# RESULTS

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# CHAPTER I

## Physico-chemical parameters in the experimental ponds or aquaria :

### 1. Temperature

The results of air and water temperatures monitoring within the experimental ponds water are presented in Tables (9 and 10). As expected, water temperature decreased progressively from August, 1997 to reach its lowest value in December 15, 1997. These values were recorded at the first two trials (when *O. niloticus* fed different levels of FFS or BSM). Then it raised during April, 1998 attaining its peak in August 15, 1998 at the $3^{rd}$ trial in which fish fed with mixture of FFS & BSM 1:1. Values fluctuated from a minimum average of 16.6±1.6 °C in December 1997 to a maximum of 33.6±2.7 °C in August 1997, during the first two experiments. While at the third trial, the lowest average value (25.0±6.0 °C) was recorded in April, 1998 and the highest (38.7±1.7 °C) in August, 1998.

**2. Dissolved oxygen**

The dissolved oxygen is a very important factor in natural waters not only as a regulator of metabolic process of organisms, but also as an indicator of water conditions.

The average values of dissolved oxygen ranged from 5.3-6.8 mg/l in the cement pond and from 5.8-6.7 mg/l in the glass aquaria during the first two experiments. Whereas its average value ranged from 4.9-5.7 mg/l in pond and from 5.0-6.3 mg/ l in glass aquaria, during the third experiment (Tables 9, 10, 11 & 12).

**3. Total alkalinity**

The alkalinity of water is the result of bicarbonates ($CaCO_3$). The average biweekly variations of total alkalinity in the selected cement pond's water are shown in tables (9 and 10) and in glass aquaria (Tables 11 and 12).

It ranged from 86-98 mg/l in the cement ponds, during the first two trials, and varied from 13.1-19.3 mg/l in the glass aquaria during the third trial.

These values ranged from 91-100 mg/l in pond, during the first two experiments, but ranged from 14-26.6 mg/l in glass aqauaria during the third trial.

## 4. Nitrites

In the cement ponds nitrite average values ranged from 0.08-0.2 mg/l while varied from 0.02-0.08 mg/l in glass aquaria during the first two experiments. Nitrite ranged from 0.07-0.1 mg/l in ponds whereas in glass aquaria ranged from 0.02-0.05 mg/l during the third trial.

## 5. Phosphates

Phosphates concentration showed an obvious variation from one month to another in the pond's water as shown in tables (9 and 10). The average phosphates values ranged from 0.1-0.3 mg/l in pond, while it varied from 0.04-0.2 mg/l in glass aquaria during the first two experiments.

The average values ranged from 0.1-0.3 mg/l in ponds, but varied from 0.04-0.1 mg/l in glass aquaria during third experiment.

## 6. Hydrogen ion concentration (pH)

Measurements of pH in August are essential as it reflects the biological activity and changes in the water as well as pollution. The pH values in the cement pond reaches its maximum value (8.4±0.9) in April, 1998, while the minimum value (6.80±0.29) was noticed in November, 1997.

In the glass aquaria the highest pH values (7.50±0.82) was recorded in July, 1998 and the lowest one (6.20±0.59) was in December, 1997.

**Table (9) : Biweekly variation of average values of physico-chemical parameters of water within the cement ponds during the experimental period (from August 1 to December 15, 1997).**

| Weeks / Physico-chemical Parameters | August | | September | | October | | November | | December |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD |
| Air temperature (°C) | 36.2±2.6 | 32.5±2.3 | 32.7±2.9 | 29.7±2.5 | 27.8±2.5 | 24.1±1.8 | 22.6±3.1 | 26.6±2.1 | 23.2±2.7 |
| Water temperature (°C) | 33.6±2.7 | 30.0±1.8 | 30.8±2.7 | 27.5±2.4 | 23.2±2.1 | 21.8±1.3 | 19.4±1.6 | 19.5±1.4 | 16.6±1.7 |
| Dissolved oxygen (mg/L) | 5.3±0.5 | 5.6±0.7 | 5.6±0.8 | 5.8±0.8 | 5.9±0.9 | 6.0±0.9 | 6.4±0.9 | 6.3±0.9 | 6.8±1.0 |
| Alkalinity ($CaCo_3$) (mg/L) | 88.0±4.1 | 86.0±4.1 | 89.0±1.4 | 98.0±1.3 | 93.0±1.0 | 94.0±0.9 | 90.0±0.9 | 90.0±0.9 | 96.0±0.9 |
| Nitrites (mg/L) | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.2±0.0 | 0.2±0.0 | 0.2±0.0 | 0.2±0.0 |
| Phosphates (mg/L) | 0.1±0.0 | 0.2±0.0 | 0.2±0.0 | 0.2±0.0 | 0.3±0.0 | 0.3±0.1 | 0.3±0.1 | 0.3±0.1 | 0.3±0.1 |
| pH | 7.7±0.6 | 7.5±0.6 | 7.5±0.5 | 7.4±0.5 | 7.5±0.5 | 7.3±0.5 | 7.1±0.4 | 6.8±0.3 | 6.9±0.3 |

$\bar{X}$ = Mean value. SD = Standard deviation.

**Table (10) : Biweekly variation of average values of physico-chemical parameters of water within the cement ponds during the experimental period (from April 1 to August 15, 1998).**

| Weeks / Physico-chemical Parameters | April | | May | | June | | July | | August |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD |
| Air temperature (°C) | 26.9±6.3 | 26.1±2.3 | 27.4±2.8 | 29.2±3.8 | 29.5±2.9 | 34.8±1.9 | 35.6±2.2 | 38.5±3.3 | 41.2±2.1 |
| Water temperature (°C) | 25.0±6.0 | 23.9±1.2 | 24.6±1.9 | 26.4±2.6 | 27.1±2.8 | 30.4±1.7 | 33.1±2.2 | 35.4±2.8 | 38.7±1.7 |
| Dissolved oxygen (mg/L) | 5.6±0.6 | 5.7±0.7 | 5.7±0.5 | 5.5±0.4 | 5.3±0.5 | 5.3±0.4 | 5.2±0.4 | 5.0±0.3 | 4.9±0.3 |
| Alkalinity ($CaCo_3$) (mg/L) | 98.0±4.6 | 99.0±3.2 | 100.0±4.0 | 94.0±5.1 | 99.0±4.9 | 94.0±3.9 | 92.0±3.8 | 98.0±5.1 | 91.0±5.2 |
| Nitrites (mg/L) | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.2±0.0 |
| Phosphates (mg/L) | 0.2±0.1 | 0.1±0.2 | 0.2±0.2 | 0.2±0.2 | 0.2±0.1 | 0.2±0.0 | 0.3±0.1 | 0.2±0.1 | 0.2±0.1 |
| pH | 8.4±0.9 | 8.0±0.7 | 7.6±0.4 | 7.6±0.4 | 7.6±0.4 | 7.3±0.4 | 7.7±0.4 | 7.9±0.6 | 7.9±0.9 |

$\bar{X}$ = Mean value. SD = Standard deviation.

**Table (11) : Biweekly variation of average values of physico-chemical parameters of water in glass aquaria during the experimental period (from August 1 to December 15, 1997).**

| Weeks / Physico-chemical Parameters | August | | September | | October | | November | | December |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD | $\bar{X}$±SD |
| Air temperature (°C) | 32.2±1.4 | 29.2±1.7 | 29.3±1.8 | 27.6±1.9 | 23.8±1.3 | 21.9±0.9 | 20.6±1.1 | 22.2±1.2 | 21.1±1.2 |
| Water temperature (°C) | Was thermostatically maintained at 26.0±0.8 °C | | | | | | | | |
| Dissolved oxygen (mg/L) | 5.8±1.0 | 6.0±1.0 | 5.9±1.0 | 6.0±0.9 | 6.4±0.9 | 6.5±1.0 | 6.7±1.1 | 6.4±0.9 | 6.5±0.9 |
| Alkalinity ($CaCo_3$) (mg/L) | 17.0±1.2 | 18.0±2.1 | 16.0±1.2 | 19.3±1.3 | 15.2±1.1 | 13.1±2.1 | 14.6±1.3 | 17.6±1.1 | 16.8±1.0 |
| Nitrites (mg/L) | 0.0±0.0 | 0.0±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.2±0.0 |
| Phosphates (mg/L) | 0.0±0.1 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 |
| pH | 7.2±0.9 | 7.0±0.9 | 6.9±0.8 | 6.7±0.7 | 6.8±0.7 | 6.8±0.9 | 6.5±1.0 | 6.4±0.8 | 7.2±0.6 |

$\bar{X}$ = Mean value. SD = Standard deviation.

