P<0.05$) increased with increasing biogen level in the diet and the highest final body weight was recorded at 0.1% biogen level.

Table (3): Means and standard error for the effect of increasing levels of biogen in the diets on body weight (BW), body length (BL) and condition factor (K) of Nile tilapia.

| Diets | No. | Body weight (BW)/g | | Body length (BL )/cm | | Condition factor (K) | |
|---|---|---|---|---|---|---|---|
| | | Initial | Final | Initial | Final | Initial | Final |
| Diet1 (Control) | 40 | 2.24±0.07 | 9.46± 0.40 c | 5.15±0.09 | 7.98±0.12 c | 1.63±0.15 | 1.87±0.06 |
| Diet2 (0.1% biogen) | 40 | 2.23±0.07 | 11.58± 0.40 b | 5.07±0.09 | 8.57±0.12 ab | 1.62±0.15 | 1.84±0.06 |
| Diet3 (0.2% biogen) | 40 | 2.18±0.07 | 13.11± 0.40 a | 4.97±0.09 | 8.89±0.12 a | 1.76±0.15 | 1.87±0.06 |
| Diet4 (0.3% biogen) | 40 | 2.25±0.07 | 12.49± 0.40 ab | 5.01±0.09 | 8.90±0.12 a | 1.82±0.15 | 1.77±0.06 |
| Diet5 (0.4% biogen) | 40 | 2.24±0.07 | 10.39± 0.40 c | 4.95±0.09 | 8.31±0.12 bc | 1.86±0.15 | 1.81±0.06 |

Averages within each column followed by different letters are significantly different ($P<0.05$)

Table (4): Analysis of variance for the effect of increasing levels of biogen in the diets on body weight (BW), body length (BL) and condition factor (K) of Nile tilapia.

| S.O.V. | df | F-ratio | | | | | |
|---|---|---|---|---|---|---|---|
| | | Body weight (BW)/gm | | Body length (BL)/cm | | Condition factor (K) | |
| | | Initial | Final | Initial | Final | Initial | Final |
| Replicate | 1 | 0.58 | 0.03 | 0.05 | 0.74 | 0.02 | 1.00 |
| Treatment | 4 | 0.18 | 13.70 *** | 0.79 | 11.02 *** | 0.49 | 0.72 |
| Reminder df | 194 | | | | | | |
| Reminder MS | | 0.19167 | 5.52440 | 0.32036 | 0.55936 | 0.04784 | 0.00676 |

*** $P<0.001$

**Abd El-Hamied *et al.,* (2002)** reported that biogen can enhance the metabolism and energy of fish body cells. Raise the efficiency of feed utilization and balance the secretion of various secretary glands. Moreover, it increases the immune responses. Also, **Elam (2004)** found that live body weight of Nile tilapia, *O. niolticus* and *Mugil cephalus* significantly improved (compared to control) when the experimental diets enriched by 2 kg biogen/ton. **Samra (2006)** incorporated Azolla, blue green algae or biogen in tilapia diets at a rate of 10, 10 and 2 kg/ton. He found that the greatest final body weights were achieved for fish group fed artificial feed enriched by biogen.

In recent study **Saleh (2007)** incorporated biogen in Shrimp, *Penaeus japonicus* diets at levels of 0, 0.1, 0.2, 0.3% and he found that, at the $1^{th}$ , $2^{th}$, $3^{th}$, $4^{th}$, $5^{th}$ and $6^{th}$ weeks from the experimental start, BW and survival rate significantly increased as biogen level increased from 0 to 0.1% then it decreased at level of 0.3%.

Results of the present study showed that there was a significant increase in BW of Nile tilapia as biogen level increased till 0.2% then decreased at level of 0.4%. At the same time, all diets containing biogen levels (0.1 to 0.4%) gave heavy BW than those fed on the control diet (0%). These results are in agreement with those of **El-Dakar *et al.,*** (unpublished data) for rabbitfish. They found that rabbitfish fed a control diet gave the lower BW than those fed the diet containing natural enhancement mixture (biogen). In addition, the above authors explained these results on the basis of the postlarvae effect of *B. subtilis* and spices which present in the natural enhancement mixture. Where *B. subtilis* have been shown to produce digestive enzymes as amylase, protease, lipase which may enrich the concentration of intestinal digestive enzymes **(Lee and Lee, 1990)** or its effect in improving digestive activity by synthesis of vitamins and co-factors or enzymatic improvement **(Gatesoupe, 1999)**. **Gullian *et al.*, (2004)** demonstrated a significant growth increase in shrimp inoculatd with *Bacillus* spp compared with the control. These probiotic effects could be the cause of the increased weight, digestion improvement or nutrient absorption.

The growth promoting effect of biogen which recorded at level of 2 g/kg feed could be also attributed to the role of some of the biogen enzymes (hydrolytic, amylolytic, lipolytic, proteolytic and cell separating enzymes) components which reached at certain level to act as a growth promoter through the increase in digestibility and absorbability of different nutrients in the gastrointestinal tract of fish.

Moreover, the growth stimulating effect may be also attributed to the various components of biogen, where allicin has anti- microbial properties (the product of garlic) and ginseng which could have a growth promoting ability via prevention and treatment of sub- clinical infections, the same findings were observed by **Khalid *et al.*, (1995)** and **Galal *et al.*, (1997).**

Probiotics are also sometimes expected to have a direct growth promoting effect on fish either by a direct involvement in nutrient uptake, or by providing nutrients or vitamins **(Ringo and Gatesoupe, 1998).**

#### 4.1.2. Body length (BL):

Data of fish body length (BL) at the start and termination of the experiment are illustrated in Table (3). As described in this table, the initial BL for fish received the different treatments ranged between 4.95 and 5.15 cm with insignificant differences in BL. At the end of the experimental period, the longest BL (8.90 cm) was recorded in group 4 which was fed on diet supplemented with 3 g of biogen/kg feed followed by those in group 3 (8.89 cm) which was fed on diet supplemented with 2 g of biogen/kg feed. The succession of decreasing length was observed in group 2 (8.57 cm) which was fed on diet supplemented with 1 g of biogen/kg feed and group 5 (8.31 cm) diet supplemented with 4 g of biogen/ kg feed. The bottom length was related to group 1 (7.98 cm) which was fed on basal diet (control).

Analysis of variance (table, 4) indicated that, final BL of Nile tilapia significantly ($P<0.001$) affected by the different levels of biogen incorporated in the experimental diets.

**Mehrim (2001)** found that dietary inclusion of biogen improved the growth performance of tilapia fish. Also, **Bayoumi (2004)** and **Samra (2006)** reported that the use of biogen as feed additive has growth promotion effect and inclusion of biogen at level of 2 kg/ton feed in tilapia fish diets results in best growth performance, better feed utilization efficiency and brings an economic advantage and reported the greatest percent of economic efficiency.

### 4.1.3. Condition factor (K):

At the start of the experiment average values of condition factor (K) ranged between 1.62 (group 2) and 1.86 (group 5) with no significant differences among the different experimental fish groups (tables 3 and 4). After 90 days from the experimental start the highest K values (1.87) were recorded by the fish in both group 1 and 3 which was fed on basal diet and 2 g of biogen/kg feed followed by those in group 2 (1.84), 5 (1.81) and group 4 (1.77), respectively.

Analysis of variance (table, 4) indicated that K values at the end of the experiment did not significantly affected by the incorporation of different biogen doses in the experimental diets.