**Table (12) : Biweekly variation of average values of physico-chemical parameters of water in glass aquaria during the experimental period (from April 1 to August 15, 1998).**

| Weeks / Physico-chemical Parameters | April | | May | | June | | July | | August |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ | $\bar{X}\pm SD$ |
| Air temperature (°C) | 23.5±0.8 | 23.1±0.9 | 25.1±0.8 | 26.9±2.0 | 27.1±2.2 | 29.8±2.3 | 31.7±2.1 | 33.0±2.0 | 35.0±4.1 |
| Water temperature (°C) | Was thermostatically maintained at 26.0±0.8 °C | | | | | | | | |
| Dissolved oxygen (mg/L) | 6.1±1.0 | 6.3±0.9 | 6.1±0.9 | 6.0±0.9 | 6.0±0.9 | 5.8±1.8 | 5.5±1.8 | 5.4±1.9 | 5.0±1.0 |
| Alkalinity ($CaCo_3$) (mg/L) | 20.1±2.2 | 24.2±1.6 | 22.2±2.9 | 26.6±3.1 | 21.1±2.3 | 19.2±3.1 | 14.0±3.9 | 18.0±4.1 | 17.6±3.2 |
| Nitrites (mg/L) | 0.1±0.0 | 0.0±0.0 | 0.1±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 |
| Phosphates (mg/L) | 0.2±0.1 | 0.1±0.0 | 0.1±0.0 | 0.0±0.0 | 0.1±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 |
| pH | 6.8±0.6 | 7.1±0.7 | 7.0±0.6 | 6.8±0.5 | 6.8±0.6 | 7.3±0.9 | 7.5±0.4 | 7.5±0.8 | 6.9±1.0 |

$\bar{X}$ = Mean value. SD = Standard deviation.

# CHAPTER II

## Evaluation of different fish meal (FM) replacers :

### Experiment 1 :

### 1. Effect of using fermented fish silage (FFS) as a fish meal (FM) replacer in *O. niloticus* diets :

**Objective :**

Determination of the optimum inclusion level of FFS as a FM replacer within *O. niloticus* diets fed to fry, fingerlings and grow-out stages.

The results of growth performance, including total weight gain (TWG), daily weight gain (DWG), specific growth rate (SGR), and condition factor (k) are given for each growth stage separately. In the mean time, feed utilization results were also given in separate section.

### 1-1. Effect of FFS inclusion on growth performance of *O. niloticus* :

#### 1-1-1. *O. niloticus* fry

The mean final weights at biweekly intervals as well as total weight gain (TWG) for *O. niloticus* fry fed the test diets are illustrated in table (13) and graphically represented in fig. (1). These results indicated that, at the level of 25% FFS inclusion (diet 2), the total weight gain (TWG) reached a maximum value (14.3 g) followed by diet 3 (13.7 g). These values were tested (according to t-test) to be insignificantly different ($p>0.05$) from the corresponding value of control group diet 1 (17.5 g), which contained 100% fish meal. Further increase in FFS inclusion level within the diets has led to a decrease in total weight gain (11.7, 9.03g for fry fed diets 4 and 5 respectively). The lowest total weight gain (9.03g) was attained for fry diet 5 (100% FFS) which was also insignificantly different ($p>0.05$) from the corresponding for the control fish.

Similar trend was obvious for the percentage weight gain (PWG). Thus, the maximum value (32.46) was sustained for fry fed diet 2 followed by those fed diet 3 (32.00). These values were tested to be insignificantly different ($p>0.05$) from the value of the control group, diet 1 as shown in table (14) and illustrated in fig. (2).

Further increase in FFS inclusion levels within the diets has led to consequent decreases in PWG (29.78 & 26.49 for fry fed diets 4 & 5 respectively). These values were insignificantly different ($p>0.05$), according to t-test, as compared with the corresponding control group diet 1.

Also, daily weight gain (DWG) results showed the same trend of variation, since the maximum DWG (0.11g/ fish / day) was attained for fry fed diet 2 followed by diet 3 (0.10g/ fish/ day) without significant differences ($p>0.05$) as compared with the corresponding diet 1 (0.13 g/ fish/ day). Further increase in FFS supplement has led to decreased DWG, attaining lowest value of 0.07g/ fish/ day for fry fed diet 5 (Table

**Table (13) : Total weight gain (g) of *O. niloticus* fry fed different levels of FFS-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | 1.30 ± 0.18 | 1.30 ± 0.20 | 1.30 ± 0.20 | 1.30 ± 0.13 | 1.30 ± 0.26 |
| 2 | $2.01^{a} \pm 0.31$ | $2.00^{a} \pm 0.43$ | $2.00^{a} \pm 0.39$ | $1.91^{a} \pm 0.26$ | $1.69^{b} \pm 0.40$ |
| 4 | $2.80^{a} \pm 0.60$ | $2.55^{b} \pm 0.67$ | $2.51^{b} \pm 0.56$ | $2.38^{b} \pm 0.39$ | $2.08^{c} \pm 0.55$ |
| 6 | $3.90^{a} \pm 1.10$ | $3.50^{b} \pm 1.19$ | $3.32^{b} \pm 1.21$ | $3.16^{b} \pm 0.89$ | $2.79^{c} \pm 0.73$ |
| 8 | $5.90^{a} \pm 1.29$ | $5.40^{b} \pm 1.73$ | $5.25^{b} \pm 1.63$ | $4.90^{c} \pm 1.42$ | $4.18^{d} \pm 1.65$ |
| 10 | $8.56^{a} \pm 3.13$ | $7.45^{b} \pm 3.17$ | $7.30^{b} \pm 2.89$ | $6.65^{c} \pm 2.06$ | $5.91^{d} \pm 1.93$ |
| 12 | $10.87^{a} \pm 3.96$ | $9.48^{b} \pm 3.68$ | $9.22^{b} \pm 3.19$ | $7.87^{c} \pm 2.75$ | $6.89^{d} \pm 2.78$ |
| 14 | $13.60^{a} \pm 4.64$ | $11.36^{b} \pm 4.10$ | $11.06^{b} \pm 3.67$ | $9.42^{c} \pm 3.35$ | $8.12^{d} \pm 3.43$ |
| 16 | $16.38^{a} \pm 4.83$ | $13.18^{b} \pm 4.45$ | $12.86^{b} \pm 4.01$ | $11.00^{c} \pm 3.79$ | $9.10^{d} \pm 3.81$ |
| 18 (Final) | $18.80^{a} \pm 5.06$ | $15.58^{b} \pm 5.00$ | $15.00^{c} \pm 4.46$ | $13.00^{d} \pm 4.00$ | $10.33^{e} \pm 3.79$ |
| Total weight gain (g) | $18.50^{a}$ | $14.28^{b}$ | $13.70^{b}$ | $11.70^{c}$ | $9.03^{d}$ |

FM = Fish meal.
FFS = Fermented fish silage.
Total weight gain = Final weight – Initial weight.
[a,b,c,d,e] Means followed by the same letters are not significantly different at levels $p < 0.05$).

SD = Standard deviation
$W_2$ = Mean weight (g)

**Table (14) : Growth performance of *O. niloticus* fry fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| Final weight | (g/fish) | 18.80 | 15.58 | 15.00 | 13.00 | 10.33 |
| Total weight gain | (g/fish) | 17.50 | 14.28 | 13.70 | 11.70 | 9.03 |
| Percentage weight gain | (PWG) | 35.21 | 32.46 | 32.00 | 29.78 | 26.49 |
| Daily weight gain | (g/fish/day) | 0.13 | 0.11 | 0.10 | 0.09 | 0.07 |
| Specific growth rate | (SGR) | 2.41 | 2.24 | 2.20 | 2.04* | 1.75* |
| Initial length | (cm/fish) | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 |
| Total length gain | (cm/fish) | 9.96 | 9.70 | 9.59 | 9.51 | 8.60 |
| Condition factor | "K" (%) | 1.87 | 1.81 | 1.88 | 1.82 | 1.87 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

### 1-1-2. *O. niloticus* fingerlings :

Similarly, final weights at biweekly intervals as well as total weight gain of *O. niloticus* fingerlings fed the test diets are summarized in table (15) and figs. (1) to (3). The results indicated that, at the level of 25% FFS inclusion (diet 2), the TWG reached a maximum value (66.2 g) followed by diet 3 (62.26g). According to t-test, these values were tested to be insignificantly different ($p > 0.05$) when compared with the corresponding control fish diet 1 (64.25g). Further increase in FFS inclusion level within the diets has led to a decrease in TWG (53.34g & 35.03g for fingerlings fed diets 4 & 5 respectively), indicating insignificant differences ($p > 0.05$) as compared with the corresponding control group.

The same trend was observed in PWG results. The maximum value (22.49) was sustained for fingerlings fed diet 2 followed by diet 3 with insignificant differences ($p > 0.05$) compared with diet 1 (22.15). the lowest PWG (16.26) was recorded for fingerlings fed diet 5, this value was tested to be significantly different ($p < 0.05$) as compared with the corresponding value diet 1 (Table 16 & Fig. 2).

Daily weight gain showed same trend as described for total weight gain (Fig. 3). The maximum DWG of which was attained for fingerlings fed diet 2 (0.49g/ fish/ day), then a decreasing trend was exhibited along with further increase in FFS inclusion.