Growth in the fish can be readily monitored by measuring the increase in weight and length. Another parameter which may be used as index of growth is the condition factor, which provides a measure of "fatness" of fish and food conversion efficiency, **(Power, 1990).** Condition factor also measure the "plumpness" or "robustness" of fish, and easily calculated from routinely collected length and weight data. Condition is frequently assumed to reflect not only characteristics of fish such as health, reproductive state and growth but also characteristics of the environment such as habitat quality, water quality and prey availability **(Liao *et al.*, 1995).**

Condition factor of fish is essentially a measure of relative muscle to bone growth and the differing growth responses of these tissues to diet treatment may be reflected by changes in condition factor **(Ostrowski and Garling, 1988).** Condition factor was considered to be a sufficient measure of shape, although shape is usually not considered as a character of interest to breeding programmes, since it has no obvious economic value **(Nilsson, 1992).**

**4.1.4. Body weight gain (WG):**

Data concerning the body weight gain of Nile tilapia in the different groups throughout the experimental period are presented in Table (5). As shown in this table, the highest average body weight gain (10.9 g) was recorded in group 3 which fed on diet supplemented by 2 g of biogen/kg feed followed in a descending order by those in group 4 (10.23 g), 2(9.35 g), 5 (8.15 g) and control group 1(7.23 g) which was fed on basal diet (control diet).

Analysis of variance (table, 6) indicating a significant difference among the different experimental fish groups fed the diets enriched by different concentrations of biogen.

Final BW and WG of Nile tilapia fed diets contained the different biogen levels were significantly (P<0.001) higher than those fed the basal diet. Similar results were obtained for *P. monodon* **(Rengpipat *et al.*, 1998 and 2000)**. **Elam (2004)** found that WG of Nile tilapia, *O. niolticus* and *Mugil cephalus* significantly improved (compared to control) when the experimental diets enriched by 2 kg biogen/ton. In the same trend**, Khattab *et al.*, (2004)** demonstrated that, weight gain of Nile tilapia *O. niloticus* was significantly (P<0.05) increased with increasing biogen level in the diet and the highest WG was recorded at 0.1% biogen level.

Also, **Gullian *et al.*, (2004)** reported that a significant growth increase in shrimp inoculated with *Bacillus* P64, *Vibrio*

Table (5): Means and standard error for the effect of increasing levels of biogen in the diets on weight gain (WG) and specific growth rate (SGR) of Nile tilapia.

| Diets | No.+ | Weight gain (g/fish) | Specific growth rate |
|---|---|---|---|
| Diet1 (Control) | 2 | 7.23±0.08 e | 1.60± 0.01 e |
| Diet2 (0.1% biogen) | 2 | 9.35±0.08 c | 1.83± 0.01 c |
| Diet3 (0.2% biogen) | 2 | 10.90±0.08 a | 1.98± 0.01 a |
| Diet4 (0.3% biogen) | 2 | 10.23±0.08 b | 1.90± 0.01 b |
| Diet5 (0.4% biogen) | 2 | 8.15±0.08 d | 1.71± 0.01 d |

Averages within each column followed by different letters are significantly different (P<0.05).

+ Average of two replicates (aquaria)

Table (6): Analysis of variance for the effect of increasing levels of biogen in weight gain (WG) and specific growth rate (SGR) of Nile tilapia.

| S.O.V. | df | Weight gain (WG) | Specific growth rate (SGR) |
|---|---|---|---|
| Replicate | 1 | 2.15 | 11.25 * |
| Treatment | 4 | 385.83*** | 230.70*** |
| Reminder df | 4 | | |
| Reminder MS | | 0.01163 | 0.00020 |

* P< 0.05 *** P<0.001

P62 and *V. alginolyticus* (LLi) compared with the control. These results may be attributed to the *Bacillus* effect in improving digestive activity by synthesis of vitamins and co-factors or enzymatic improvement **(Gatesoupe, 1999).**

The improvement in WG of fish in group 3 due to the growth promoter effect of biogen may be attributed to the fact that biogen has a particular good flavor and appetizing function which can increase the palatability of feed, promote the secretion of digestive fluids and stimulate the appetite, also to the mode of action of probiotics (as one of biogen components) which may operate by producing antibiotic substances and inhibiting harmful bacteria altering microbial metabolism and decrease intestinal pH **(Sissons, 1988 ; Makled, 1991 and Bayoumi, 2004).**

Moreover, the presence of some valuable nutrients such as vitamins and minerals in some growth promoters may be essential for the growth performance. Also the enhancement in body weight gain as a result of other various components of biogen such as allicin, which is one of the garlic by-product which stimulated growth because of its thyroid like activity **(El-Nawawy 1991).**

**Lun *et al.*, (1994)** reported that allicin can activate and coordinate the function of various endocrine glands and thus enables them to secrete hormones especially the growth hormone, also allicin decrease the level of uric acid in fish feces resulting in the decreases in the level of ammonia in the water leading to a good water quality suitable for better growth rate.

In addition, biogen increase the resistance to the bad environmental condition and water pollution. **Safinaz, (2000)** reported that the addition of biogen to fish diet at level of 0.3% improved the normal physiological function of *O.niloticus* exposed to 30 ppm phenol. Also, the biogen minimized the direct and indirect drastic negative effects of phenol on immune response of exposed *O.niloticus*. Also, it prevents the accumulation of phenol in the muscles. **Elam (2004)** indicated that, supplementation of *O. niloticus* and *Mugil cephalus* by 0.1 or 0.2% biogen significantly increased serum albumin and globulin indicating that biogen can improve the general health and immune system of fish and decreased serum cholesterol and glucose in all treated groups compared to control group.

Also allicin enhance the blood circulation in fish body specially in gills resulting in increase the ability of fish to use any little amount of dissolved oxygen. biogen also contain ginseng extract that needed by the fish body to maintain its physiological functions, and have the ability to enhance the natural body resistance through activation of immune cells.

Biogen also have a response as a palatability enhancer with better taste that increase the feed consumption by fish and consequently increase the growth rate and this my be due its content of different kind of enzymes that increase the digestibility and absorbability of feed and activation of the intestinal villi.

In the same respect, **Saleh (2007)** found that WG of Shrimp, *Penaeus japonicus* fed experimental diets contained 0, 0.1, 0.2 and 0.3% significantly increased as biogen level increased from 0 to 0.1% then it decreased at level of 0.3% at the end of the 1th , 2th, 3th, 4th, 5th and 6th weeks from the experimental start.

**4.1.5. Specific growth rate (SGR):**

Results of SGR as affected by biogen levels in Nile tilapia diets were illustrated in Table (5). Average values of SGR found to be 1.6, 1.83, 1.98, 1.90 and 1.71% for fish groups fed the experimental diets contained 0, 1, 2, 3, 4 and 5 g biogen/kg diets, respectively.

Analysis of variance (table, 6) showed that the differences in SGR values among the different experimental treatments were significant ($P<0.001$). The highest SGR value was recorded for T3 in which fish received the experimental diet supplemented with 2g biogen/kg diet. The obtained results are in agree with those reported by **Samra (2006)** who indicated that, during the entire experimental period (180 days) Nile tilapia, *Oreochromis niolticus* fed the diet supplemented by 2 g biogen/kg diet showed the best SGR values compared to the other diets supplemented by each of Azolla or blue green algae.

The obtained results were parallel with the other growth parameters of tilapia fish such as BW (table, 3) and WG (table, 5). The highest values of SGR that observed in T3 may be attributed to the positive effect of biogen at the level of 2 g biogen/Kg of feed on fish growth rate through strength their immunity and save food for growth. the SGR of group 3 was less than value of 2.27% reported by mirror carps (*Cyprinus carpio*) obtained by **Misiska *et al.*, (1991)** and much higher than earlier values of 0.96% for *Oreochromis karongae* **(Maluwa *et al.***

**1995)**. Also, **Bayoumi 2004)** reported that fish fed artificial diet supplemented with 2g of biogen/kg diet exhibited highest SGR. **Khattab *et al*., (2004)** incorporated biogen in *O. niloticus* diets at 0.1, 0.2 and 0.4% and he found that SGR of Nile tilapia *O. niloticus* was significantly ($P<0.05$) increased with increasing biogen level in the diet and the highest SGR was recorded at 0.1% biogen level.

The positive effect of biogen on SGR of Nile tilapia *O. niloticus* may be due to its spices (garlic and ginger) and probiotic effects which serve as antitoxic, antibacterial and antifungal agents, which may lead to control of pathogen. Challenge of bacteria to pathogen as a universal probiotic bacterium was studied by **El-Dakar and Goher (2004).** They evaluated its action against three different aquaculture bacteria pathogens namely, *Aeromones hydrophicus*, *Edwaredsilla tarde* and *Vibrio pioteolyticus*. They found that a considerable change in the intra and extra-cellular proteins profiles of the three bacterial pathogens were observed when electrophoresed via SDS-PAGE techniques after mixing with *B. subtilis*. They added also that, the proteolytic activity of the bacterial pathogens exhibited a sharp decrease when subjected to *B. subtilis* extra-cellular products. In addition, it is noted a positive effect on the extra-cellualr products of *B. subtilis* against pathogens and on reducing the antibiotic susceptibility when presence in culture water or in feed of shrimp. This phenomenon operates by substitution of depressive microbial agents which hinder growth (**Gullian *et al*., 2004**). Also, the growth promoter effect is conditioned to ambient factors; therefore; the results are subjected to a high degree of variability. Consequently, the probiotic used as growth stimulate can yield different results under different culture conditions. A live bacteria and exo-cellular protein of two vibrio marine pathogen (*V. penaeicida* and *V. nigripulchritudo*) exhibited significantly high mortalities in blue shrimp species *Litopenaeus stylirostris* (**Aguirre-Guzman *et al.,* 2003**). In the present study, probiotic bacteria of *B. subtilis* that present in biogen increased as the biogen dose increased. *B. subtilis* is currently being used for oral bacteriotherapy and bacterioprophylaxis of gastrointestinal disorders (mostly as a direct result of antibiotic treatment). Ingestion of significant quantities of *B. subtilis* is thought to restore the normal microbial flora following extensive antibiotic use of illness **(Green *et al.,* 1999).** In addition, **Moriarty (1998)** stated that use of *Bascillus* has been promoted and accepted within the industry due to it has not been associated with aquatic organism pathogies. The present study confirms the above findings. **Gatesoupe (1999)** reported that probiotic treatment decreased the proportion of pathogenic *Vibrino* spp in sediments and to a lesser extent in the water.

Probiotic actively inhibit the colonization of potential pathogens in the digestive tract by antibiosis or by competition for nutrients and space, and alteration of the microbial metabolism. It also improves the nutrition by detoxifying the potentially harmful compounds in feeds by denaturing the potentially indigestible components in the diet by hydrolytic enzymes including amylases and proteases, by producing vitamins such as biotin and Vitamin $B_{12}$ **(Sugita *et al.,* 1996** and

**Hoshino *et al.*, 1997),** by producing inhibitory compounds **(Spanggaard *et al.*, 2001)** and by stimulating the immunity **(Fuller, 1992** and **Gibson *et al.*, 1997)**. Another possible explanation for increased growth performance with adding probiotic is the improvement in digestibility, which may in turn explain the better growth and feed efficiency observed with the supplemented diets. Otherwise, probiotic influence digestive processes by enhancing the population of beneficial microorganisms, microbial enzyme activity; improving the intestinal microbial balance, consequently improving the digestibility and absorption of food and feed utilization **(Bomba, *et al.*, 2002)**.

The commercial probiotic biogen had allicin and was found to contain Bacillus spp. as the major species. **El-Saidy and Gaber (1997)** indicated that the growth of Nile tilapia was affected by feeding diets containing different levels of garlic meal (a major compound of biogen). Hence, fish fed dry garlic meal was heavier than those fed 0% garlic meal diet. **El-Dakar *et al.*, (2005)** found positive growth response of shrimp juveniles of *P. japonicus* was positively when fed on ginger roots meal or marjoram leaves meal showing that no significant differences in body weight gain, and growth index among ginger and marjoram diet. On the other hand **Mehrim (2001)** found that use of 0.3% biogen in Nile tilapia diet was significantly increased SGR compared to diets free biogen. These results agreed with the present study which found that 0.2 - 0.3% of biogen was the optimum addition level for Nile tilapia fry.

## 4.1.6. Feed Intake (FI):

Results of FI as affected by increased levels of biogen in the diets are presented in Tables (7 and 8). Feed intake during the entire period (90 days) found to be 28.15, 32.30, 26.33, 27.49 and 26.93 g for the diet enriched by, 0, 1, 2, 3, and 4 g biogen/kg diet, respectively and the differences between the obtained FI values were significant ($P<0.05$) .

The obtained results indicated that, the highest FI (32.30) was recorded for the lowest biogen level (1 g/kg diet) whereas the lowest ($P<0.05$) FI (26.33 g) was recorded by the fish in group 3 which was fed on diet supplemented with 2 g of biogen/kg feed. Although the lowest biogen level (1 g/kg diet) caused the highest FI, the other increased of biogen levels 2, 3 or 4 g biogen/kg diet in diets D3, D4 and D5 did not significantly altered feed intake compared to the control group (table, 7).

Analysis of variance (table, 8) indicated that average FI of Nile tilapia were significantly differ among fish groups fed the experimental diets contained the increased levels of biogen. In this respect, **Bayoumi (2004)** found no significant differences in the feed consumption of fish fed different levels of biogen. Also, **Mehrim (2001)** found that the dietary inclusion of biogen increased fish utilization of FI and improved the growth performance.