Specific growth rate exhibited also the same behaviour as shown in table (16) and fig. (4). The lowest value (0.91) was tested to be significantly different at level $p < 0.05$ as compared with the control group (diet 1).

**Table (15) : Total weight gain (g) of *O. niloticus* fingerlings fed different levels of FFS-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | $12.75 \pm 2.09$ | $12.75 \pm 1.88$ | $12.75 \pm 1.89$ | $12.75 \pm 1.69$ | $12.70 \pm 2.11$ |
| 2 | $14.70^{b} \pm 2.59$ | $15.00^{a} \pm 2.76$ | $15.10^{a} \pm 2.90$ | $14.75^{b} \pm 2.54$ | $14.35^{c} \pm 2.60$ |
| 4 | $17.50^{b} \pm 3.04$ | $18.20^{a} \pm 2.96$ | $18.25^{a} \pm 3.06$ | $17.89^{b} \pm 3.02$ | $16.80^{c} \pm 3.00$ |
| 6 | $21.50^{b} \pm 4.06$ | $22.70^{a} \pm 4.22$ | $22.06^{a} \pm 3.98$ | $20.95^{b} \pm 3.82$ | $18.85^{c} \pm 3.75$ |
| 8 | $26.90^{b} \pm 5.11$ | $28.80^{a} \pm 5.65$ | $28.00^{a} \pm 5.27$ | $26.55^{b} \pm 4.29$ | $21.75^{c} \pm 4.87$ |
| 10 | $33.10^{b} \pm 5.79$ | $35.90^{a} \pm 6.14$ | $34.81^{b} \pm 5.80$ | $32.51^{b} \pm 5.73$ | $26.05^{c} \pm 5.33$ |
| 12 | $41.09^{b} \pm 6.08$ | $44.50^{a} \pm 6.81$ | $42.85^{b} \pm 6.16$ | $39.00^{c} \pm 6.03$ | $29.65^{d} \pm 5.85$ |
| 14 | $50.90^{b} \pm 6.68$ | $55.00^{a} \pm 7.32$ | $52.00^{c} \pm 7.11$ | $47.13^{d} \pm 6.88$ | $34.73^{e} \pm 6.75$ |
| 16 | $62.85^{b} \pm 9.81$ | $66.90^{a} \pm 9.89$ | $62.80^{b} \pm 9.73$ | $56.13^{c} \pm 8.64$ | $40.68^{d} \pm 7.34$ |
| 18 (Final) | $77.00^{b} \pm 10.24$ | $78.95^{a} \pm 10.36$ | $75.00^{c} \pm 10.16$ | $66.09^{d} \pm 9.17$ | $47.78^{e} \pm 7.98$ |
| Total weight gain (g) | $64.25^{b}$ | $66.20^{a}$ | $62.26^{c}$ | $53.34^{d}$ | $35.03^{e}$ |

SD = Standard deviation
$W_2$ = Mean weight (g)

FM = Fish meal.
FFS = Fermented fish silage.
Total weight gain = Final weight – Initial weight.
[a,b,c,d,e] Means followed by the same letters are not significantly different at levels $p < 0.05$).

**Table (16) : Growth performance of *O. niloticus* fingerlings fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 12.75 | 12.75 | 12.75 | 12.75 | 12.75 |
| Final weight | (g/fish) | 77.00 | 78.95 | 75.00 | 66.10 | 47.78 |
| Total weight gain | (g/fish) | 64.25 | 66.20 | 62.25 | 53.34 | 35.03 |
| Percentage weight gain | (PWG) | 22.15 | 22.49 | 21.78 | 20.10 | 16.26* |
| Daily weight gain | (g/fish/day) | 0.48 | 0.49 | 0.46 | 0.40 | 0.26 |
| Specific growth rate | (SGR) | 1.21 | 1.30 | 1.27 | 1.17 | 0.91* |
| Initial length | (cm/fish) | 8.16 | 8.16 | 8.16 | 8.16 | 8.16 |
| Total length gain | (cm/fish) | 16.29 | 16.71 | 16.47 | 15.84 | 14.31 |
| Condition factor | "K" (%) | 1.90 | 1.87 | 1.81 | 1.79 | 1.75 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

Total length gain and condition factor "k" showed the same trend as described for TWG, PWG, DWG & SGR, but their values were tested to be insignificantly different from the corresponding control fish. (Table 16 & Figs. 5, 6).

**1-1-3. *O. niloticus grow-out*:**

Final weights at biweekly intervals as well as total weight gain of *O. niloticus* grow-out stage fed FFS test diets are given in table (17) and represented in figs. (1) to (3). The results indicated that grow-out stage fed diet 2 gave the highest TWG (156.2 g), while continuous supplement of higher FFS levels led to continuous lowering in TWG values. The lowest value (83.7 g) was sustained for grow-out stage fed diet 5. This value was tested to be significant ($p<0.05$) as compared with the corresponding of control diet 1.

As shown in table (18) and fig. (2) the PWG exhibited the same tendency as that of TWG. The highest value being 23.16 was sustained for grow-out stage fed diet 2, while the lowest (16.54) was recorded for grow-out stage fed diet 5. The lowest value was tested to be significant at level $p<0.05$ compared with the corresponding control diet 1.

The results of the DWG showed that the highest value was attained for fish fed diet 2 with a lowering trend along with the increase of FFS inclusion levels. All values obtained were tested to be insignificantly different ($p < 0.05$) as compared with the control diet 1 (Table 18 & Fig. 3).

As for SGR values, the highest value was also sustained for fish fed diet 2. Further increase in FFS inclusion has led to lower SGR (1.37, 1.27 & 0.90 for grow-out fed diet 3, 4 & 5 respectively. These values were tested to be significantly different at levels $p<0.05$ compared with the control diet 1 (Table 18 & Fig. 4).

Total length gain reached a maximum (21.30 cm/ fish) for grow-out stage fed diet 2. Further increase in FFS inclusion has led to decreases in TLG (Table 18 & Fig. 5).

Condition factor "k" remained high within all diet levels inclusion with values 1.80, 1.77 & 1.72 for grow-out fed diets 3, 4 & 5 respectively. These values were tested to be significantly different ($p<0.05$) compared with the control diet 1 (Table 18 & Fig. 6).

Statistical analyses of the results of growth performance parameters for all treatments as compared with the corresponding control group are given in table (19).

## 1-2. Effect of using (FFS) as (FM) replacer on feed utilization parameters of *O. niloticus*:

### 1-2-1. *O. niloticus* fry :

The effect of using different levels of FFS on feed utilization of *O. niloticus* fry are summarized in table (20). The lowest FCR (1.66 & 1.71) were shown for fry fed diets 2 & 3 respectively, whereas the highest (2.12) was for that fed diet 5. These values were tested to be insignificantly different ($p> 0.05$) from the corresponding for the control group which was the lowest among all treatments (Table 20 & Fig. 7).

**Table (17) : Total weight gain (g) of *O. niloticus* grow-out fed different levels of FFS-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | 28.60 ± 5.69 | 28.60 ± 4.99 | 28.60 ± 6.08 | 28.60 ± 5.15 | 28.60 ± 5.32 |
| 2 | 34.91 [a] ± 7.34 | 34.62 [b] ± 6.80 | 34.01 [c] ± 7.87 | 32.81 [d] ± 6.65 | 31.30 [e] ± 6.69 |
| 4 | 43.50 [a] ± 10.13 | 42.91 [b] ± 8.88 | 42.06 [c] ± 9.65 | 40.90 [d] ± 7.98 | 35.12 [e] ± 8.03 |
| 6 | 60.00 [a] ± 14.16 | 58.11 [b] ± 13.70 | 54.40 [c] ± 12.77 | 50.19 [d] ± 11.89 | 40.16 [e] ± 9.19 |
| 8 | 75.00 [a] ± 17.62 | 74.00 [b] ± 16.82 | 69.80 [c] ± 16.81 | 67.59 [d] ± 14.99 | 48.14 [e] ± 10.73 |
| 10 | 92.80 [a] ± 20.23 | 90.40 [b] ± 19.63 | 86.40 [c] ± 19.71 | 83.91 [d] ± 17.39 | 60.81 [e] ± 13.21 |
| 12 | 113.70 [a] ± 21.17 | 108.00 [b] ± 20.62 | 103.90 [c] ± 21.04 | 95.00 [d] ± 19.62 | 70.43 [e] ± 16.39 |
| 14 | 130.50 [a] ± 23.40 | 123.60 [b] ± 21.01 | 117.12 [c] ± 22.60 | 113.72 [d] ± 21.04 | 87.74 [e] ± 18.38 |
| 16 | 159.80 [a] ± 25.09 | 148.80 [b] ± 22.38 | 141.75 [c] ± 24.08 | 129.62 [d] ± 22.94 | 99.61 [e] ± 20.30 |
| 18 (Final) | 197.30 [a] ± 26.23 | 184.80 [b] ± 24.37 | 168.62 [c] ± 26.17 | 143.20 [d] ± 23.48 | 112.30 [e] ± 21.37 |
| Total weight gain (g) | 168.70 [a] | 156.20 [b] | 140.02 [c] | 114.60 [d] | 83.70* [e] |

FM = Fish meal.
FFS = Fermented fish silage.
Total weight gain = Final weight – Initial weight.
[a,b,c,d,e] Means followed by the same letters are not significantly different at levels $p < 0.05$).
SD = Standard deviation
$W_2$ = Mean weight (g)
* = Significant at level $P<0.05$.