In the present study, results indicated that FI of Nile tilapia fed the experimental diets was significantly affected by biogen compounds (garlic, ginger, *B. subtilis* and digestive enzymes). Results showed that Nile tilapia fry fed the diet containing 0.1% biogen consumed more feed than those fed the

Table (7): Means and standard error for the effect of increasing levels of biogen in the diets on feed intake, feed conversion ratio and protein efficiency ratio of Nile tilapia.

| Diets | No.+ | Feed intake (gm/fish | Feed conversion ratio | Protein efficiency Ratio |
|---|---|---|---|---|
| Diet1 (Control) | 2 | 28.15±1.05 b | 3.91±0.16 a | 0.86±0.05 b |
| Diet2 (0.1% biogen) | 2 | 32.30±1.05 a | 3.46±0.16 a | 0.97±0.05 b |
| Diet3 (0.2% biogen) | 2 | 26.33±1.05 b | 2.42±0.16 c | 1.39±0.05 a |
| Diet4 (0.3% biogen) | 2 | 27.49±1.05 b | 2.71±0.16 bc | 1.24±0.05 a |
| Diet5 (0.4% biogen) | 2 | 26.93±1.05 b | 3.30±0.16 ab | 1.01±0.05 b |

Averages within each column followed by different letters are significantly different (P<0.05)

+ Average of two replicates (aquaria)

Table (8): Analysis of variance for the effect of increasing levels of biogen in the diets on feed intake, feed conversion ratio and protein efficiency ratio of Nile tilapia.

| S.O.V. | df | Feed intake (gm/fish | Feed conversion ratio | Protein efficiency ratio |
|---|---|---|---|---|
| Replicate | 1 | 1.40 | 0.15 | 0.33 |
| Treatment | 4 | 5.11* | 14.51** | 16.01*** |
| Reminder df | 4 | | | 0.93 |
| Reminder MS | | 2.19250 | 0.04892 | 0.00572 |

* P<0.05 ** P<0.01 *** P<0.001

other experimental diets and this may be due to increasing the palatability of diets containing biogen by Nile tilapia through its attractive fragrant. Similar results were obtained by **Saleh (2007)** who found that incorporation of biogen in the diets of *P. japonicus* and *P. semiselicatus* increased feed intake compared to control diet. This may be show the possibility that biogen plays an important role in the exploratory and feeding behavior of Nile tilapia. This may be due to its digestive and stimulant effect **(Garland, 1993)**, as well as fragrant and volatile oil **(Abo zeid, 1998),** controlling and buffering the conditions of the stomach and intestine **(Boulos, 1983)**.

**4.1.7. Feed conversion ratios (FCR):**

FCR of the experimental diets provided a picture comparable to that of growth. Results of Table (7) show that average of FCR (calculated as g of diet require for each g gain in weight) for fish fed diets contained 0, 1, 2, 3 and 4 g biogen/kg diet. During the experimental period found to be 3.91, 3.46, 2.42, 2.71 and 3.30 with significant differences (P<0.01) among these means (table, 8).

The obtained results indicated that, FCR was improved with increasing biogen level in the diet up to 2 g biogen/kg diet whereas the highest level of biogen 4 g biogen/kg diet re-increased feed required for the production of the same unit of weight gain. The obtained results agree with those of **El-Gendi *et al.*, (1994)** who found productive improvement in FCR due to herbal products supplementation as a result of improving FCR which may be attributed to its effect on improving the digestibility of dietary protein in small gut of broiler chicken.

In the same respect **Elam (2004)** found that, FCR of Nile tilapia *O. niloticus* and *Mugil cephalus* was improved when biogen was supplemented to diets. The author indicated that, FCR for *O. niloticus* were, 2.8, 2.5 and 2.0, and were 2.4, 2.1 and 3.0, for *Mugil cephalus* fed diets contained 0, 0.1 and 0.2% biogen, respectively.

It is interest to note that biogen did not only have an effect on FI and subsequently WG, but also affected FCR, indicating an overall increase in the efficiency of utilization in the deposition of tissues. The values of FCR recorded from the present study in groups 1, 2, 3, 4, and 5 were inferior to the value of 1.71 and 1.56 reported respectively for Nile tilapia obtained by **De-Silva and Gunasekera (1989).**

**Bayoumi, (2004)** reported that total FCR value was decreased (improved) (1.87) for fish fed on diet supplemented with 2 g of biogen/kg feed. The values of FCR recorded from the present study in group 3 and group 4 were in agreement with the value of 1.87 and 2.95 reported respectively for Nile tilapia by **Bayoumi (2004).** Recently, **Saleh (2007)** found that FCR and feed efficiency ratio for *Penaeus japonicus* was the lowest for postlarvae groups fed 0% (control diet) than those fed the experimental diets contained 0.1, 0.2 or 0.3% biogen.

The best FCR values observed with probiotic supplemented diets suggest that addition of probiotic improved feed utilization. Similar results have been reported for probiotic use in diets of tilapia **(El-Haroun *et al.*, 2006)**, rabbitfish **(El-Dakar *et al*., unpublished dada)**. In practical terms, this means that biogen use can decrease the amount of feed necessary for fish growth, which could result in reduction of production costs.

In addition to the above mentioned modality of action, the improvement in growth performance parameters and feed conversion ratio, due to biogen addition may be explained on the basis that it supply the fish intestine by *Bacillus subtilis*, the pH shift of the intestine would increase the growth rate of these beneficial commercial bacterium which is also a component of biogen.

**4.1.8. Protein efficiency ratio (PER):**

Results of protein efficiency ratio (PER) as affected by increased levels of biogen in the diets are presented in Table (7). As described in this table, PER during the entire period (90 days) found to be 0.86, 0.97, 1.39, 1.24 and 1.01 g for the diet enriched by, 0, 1, 2, 3, and 5 g/kg diet, respectively and the differences between the obtained PER values were significant (P<0.0 01) .

Data in Table (8) indicated that supplementation of tilapia diet by each of the examined levels 1, 2, 3, and 4 g biogen/kg diet significantly (P<0.001) improved PER specially fish groups fed the diets enriched by 2 or 3 g biogen/kg diet.

The benefit effect achieved by using biogen may be attributed to the presence of enzymes as one of the biogen components which assisting in the utilization of proteins.

**Bayoumi (2004)** showed that Nile tilapia fed the diet supplemented with 2 g biogen/kg feed recorded the best (1.62) PER of fish.

**Saleh (2007)** found that PER for *Penaeus japonicus* was the lowest for postlarvae groups fed 0% (control diet) than those fed the experimental diets contained 0.1, 0.2 or 0.3% biogen and the average of PER of shrimp varied according to age at which the experiment started.

Results of PER indicated that supplementing diets with biogen significantly improves dietary protein. This contributes to an optimized protein use for growth of Nile tilapia. **Ringo and Gatesoupe (1998)** and **Saleh (2007)** showed similar improvement in the biological value of the diets supplemented with probiotics. Also, **DeSchrijver and Ollevier (2000)** showed a positive effect on apparent protein digestion when supplementing turbot, *S. Maximus* feeds with the bacteria *Vibrio proteolyticus*. They attributed this effect to the proteolytic activity of bacteria. **Flores *et al.*, (2003)** also observed a similar trend where the addition of 0.1% probiotics in tilapia fry diets improved growth and apparent protein digestibility and mitigated the effects of stress factors.

From nutritional point of view and in agreement with the data of **Shelby *et al.*, (2006)** and **Saleh (2007)**, the present results revealed that the use of the probiotic biogen as a feed additive for Nile tilapia is recommended to stimulate productive growth performance and nutrient utilization (FCR and PER). Feed utilization was the highest in Nile tilapia fed the biogen supplemented diets, meaning that the nutrients were more efficiently used for growth performance. **Shelby *et al.*, (2006)** studied *Streptoccus iniae* infection in young Nile tilapia fed diets supplemented with probiotics in powdered forms (*Bacillus,* *Pediococcus, Enterococcus* and *Saccharomyces*) and observed no differences in growth, lysozyme, total serum immunoglobulin, complement, specific anti-streptococcal antibody levels or mortality either before or after disease challenge.

**4.1.9. Chemical composition of fish:**

Concerning the chemical composition of whole fish body of Nile tilapia as affected by increasing levels of biogen in tilapia diets, results of Table (9 and 10) indicated that, fish group fed control diet had the lowest dry matter content (DM) compared to the other groups. Crude protein content in whole fish body was significantly ($P<0.05$) decreased with the increasing levels of biogen (50.39, 44.48, 47.54 and 48.72% with 0.1, 0.2, 0.3 and 0.4% biogen level, respectively) and the highest protein content was obtained in control group (55.45%).

With respect to ether extract, results of Table (9) indicated that values of ether extract lie in two groups, the first group include fish fed the first and the second diets (Diet 1 and Diets 2) and the second group included fish fed the diets D3, D4 and D5. Statistical analysis indicated that the differences between the two groups were significant while the differences diets within each group were not significant and the indicated that the low biogen level (0.1%) in the diet did not affected the ether extract content of whole fish compared to fish fed the basal diet while the other levels of biogen (0.2, 0.3 or 0.4%) significantly increased the ether extract of whole fish. The lowest EE content was obtained in the control fish group (34.29%).

Table (9): Means and standard error for the effect of increasing levels of biogen in the diets on chemical composition of Nile tilapia.

| Diets | No. | Dry matter | Crude protein | Ether extract | Ash |
|---|---|---|---|---|---|
| Diet1 (Control) | 6 | 29.49±0.63 b | 55.45±2.23 a | 34.29±1.34 b | 10.14±0.96 b |
| Diet2 (0.1% biogen) | 6 | 32.21±0.63 a | 50.39±2.23 ab | 35.53±1.34 b | 12.26±0.96 ab |
| Diet3 (0.2% biogen) | 6 | 30.50±0.63 ab | 44.48±2.23 b | 38.08±1.34 a | 15.05±0.96 a |
| Diet4 (0.3% biogen) | 6 | 31.41±0.63 ab | 47.54±2.23 b | 38.82±1.34 a | 12.16±0.96 ab |
| Diet5 (0.4% biogen) | 6 | 30.05±0.63 b | 48.72±2.23 b | 37.36±1.34 a | 13.90±0.96 b |

Averages within each column followed by different letters are significantly different (P<0.05)

Table (10): Analysis of variance for the effect of increasing levels of biogen in the diets on chemical composition of Nile tilapia.

| S.O.V. | Df | F-ratio | | | |
|---|---|---|---|---|---|
| | | Dry matter | Crude protein | Ether extract | Ash |
| **Replicate** | 1 | 0.00 | 7.57*** | 8.24** | 3.63* |
| **Treatment** | 4 | 2.96* | 6.80* | 4.23** | 1.82 |
| **Reminder df** | 24 | | | | |
| **Reminder MS** | | 2.3790 | 29.70747 | 10.7288 | 5.51000 |

* P<0.05 ** P<0.01 *** P<0.001

Ash content in the whole fish body was significantly increased with diets containing 0.2 and 0.4% biogen (15.05 and 13.90%, respectively) where the least one was observed in control group (10.14%).

The obtained results did not in agreement with those obtained by **Mehrim (2001)** and **Abdel-Hamied *et al.*, (2002)** who found that the dietary inclusion of biogen increased the protein content of fish and lowered the fat content of the whole fish body, without significant differences in ash content of Nile tilapia. Also, **Khattab *et al.*, (2004)** found that, protein in whole fish body was significantly increased and fat and ash contents of whole fish body weight of Nile tilapia were decreased with biogen levels 0.1, 0.2 and 0.3%.

The negative relation between crude protein and fat contents of fish body here in was proved before by **Abdel-Hamied *et al.*, (1995)**. On the other hand, **Diab *et al.*, (2002)** found that there were no significant changes in fish body composition due to the biogen levels in Nile tilapia diets.

## 4.2. Second experiment

### 4.2.1. Body weight (BW):

Data concerning body weight of tilapia fish fed the experimental diets contained the different replacing levels of soybean meal by sunflower meal throughout the experimental period are illustrated in Table (11 and 12). The initial body weight for fish fed the different experimental diets ranged between 6.04 and 6.20 g with insignificant differences in BW indicating the random distribution of fish among the different experimental treatments.

Table (11): Effect of increasing levels of sunflower in the diets on body weight (BW), body length (BL) and condition factor (K) of Nile tilapia.

| Diets | No. | Body weight (BW)/gm | | Body length (BL)/cm | | Condition factor | |
|---|---|---|---|---|---|---|---|
| | | Initial | Final | Initial | Final | Initial | Final |
| D1 (0% SFM) | 24 | 6.12±0.5 | 16.76±0.9 a | 7.06±0.2 | 10.12±0.2 a | 1.75±0.04 | 1.72±0.01 b |
| D2 (25% SFM) | 24 | 6.16±0.5 | 14.89±0.9 a | 7.06±0.2 | 10.36±0.2 a | 1.75±0.04 | 1.82±0.01 b |
| D3 (50% SFM) | 24 | 6.05±0.5 | 15.25±0.9 a | 7.04±0.2 | 10.54±0.2 a | 1.74±0.04 | 1.76±0.01 b |
| D4 (75% SFM) | 24 | 6.04±0.5 | 14.73±0.9 a | 7.05±0.2 | 10.47±0.2 a | 1.73±0.04 | 1.74±0.01 b |
| D5 (100 SFM) | 24 | 6.20±0.5 | 12.62±0.9 b | 7.08±0.2 | 8.35±0.2 b | 1.75±0.04 | 2.17±0.01 a |

Averages within each column followed by different letters are significantly different (P<0.05)

Table (12): Analysis of variance for the effect of increasing levels of sunflower in the diets on body weight (BW), body length (BL) and condition factor (K) of Nile tilapia.

| S.O.V | df | F-ratio | | | | | |
|---|---|---|---|---|---|---|---|
| | | Body weight (BW)/gm | | Body length (BL)/cm | | Condition factor (K) | |
| | | Initial | Final | Initial | Final | Initial | Final |
| Replicate | 1 | 0.2 | 0.39 | 0.12 | 1.61 | 0.89 | 0.86 |
| Treatment | 4 | 0.2 | 5.00* | 0.01 | 5.42* | 0.49 | 5.14* |
| Reminder df | 114 | | | | | | |
| Reminder MS | | 6.54664 | 8.44072 | 1.05693 | 0.90198 | 0.00044 | 0.00144 |

* P<0.05

At the end of the experimental period, the highest average body weight (16.76 g) was recorded in group 1 which was fed on basal diet followed in a descending order by those fed the diet D3 (15.25 g), D2 (14.89 g), D4 (14.73 g) and D5 (12.62 g), respectively and the differences between these means were significant ($P<0.05$) indicating the possibility of replacing up to 75% of soybean meal by sunflower meal in the diets without adverse effect on final body weight while the complete replacement significantly ($P<0.05$) decreased the final body weight of Nile tilapia.

In previous study, **Sanz *et al.*, (1994)** evaluated the nutritive potential of sunflower meal protein as compared to soybean meal and fish meal protein in trout diets and they found that, sunflower meal protein could replace up to 40% of fish meal protein or soybean meal protein in the diet at the same replacing percentage in trout diets without any negative effect on BW. In another study, **Abdul-Aziz *et al.*, (1999)** evaluated the possibility of replacing soybean meal by different cheap plant protein sources, sunflower, cottonseed, linseed and rapeseed as a partial replacement of soybean meal in practical diets for Nile tilapia fingerlings and they showed the possibility of partial substitution of soybean protein by sunflower protein up to 50% without adverse effect on BW of Nile tilapia fingerlings.

In recent studies, some attempts were carried out to replace the high cost animal protein source by sunflower meal (low costs plant protein). **Fagbenro and Davies (2000)** replaced 67% of fish meal in tilapia diets by each of soybean, sunflower meal, peanut, roselle seed, cottonseed, sesame seed and winged bean.