**Table (18) : Growth performance of *O. niloticus* grow-out fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 28.60 | 28.60 | 28.60 | 28.60 | 28.60 |
| Final weight | (g/fish) | 197.30 | 184.80 | 168.62 | 143.20 | 112.30 |
| Total weight gain | (g/fish) | 168.70 | 156.20 | 140.02 | 114.60 | 83.70* |
| Percentage weight gain | (PWG) | 24.06 | 23.16 | 22.12 | 19.81 | 16.54* |
| Daily weight gain | (g/fish/day) | 1.25 | 1.16 | 1.04 | 0.85 | 0.62 |
| Specific growth rate | (SGR) | 1.49 | 1.45 | 1.37* | 1.27* | 0.90* |
| Initial length | (cm/fish) | 11.70 | 11.70 | 11.70 | 11.70 | 11.70 |
| Total length gain | (cm/fish) | 21.83 | 21.30 | 20.96 | 19.92 | 18.51 |
| Condition factor | "K" (%) | 1.86 | 1.83 | 1.80* | 1.77* | 1.72* |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (19) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of growth performance for fish fed different levels of fermented fish silage (FFS).**

| Different stages | Test diets | Total Weight Gain (TWG) | Percentage Weight Gain (PWG) | Specific Growth Rate (SGR) | Condition Factor (CF) |
|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.459 | 0.409 | 1.244 | 0.621 |
| | D3 | 0.540 | 0.462 | 1.510 | -0.046 |
| | D4 | 0.903 | 0.825 | 2.890* | 0.374 |
| | D5 | 1.344 | 1.357 | 6.051* | -0.016 |
| Fingerlings | D2 | -0.193 | -0.234 | -1.463 | 0.201 |
| | D3 | -0.052 | 0.276 | -1.102 | 0.910 |
| | D4 | 0.258 | 1.366 | 0.673 | 1.102 |
| | D5 | 1.148 | 4.478* | 5.665* | 1.541 |
| Grow-out | D2 | 0.166 | 0.306 | 1.004 | 0.983 |
| | D3 | 0.364 | 0.734 | 2.588* | 2.527* |
| | D4 | 0.647 | 1.310 | 3.744* | 3.163* |
| | D5 | 1.513* | 2.715* | 9.082* | 4.993* |

* Significant at levels $P<0.05$.