They found that, replacement of 67% of fish meal by each of soybean meal or sunflower meal in tilapia diets did not significantly altere the final weight of tilapia fish while the other plant protein sources significantly affected the final body weight of tilapia fish.

In this respect, **Olvera-Novoa *et al.*, (2002)** showed the possibility to replace animal protein source in tilapia fry diets with sunflower seed meal up to 20% without significant effect in BW of Nile tilapia fry while the highest replacing levels significantly decreased the BW.

In another study, **El-Saidy and Gaber (2002)** replaced fish meal protein by dehulled sunflower meal protein at replacing levels of 0, 25, 50, 75 and 100% in Nile tilapia diets and they found that up to 50% dehulled sunflower meal protein could be used to replace fish meal as a protein source in the diet of Nile tilapia, *Oreochromis niloticus* without significant effect on the BW of Nile tilapia.

**Abbas *et al.*, (2005)** conducted an experiment to evaluate the growth performance of major carps as influenced by partial replacement of fish meal by sunflower meal in the diet and they indicated that, the net production was calculated as 1651.6, 1602.2, 1526.0 and 1328.6 kg/ha/year for fish fed the basal diet (0% sunflower meal), T2 (25% sunflower meal), T3(50% sunflower meal) and T4(75% sunflower meal), respectively. They found that, the replacement of fish meal with sunflower meal in the diet of major carps caused statistically significant ($P<0.05$) decrease in fish production in the treated ponds. The gradual rise in replacement level negatively affected growth performance of major carps and the minimum decrease in fish production was recorded at 25% replacement level while the maximum decrease was recorded at 75% replacing level of fish meal by sunflower meal.

### 4.2.2. Body length (BL):

Data concerning the body length of fish in the different groups throughout the experimental period are illustrated in Tables (11) and (12).

Averages BL at the beginning of the experiment in the different treatments ranged between 7.04 and 7.08 cm with insignificant differences between the different experimental treatments (table, 11). At the experiment termination, complete replacement of soybean meal by sunflower meal released the lower BL (8.35 cm) while fish fed the diet (D3) gained the longest BL (10.54 cm) and the differences in BL among the different treatments were significant ($P<0.05$).

Results of tilapia BL as affected by replacing soybean meal by sunflower meal indicated that replacing soybean meal by sunflower meal in tilapia diets up to 75% did not affect the final BL while the complete replacement significantly reduced the BL of tilapia and these results relatively similar to those obtained for BW (tables, 11 and 12).

### 4.2.3. Condition factor (K)

At the start of the experiment average values of condition factor (K) ranged between 1.73 and 1.75 and the differences among the experimental groups (tables, 11 and 12) were not significant while at experimental termination, fish group fed the diet D5 showed the highest (2.17) K value and this value is significantly different (P<0.05) from those recorded for the other experimental diets, D1(1.72), D2(1.82), D3, (1.76), and D4 (1.74).

In the study of **Abdul-Aziz *et al.*, (1999)** soybean meal was replaced by different cheap plant protein sources, sunflower, cottonseed, linseed and rape seed as a partial replacement in practical diets for Nile tilapia fingerlings and the authors reported that condition factor did not significantly affect when 25 or 50% of soybean meal was replaced by sunflower meal in tilapia diet.

**4.2.4. Body weight gain (WG):**

Results of Table (13) showed that, after 90 days of the experimental start, the averages of weight gain (WG) were found to be 10.64, 8.74, 9.20, 8.70 and 6.42 g for the experimental diets D1, D2, D3, D4 and D5, respectively. Analysis of variance (table, 14) indicated that the differences in WG between the different experimental treatments were significant (P<0.05) indicating the possibility of replacing soybean meal by sunflower meal up to 75% without significant adverse effect on body weight of Nile tilapia while the complete replacement significantly reduced the WG of Nile tilapia.

**Sanz *et al.*, (1994)** evaluated the nutritive potential of sunflower meal protein as compared to soybean meal and fish meal protein in trout diets and they found that, sunflower meal protein could replace up to 40% of fish meal protein or soybean meal protein in the diet at the same replacing level in trout diets without significant effect on WG of trout.

Table (13): Effect of increasing levels of sunflower in the diets on body weight gain (WG) and specific growth rate (SGR) of Nile tilapia fed experimental diets.

| Diets | No.+ | Weight gain (g/fish) | Specific growth rate |
|---|---|---|---|
| D1 (0% SFM) | 2 | 10.64±0.62 a | 1.12±0.05 a |
| D2 (25% SFM) | 2 | 8.74±0.62 ab | 0.98±0.05 a |
| D3 (50% SFM) | 2 | 9.20±0.62 a | 1.03±0.05 a |
| D4 (75% SFM) | 2 | 8.70±0.62 ab | 0.99±0.05 a |
| D5 (100 SFM) | 2 | 6.42±0.62 b | 0.79±0.05 b |

Averages within each column followed by different letters are significantly different (P<0.05)

+ Average of two replicates (aquaria)

Table (14): Analysis of variance effect of increasing percentage of sunflower in body weight gain (WG) and specific growth rate (SGR) of Nile tilapia.

| S.O.V | df | F-ratio | |
|---|---|---|---|
| | | Weight gain | Specific growth rate |
| Replicate | 1 | 0.54 | 0.41 |
| Treatment | 4 | 5.02* | 4.73* |
| Reminder df | 4 | | |
| Reminder MS | | 0.77430 | 0.00479 |

* P<0.05

**Abdul-Aziz *et al.,* (1999)** evaluated the possibility of replacing soybean meal by different plant protein sources, sunflower, cottonseed, linseed and rape seed as a partial replacement in practical diets for Nile tilapia fingerlings. They found that, fish fed on rape seed and soybean diets achieved the best WG followed by that fed sunflower, cottonseed and linseed diet.

**El-Saidy and Gaber (2002)** replaced fish meal protein by dehulled sunflower meal protein at replacing levels of 0, 25, 50, 75 and 100% in Nile tilapia diets. They showed that up to 50% dehulled sunflower meal protein could be used to replace fish meal as a protein source in the diet of Nile tilapia, *Oreochromis niloticus* without significant effect on the weight gain of Nile tilapia.

On the other hand, **Fagbenro and Davies (2000)** substitute fish meal in tilapia diets by each of soybean meal or sunflower meal and they found that replacing 67% of fish meal by soybean meal did not significantly affected weight gain of Nile tilapia while the same level of replacing fish meal by sunflower meal significantly (P<0.05) adversed WG of Nile tilapia. In the same respect, **Furuya *et al.,* (2000)** incorporated sunflower meal in Nile tilapia diets at inclusion levels of 0, 7, 14, 21 and 28% and they concluded that, increasing sunflower meal in tilapia diets resulted in quadratic effect (P<0.05) on WG of Nile tilapia. Also, **Olvera-Novoa *et al.,* (2002)** showed that it possible to replace animal protein source in tilapia fry diets with sunflower seed meal up to 20% without significant effect on WG of Nile tilapia fry while the highest replacing levels significantly decreased the final body weight of Nile tilapia fry.

Reduced growth response in Nile tilapia fed diets in which soybean meal was completely replaced by sunflower meal have been explained by sub-optimal amino acid balance, inadequate levels of phosphorus, inadequate levels of energy, low feed intake caused by palatability, presence of high content of endogenous anti-nutrients **(Lim and Dominy, 1991)**. Lower growth at the complete replacement of soybean meal by sunflower meal in the present study may have been caused by one or some of these factors.