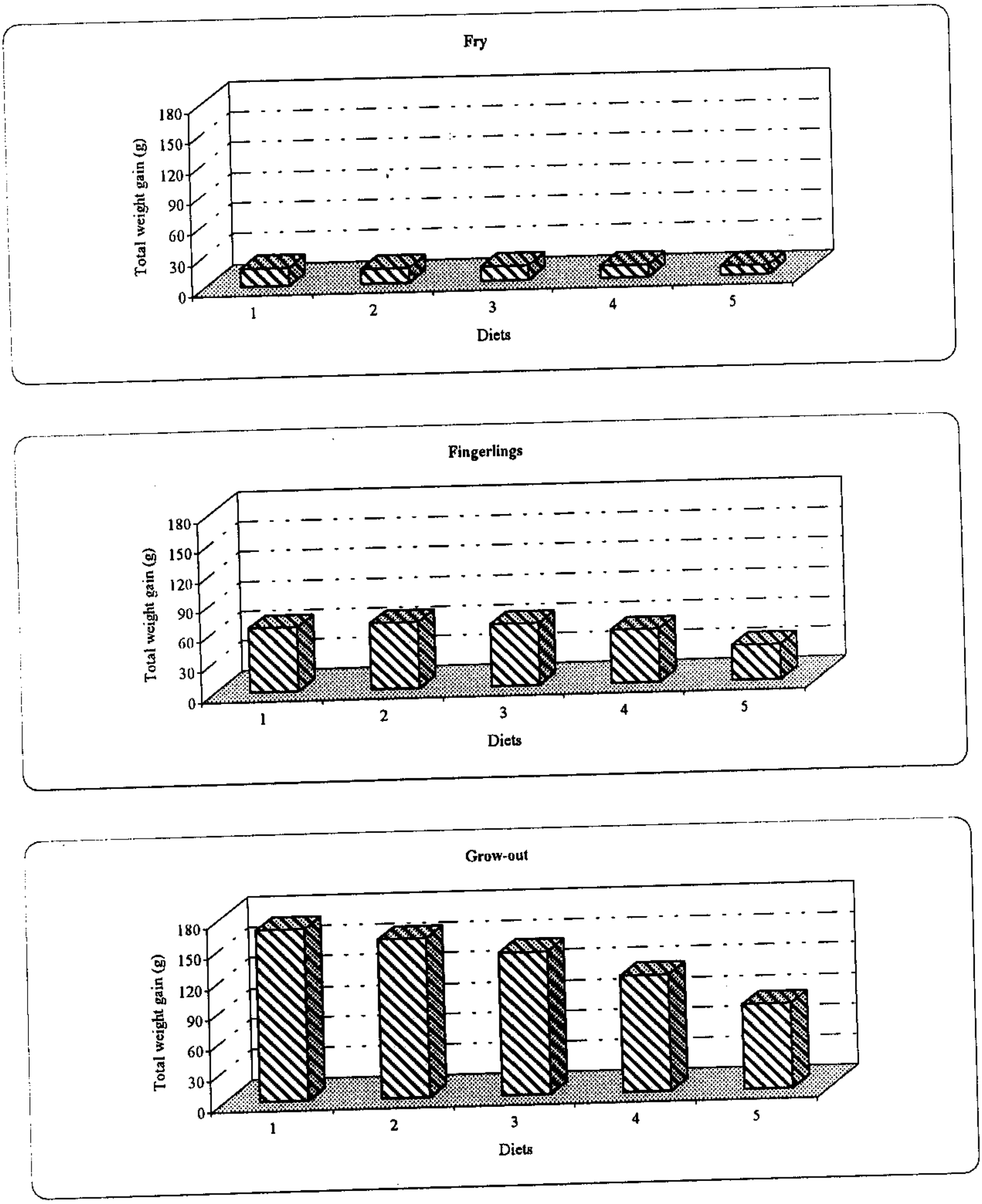



**Fig. (1): Total weight gain (TWG) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

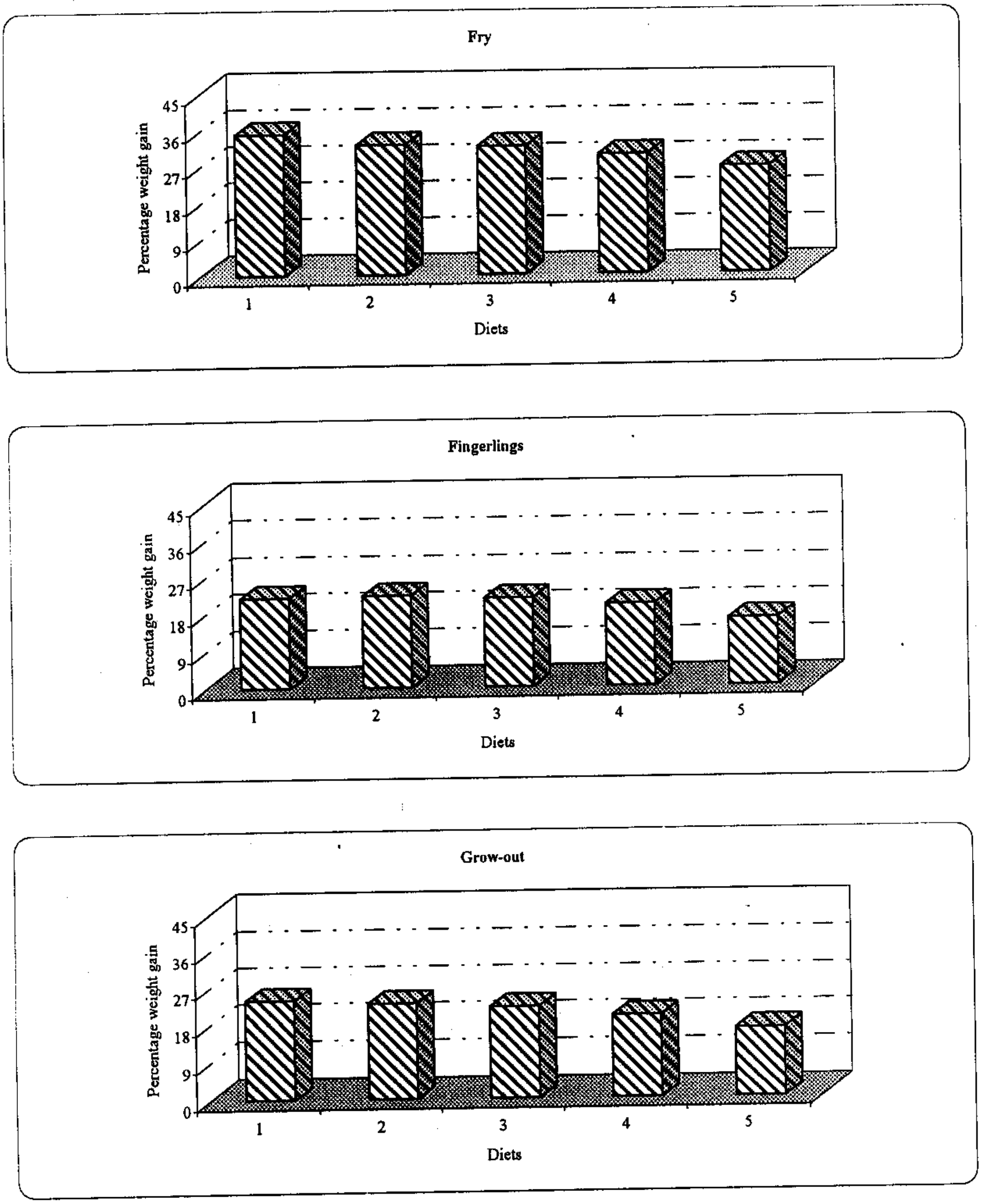



**Fig. (2) : Percentage weight gain (PWG) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

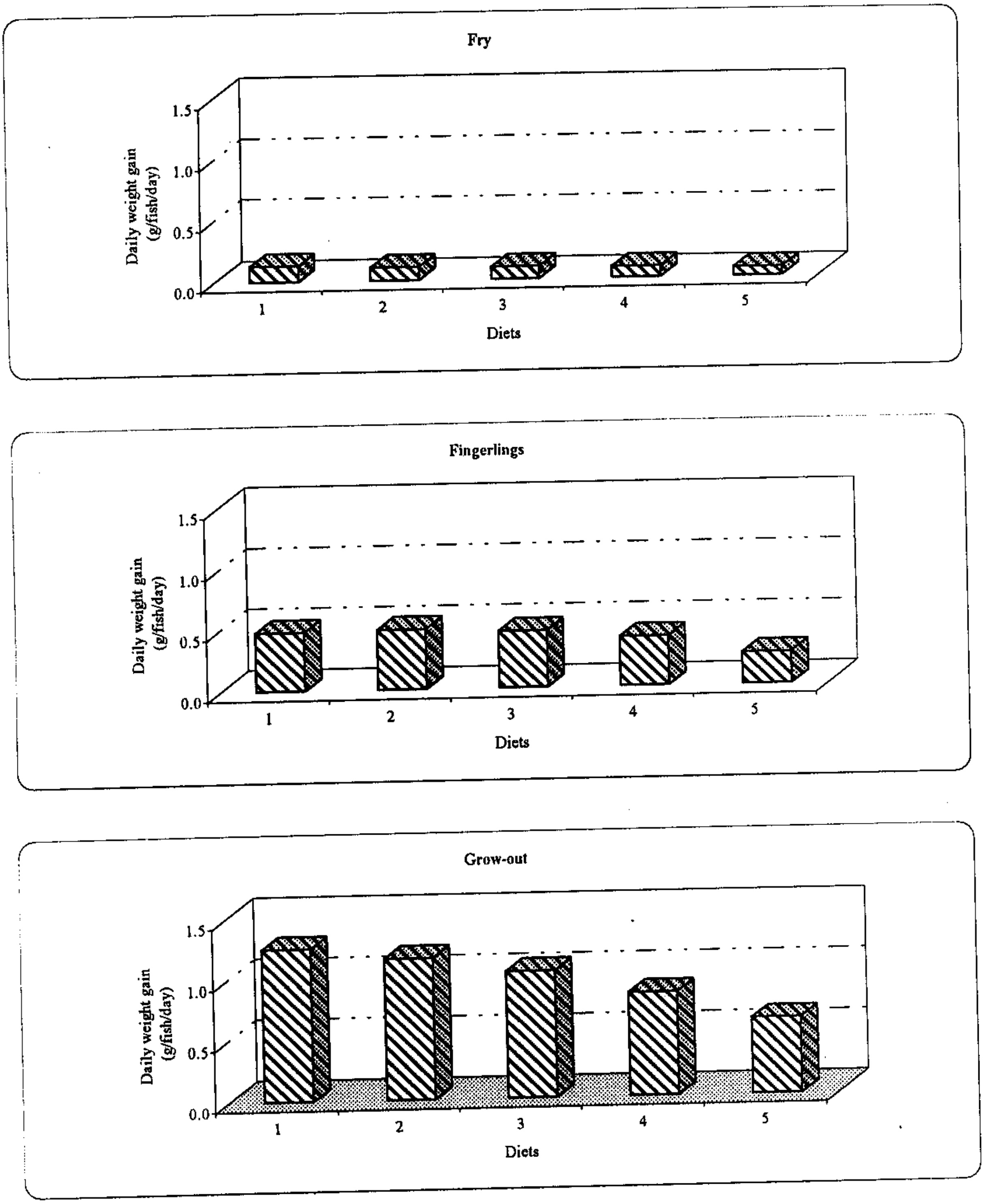



**Fig. (3): Daily weight gain (g/fish/day) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

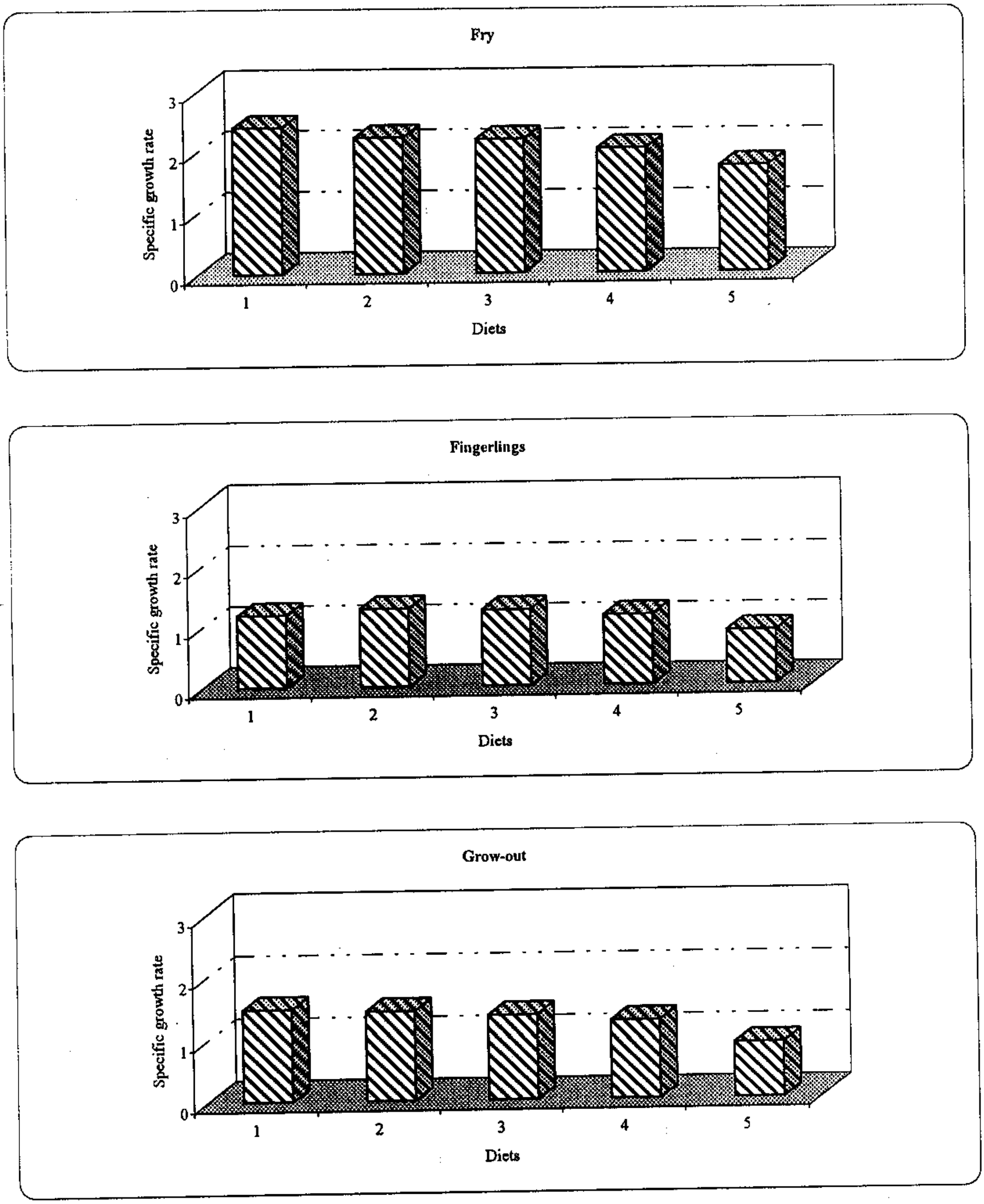



**Fig. (4) : Specific growth rate (SGR) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

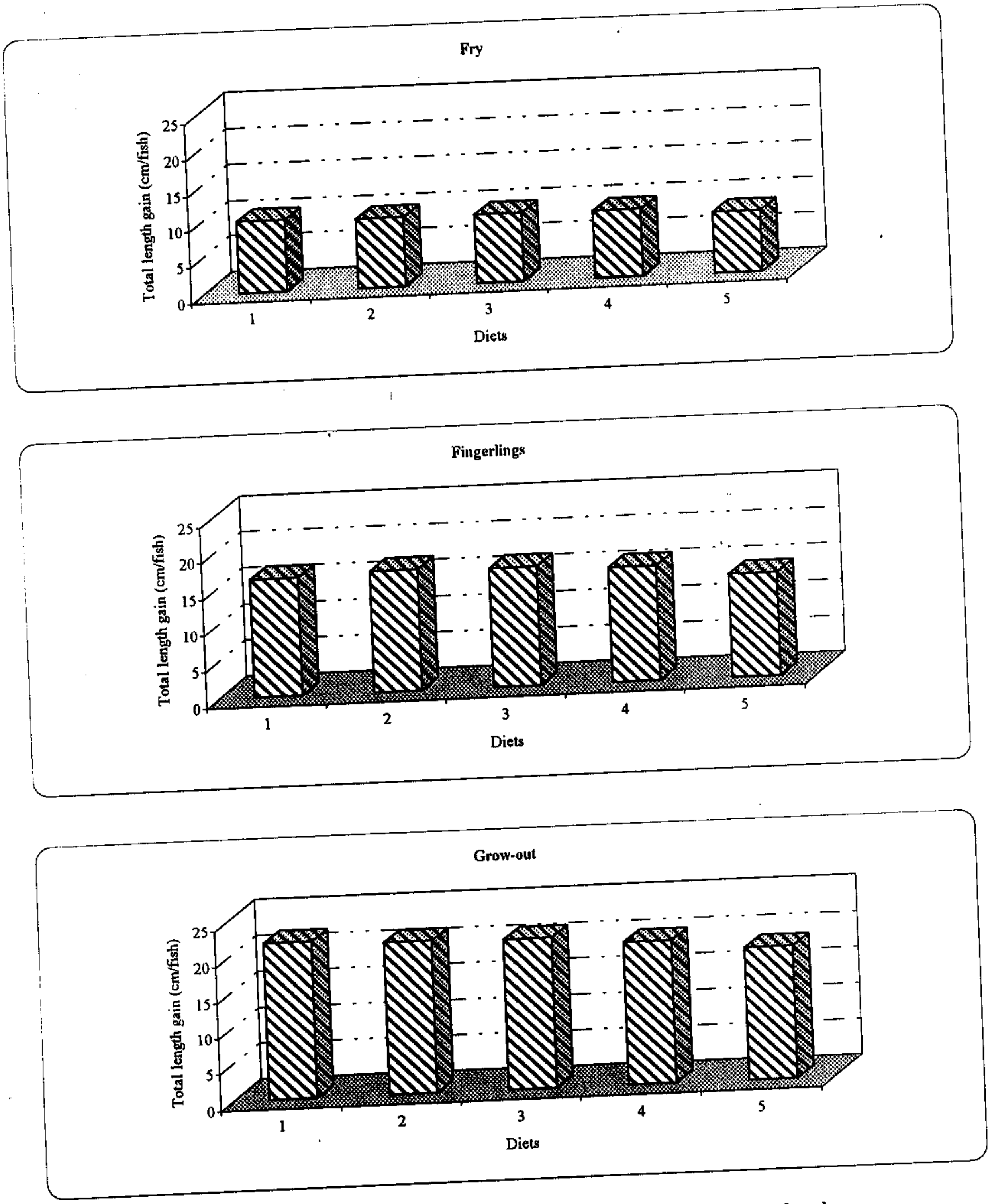



**Fig. (5) : Total length gain (TLG) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

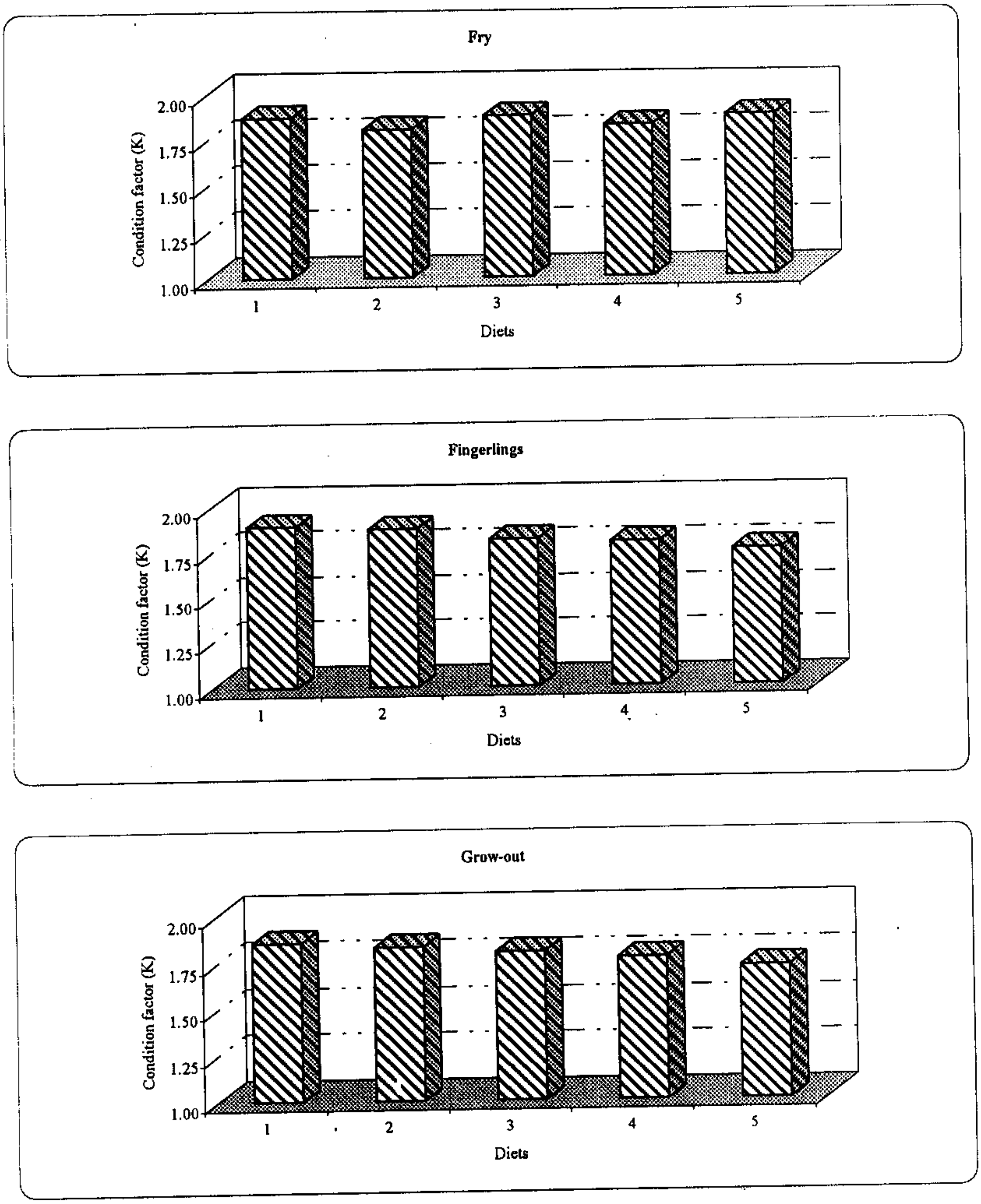



**Fig. (6) : Condition factor (K) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks.**

Recorded values of PER for fry fed diets 2 and 3 (2.57 & 2.55 respectively), were the highest among all treatments except for the control group which showed the maximum PER (2.79) (Table 20 & Fig. 8). Variations between PER for fry fed diets 2 & 3 and the CTR group were proved to be insignificant.

Generally, further increases in FFS inclusions within the diets led to insignificant decreases in both PER (2.55, 2.38 & 2.13) and DFI (0.18, 0.16 & 0.14), but at the same time increases in FCR (1.71, 1.79 & 2.12) for fry fed diets 3, 4 & 5 respectively (Table 20 & Figs. 7, 8 & 9).

Protein productive value (PPV) of *O. niloticus* fry decreased slightly with the increase of the FFS inclusion within the test diets. Differences among PPV values of each diet were insignificant ($p>0.05$), according to t-test, when compared with the CTR group. The highest value (8.36) was recorded for fry fed diet 2 followed by diet 3 (8.1), which were insignificant when compared with the CTR group (Table 20 & Fig. 10). On the other hand, the least value (6.47) was recorded for fry fed diet 5 (100% FFS).

Fat retention was highest for fry fed diet 3 (20.71), while its values were lower for fry fed the other test diets, but all recorded FR values were insignificantly different as compared with the corresponding for the control fish (Table 20 & Fig. 11).

Energy retention was maximum for fry fed diet 2 (15.28), but were lower for fry fed the other diets. No significant ER effect appeared for *O. niloticus* fry fed the test diets (Table 20 & Fig. 12).

**Table (20) : Nutritional parameters of *O. niloticus* fry fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 1.52 | 1.66 | 1.71 | 1.79 | 2.12 |
| Protein efficiency ratio | (PER) | 2.79 | 2.57 | 2.55 | 2.38 | 2.13 |
| Daily feed intake | (g/fish/day) | 0.22 | 0.19 | 0.18 | 0.16 | 0.14 |
| Protein productive value | | 8.80 | 8.36 | 8.10 | 7.74 | 6.47 |
| Fat retention | | 16.71 | 16.07 | 20.71 | 16.43 | 14.30 |
| Energy retention | | 10.28 | 15.28 | 10.22 | 9.55 | 8.09 |

FM = Fish meal.
FFS = Fermented fish silage.

### 1-2-2. *O. niloticus* fingerlings :

The lowest FCR value (2.04) was sustained for fingerlings fed test diets 2 and 3. Further increase in FFS inclusion levels led to increases in FCR values. The highest records (2.52 & 2.83) were revealed for fingerlings fed diets 4 & 5 respectively. These values were tested to be significantly different ($p<0.05$) as compared with the corresponding CTR group (Table 21 & Fig. 7).

Protein efficiency ratio (PER) values were highest for fingerlings fed diets 2 followed by diet 3. Further increase in FFS inclusion level led to lower PER. The lowest values (1.44 & 1.31) were shown for fingerlings fed diets 4 & 5 respectively, indicating thus significant differences ($p < 0.05$) as compared with the CTR group (Table 21 & Fig. 8).

Feed conversion ratio (FCR), protein efficiency ratio (PER) and Daily feed intake (DFI) revealed similar trend of variation each in turn as mentioned before for *O. niloticus* fry and summarized in table (21) and graphically represented in Figs. (7, 8 & 9).

Maximum PPV were obtained for fingerlings fed diets 2 and 3 without significant effect as compared with the control group (Table 21 & Fig. 10).

The maximum FR (fat retention) value was recorded for fingerlings fed diet 3 (4.75). Lower FR values were attained for fingerlings fed diets 2, 4 & 5 without significant effects compared with the corresponding control fish (Table 21 & Fig. 11).

The highest ER (Energy retention) value was recorded for fingerlings fed diet 2 (2.30), while the lowest was for fish fed diet 5 (1.07) without significant effects as compared with the control fish (Table 21 & Fig. 12).

**Table (21) : Nutritional parameters of *O. niloticus* fingerlings fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 2.08 | 2.04 | 2.04 | 2.52* | 2.83* |
| Protein efficiency ratio | (PER) | 1.75 | 1.78 | 1.75 | 1.44* | 1.31* |
| Daily feed intake | (g/fish/day) | 0.94 | 1.00 | 0.99 | 0.89 | 0.72 |
| Protein productive value | | 1.96 | 1.90 | 1.80 | 1.69 | 1.78 |
| Fat retention | | 4.31 | 3.99 | 4.75 | 3.52 | 3.02 |
| Energy retention | | 2.39 | 2.30 | 2.28 | 2.06 | 1.07 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $p < 0.05$.

**1-2-3. *O. niloticus* grow-out :**

Similary, FCR, PER, DFI and PPV of *O. niloticus* grow-out stage fed the test diets are summarized in table 22 and represented in figs. 7 to 10. The results indicated that the lowest FCR values were observed for grow-out fed diet 2 and 3, while further increase in FFS inclusions led to highest values (2.58 & 3.01 for grow-out fed diets 4 & 5 respectively). These highest values were tested to be significantly different ($p < 0.05$) from the corresponding CTR group (Table 22 & Fig. 7).

Protein efficiency ratio (PER) values exhibited lowering trend along with increases in FFS inclusion levels. The lowest value (1.33) was sustained for grow-out fed diet 5, which was significantly different ($p<0.05$) compared with the CTR group as shown in table (22) and fig. (8).

The DFI as well as PPV revealed the same trend of variation as mentioned before for *O. niloticus* fingerlings (Table 22 & Figs. 9 & 10).

Fat retention was highest for grow-out fed diet 3 (7.23) and lower values were recorded for fish fed the other diets, without significant effects as compared with the corresponding control fish (Table 22 & Fig. 11).

Energy retention was highest for fish fed diet 2 (3.55) followed by diet 3 (3.46) and lower values were for fish fed diets 4 & 5 respectively. All recorded ER values were insignificant different as compared with the corresponding control fish (Table 22 & Fig. 12).

Table (23) summarized the statistical analyses among the test diets as compared with the CTR group.

**Table (22) : Nutritional parameters of *O. niloticus* grow-out fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 1.97 | 2.05 | 2.17 | 2.58* | 3.01* |
| Protein efficiency ratio | (PER) | 1.89 | 1.83 | 1.74 | 1.58 | 1.33* |
| Daily feed intake | (g/fish/day) | 2.46 | 2.36 | 2.26 | 2.14 | 1.67 |
| Protein productive value | | 3.01 | 2.93 | 2.72 | 2.37 | 2.12 |
| Fat retention | | 6.63 | 6.23 | 7.23 | 5.08 | 5.04 |
| Energy retention | | 3.67 | 3.55 | 3.46 | 2.91 | 2.73 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