**4.2.5. Specific growth rate (SGR):**

Results of SGR as affected by the different substitution levels of soybean meal by sunflower meal were presented in Tables (13) and (14). As described in these tables, average values of SGR found to be 1.12, 0.98, 1.03, 0.99 and 0.79 for the different experimental diets D1, D2, D3, D4 and D5, respectively.

Analysis of variance (table, 14) showed that the differences in SGR values among the different experimental treatments were non significant except the D5 was significantly released the lowest SGR value.

The obtained results were parallel with the other growth parameters of tilapia fish, BW, BL (table, 10) and WG (table, 12).

The higher value of SGR (1.12) was recorded for fish group fed the basal diet and this may be attributed to the positive effect of balanced amino acid composition content of soybean meal compared to sunflower meal.

In this connection, **Abdul-Aziz *et al.*, (1999)** compared the possibility of replacing soybean meal by different plant protein sources, sunflower, cottonseed, linseed and rape seed as a partial replacement in practical diets for Nile tilapia fingerlings and they found that, fish fed on rape seed and soybean diets achieved the best SGR followed by that fed sunflower, cottonseed and linseed diet.

In the study of **El-Saidy and Gaber (2002)** fish meal protein was replaced by dehulled sunflower meal protein at levels of 0, 25, 50, 75 and 100% in Nile tilapia diets. They found that up to 50% dehulled sunflower meal protein could be used to replace fish meal in the diet of Nile tilapia without significant effect on SGR while the highest replacing levels (75 or 100%) significantly decreased SGR.

On the other hand, **Fagbenro and Davies (2000)** substitute fish meal in tilapia diets by each of soybean meal or sunflower meal and they found that replacing 67% of fish meal by soybean meal did not significantly affected SGR of Nile tilapia while the same level of replacing fish meal by sunflower meal significantly ($P<0.05$) reduced SGR of Nile tilapia. In this respect, **Sanz, *et al.*, (1994)** concluded that, up to 40% of fish meal in trout diets could be replaced by each of soybean meal or sunflower meal without significant effect of SGR. Also, **Shipton and Britz (2001)** replaced dietary fish meal by each of soybean meal or sunflower meal in abalone diets at replacing levels of 30, 50, 75 or 100% and they found no significant differences in growth rates between control diet (100% fish meal) and diets in which 30% fish meal component had been replaced by either soybean or sunflower meal.

In another study, **Olvera-Novoa *et al.*, (2002)** showed that replacement of fish meal in tilapia fry diets with sunflower seed meal up to 20% did not significantly affected SGR of Nile tilapia fry while the highest replacing levels significantly decreased SGR of Nile tilapia fry.

Results of growth performance parameters illustrated in Tables (11 and 12) of Nile tilapia indicated that replacement of soybean by sunflower meal up to 75% did not affected BW, BL, WG and SGR while the complete replacement significantly ($P<0.05$) reduced these growth parameters. Sunflower meal has been reported to contain a lot of endogenous anti-nutritional factors, such as a protease inhibitor, an arginase inhibitor and the polyphenolic tannin chlorogenic acid **(Tacon *et al.*, 1984)**. It has relatively high crude fiber content, which can reduce the pelleting quality and protein digestibility of the feed included at high levels **(Kamarudin *et al.*, 1989)**. Sunflower meal also contains low levels of lysine. Despite these drawbacks, sunflower meal has been reported to be a good protein source for Nile tilapia, *Oreochromis niloticus* even at 696 g/kg of the diet **(Jackson *et al.*, 1982)**.

## 4.2.6. Feed conversion ratios (FCR):

Feed conversion ratios (g of feed per g of live weight gain) of fish in the different groups throughout the experimental period are shown in Table (15).

Table (15): Effect of increasing levels of sunflower in the diets on feed conversion ratio (FCR) and protein efficiency ratio (PER) of Nile tilapia fed the experimental diets.

| Diets | No.+ | Feed conversion ratio (FCR) | Protein efficiency ratio (PER) |
|---|---|---|---|
| D1 (0% SFM) | 2 | 2.44±0.30 c | 1.36±0.06 a |
| D2 (25% SFM) | 2 | 2.97±0.30 b | 1.10±0.06 b |
| D3 (50% SFM) | 2 | 2.83±0.30 ab | 1.15±0.06 b |
| D4 (75%  SFM) | 2 | 2.99±0.30 ab | 1.09±0.06 b |
| D5 (100 SFM) | 2 | 4.05±0.30 a | 0.80±0.06 c |

Averages within each column followed by different letters are significantly different (P<0.05)

+ Average of two replicates (aquaria)

Table (16): Analysis of variance for the effect of increasing levels of sunflower in the diets on feed intake, feed conversion ratio and protein efficiency ratio

| S.O.V | df | F-ratio | |
|---|---|---|---|
| | | Feed conversion ratio (FCR) | Protein efficiency ratio (PER) |
| Replicate | 1 | 0.81 | 0.63 |
| Treatment | 4 | 5.72* | 9.11** |
| Reminder df | 4 | | |
| Reminder MS | | 0.14477 | 0.00633 |

* P<0.05 ** P<0.01

The final FCR at the end of the experimental period were ranged from 2.44 for fish fed the basal diet (D1) to 4.05 for fish fed the diet D5(complete replacement of soybean meal) and the differences in FCR between the different treatment were significant (table, 16).

The present results are in good agreement with those obtained by **Furuya *et al.*, (2000)** who incorporated sunflower meal in Nile tilapia diets at inclusion levels of 0, 7, 14, 21 and 28% . They concluded that, increasing sunflower meal in tilapia diets resulted in quadratic effect ($P<0.05$) on feed conversion ratio of Nile tilapia.

**Abdul-Aziz *et al.*, (1999)** studied the possibility of replacing soybean meal by different plant protein sources, sunflower, cottonseed, linseed and rape seed as a partial replacement in practical diets for Nile tilapia fingerlings. They found that, replacement of soybean meal by sunflower meal at a replacing levels of 25% or 50% significantly adversed FCR of Nile tilapia. Also, **Olvera-Novoa *et al.*, (2002)** showed that replacement of fish meal source by sunflower seed meal up to 50% in tilapia fry diets improved FCR of Nile tilapia fry. In the study of **El-Saidy and Gaber (2002)** fish meal protein was replaced by dehulled sunflower meal protein at replacing levels of 0, 25, 50, 75 and 100% in Nile tilapia diets and the authors found that up to 50% dehulled sunflower meal protein could be used to replace fish meal as a protein source in the diet of Nile tilapia without significant effect on the FCR of Nile tilapia, *O. niloticus* while the highest replacing levels significantly adversed FCR of Nile tilapia. **Fagbenro and Davies (2000)** replaced 67%

of fish meal in tilapia diets by each of soybean, sunflower meal, peanut, roselle seed, cottonseed, sesame seed and winged bean and they found that, replacement of 67% of fish meal by each of soybean meal or sunflower meal in tilapia diets did not significantly altered the FCR of Nile tilapia fish while the other plant protein sources significantly affected the final body weight of tilapia fish.

## 4.2.7. Protein efficiency ratio (PER):

Protein efficiency ratio values of fish in different groups throughout the experimental period are presented in Table (15). As described in this table, PER ranged from 0.80 (for D5) to 1.36% for the basal diet (D1).

Analysis of variance (table, 16) indicated that PER for fish fed the basal diet significantly different ($P<0.01$) from those recorded for the other treatments. PER for fish group fed the basal diet released the highest PER and the increasing inclusion levels of sunflower meal in tilapia diets followed by significantly decrease in the values of PER.

In the study of **Martinez (1986)** sunflower meal was used as a replacer of soybean meal up to 100% and growth assessed by means of body weight, specific growth rate, feed conversion ratio, protein efficiency ratio, nutrient digestibility and proximate carcass composition and he decided that sunflower meal is a good dietary replacement for soybean meal in rations of trout.

**El-Saidy and Gaber (2002)** reported that the fish fed with 100% fish meal and diets including 25 or 50% dehulled sunflower meal had significantly better final protein efficiency ratio than fed with 75% and 100% dehulled sunflower meal.

Also, **Furuya *et al.*, (2000)** incorporated sunflower meal in Nile tilapia diets at inclusion levels of 0, 7, 14, 21 and 28% and they concluded that, increasing sunflower meal in tilapia diets resulted in quadratic effect (P<0.05) on PER of Nile tilapia.

In the study of **Abdul-Aziz *et al.*, (1999)** 25% only of soybean meal could be replaced by sunflower meal without significant effect on PER of Nile tilapia. Also, **Olvera-Novoa *et al.*, (2002)** showed that replacement of fish meal source by sunflower seed meal up to 50% in tilapia fry diets improved PER of Nile tilapia fry.

On the other hand, **Fagbenro and Davies (2000)** substitute fish meal in tilapia diets by each of soybean meal or sunflower meal and they found that replacing 67% of fish meal by soybean meal did not significantly affected PER of Nile tilapia while the same level of replacing fish meal by sunflower meal significantly (P<0.05) reduced PER of Nile tilapia. Also, **Sanz *et al.*, (1994)** found that replacement of fish meal by each of soybean meal or sunflower meal up to 40% did not significantly alter PER of trout while the same replacing level of fish meal by sunflower meal significantly adversed SGR of trout.

### 4.2.8. Chemical composition of fish:

Results of body composition of whole fish body (table, 17) showed that, dry matter (DM) of whole fish lie in three groups the first group included fish fed the diet D2 and the second group included fish fed the diet D3 while the third one included fish groups fed the diets D1, D4 and D5. Analysis of variance (table, 18) indicated that the differences between fish in the first and the second groups (D2 and D3) were significant (P<0.05) while the

Table (17): Means and standard error for the effect of increasing levels of sunflower in the diets on chemical composition of Nile tilapia.

| Diets | No.+ | Dry matter (DM) | Crude protein( CP) | Ether extract (EE) | Ash |
|---|---|---|---|---|---|
| D1 (0% SFM) | 6 | 25.66±0.46 ab | 52.16±1.62 b | 16.92±1.50 | 14.63±0.61 |
| D2 (25% SFM) | 6 | 26.24±0.46 a | 42.78±1.62 c | 14.63±1.50 | 15.39±0.61 |
| D3 (50% SFM) | 6 | 24.41±0.46 b | 48.94±1.62 b | 13.92±1.50 | 14.68±0.61 |
| D4 (75% SFM) | 6 | 25.85±0.46 ab | 50.94±1.62 b | 14.03±1.50 | 13.61±0.61 |
| D5 (100 SFM) | 6 | 25.57±0.46 ab | 60.05±1.62 a | 15.42±1.50 | 15.02±0.61 |

Averages within each column followed by different letters are significantly different ($P<0.05$)

Table (18): Analysis of variance for the effect of increasing levels of sunflower in the diets on chemical composition of Nile tilapia.

| S.O.V. | df | F-ratio | | | |
|---|---|---|---|---|---|
| | | Dry matter (DM) | Crude protein (CP) | Ether extract (EE) | Ash |
| **Replicate** | 1 | 1.97 | 4.91* | 0.02 | 0.76 |
| **Treatment** | 4 | 2.22 | 14.82*** | 0.68 | 1.20 |
| **Reminder df** | 24 | | | | |
| **Reminder MS** | | 1.27078 | 15.70252 | 13.45441 | 2.20637 |

* $P<0.05$ *** $P<0.001$

differences between each of the first (D2) or the second group (D3) and the third group were not significant (P>0.05).

The complete substitution of soybean by sunflower meal released the highest (60.05) crude protein content (CP) of whole fish followed in a descending order by those fed the diets D1(52.16%), D4(50.94%), D3(48.94%) and D2(42.78%), and the differences between fish groups for protein content were significant (P<0.01).

Ether extract and ash content of whole fish body found to be 16.92, 14.63, 13.92, 14.03 and 15.42% and 14.63, 15.39, 14.68, 13.61 and 15.02%, respectively for D1, D2, D3, D4 and D5 and the differences in ether extract or ash contents among fish groups fed the diets contained the graded levels of sunflower meal were not significant.

### 4.2.9. Economical efficiency:

The current investigation highlights the potential of using sunflower meal for partial or complete replacement for soybean meal in Nile tilapia diets. Generally, results of the present study showed the possibility of replacing of soybean meal by sunflower meal up to 75% with no adverse effect on growth performance and feed utilization.

Feed cost is considered to be the highest recurrent cost in aquaculture, often ranging from 30 to 60%, depending on the intensity of the operation. Any reduction in feed costs either through diet development, improved husbandry or other direct or indirect means is therefore decreased the total production investment and increased the net return **(Collins and Delmendo, 1979; Green; 1992** and **De Silva and Anderson, 1995)**.

All other costs are almost constant, therefore, the feeding costs required to produce one kg gain in weight could be used to compare the economical efficiency of different experimental treatments.

As shown in Tables (19 and 20), feed costs (LE/ton) decreased gradually with increasing substitution level of soybean meal by sunflower meal. Data presented in the same table showed that, increasing substitution level of soybean meal by sunflower meal at 25, 50, 75 and 100% decreased feed costs by 5.04, 10.08, 15.13 and 20.17, respectively. Compared to the control diet, feed costs (LE/kg WG) were decreased for all substitution levels of soybean meal by sunflower meal and the experimental diet D5 released the lowest feed costs while the control diet released the highest one. In conclusion, replacing 75% of soybean meal by sunflower meal reduced feeding costs by 15.13%.

Table (19): Feed costs (L.E) for producing one kg weight gain by fish fed the experimental diets.

| Diets | Costs (L.E)/ ton | Relative to control % | Decrease in feed cost (%) |
|---|---|---|---|
| D1 (0% SFM) | 2975 | 100 | 0 |
| D2 (25% SFM) | 2825 | 94.96 | 5.04 |
| D3 (50% SFM) | 2675 | 89.92 | 10.08 |
| D4 (75%  SFM) | 2525 | 84.87 | 15.13 |
| D5 (100 SFM) | 2375 | 79.83 | 20.17 |

* Feed costs/kg weight gain = FCR × costs of kg feed.

Table (20): Local market price (L.E./ton) for feed ingredients used for formulating the experimental diets when the experiment was started.

| Ingredients | Price (L.E.) / ton |
|---|---|
| Fish meal | 7000 |
| Yellow corn | 1250 |
| Soybean meal | 2500 |
| Sunflower meal | 1000 |
| Wheat bran | 1000 |
| Corn oil | 4000 |
| Vit. & Min. Mixture | 1000<br>0 |