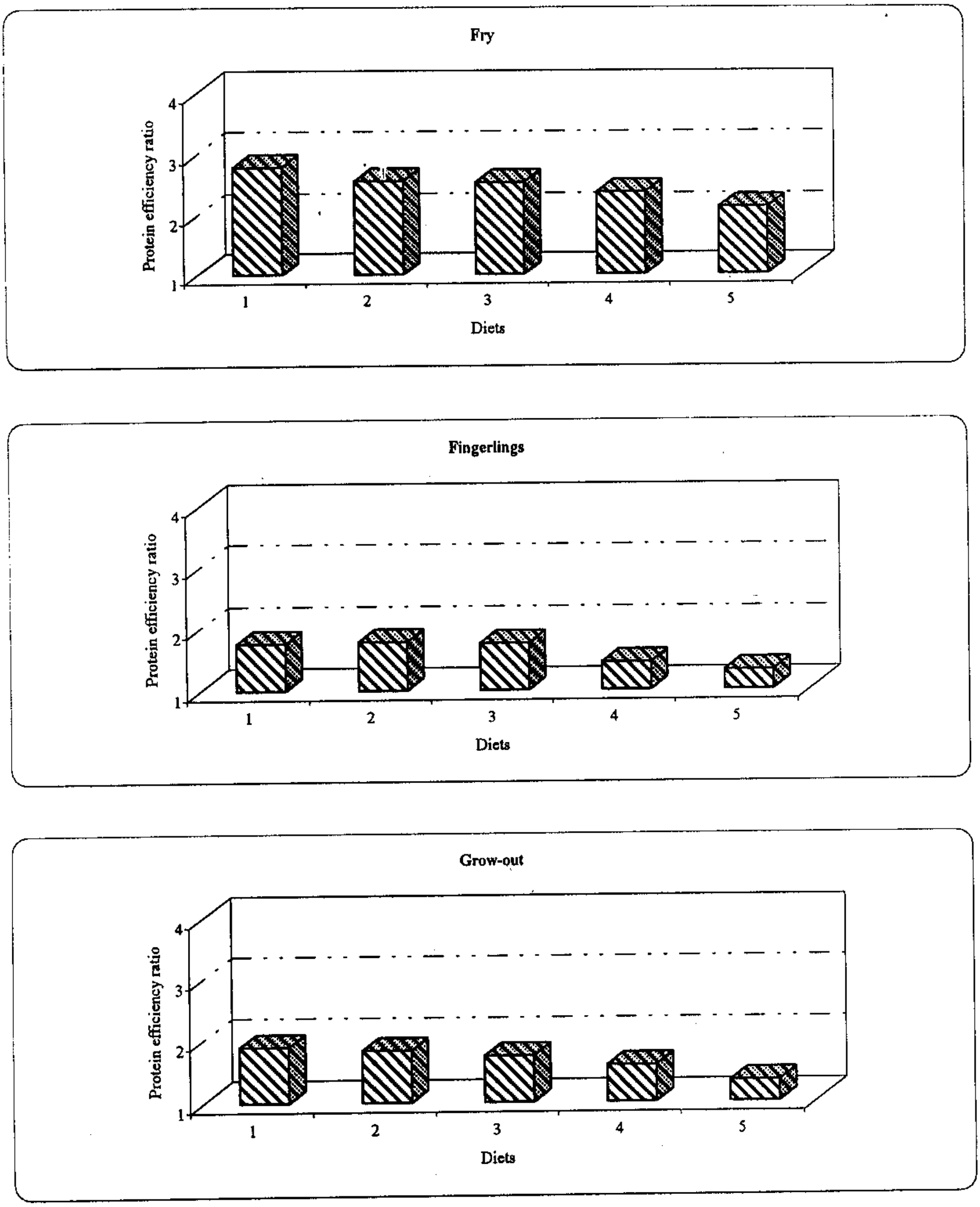



**Fig. (8) : Protein effieciency ratio (PER) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

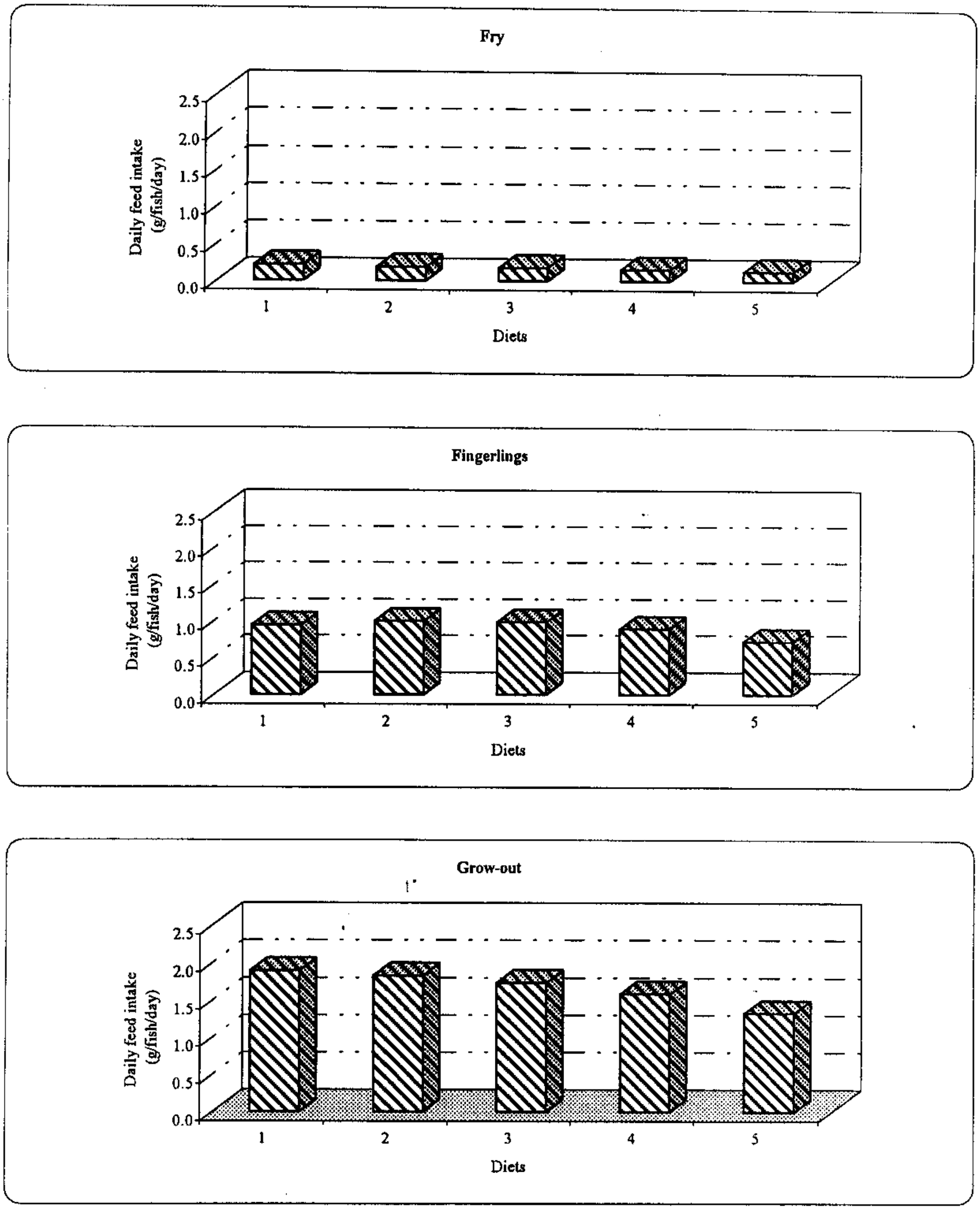



**Fig. (9): Daily feed intake (DFI g/fish/day) for different stages of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

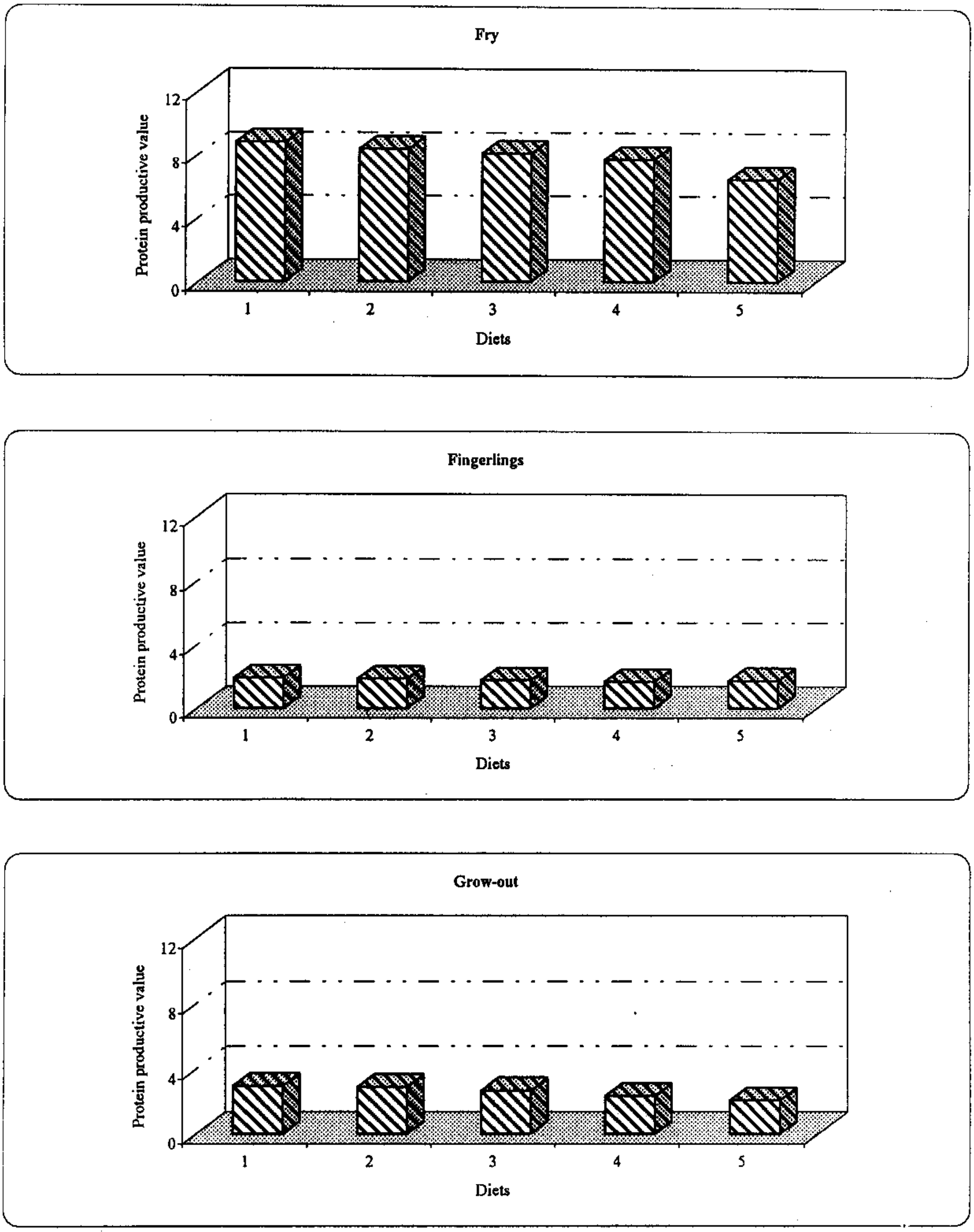



**Fig. (10) : Protein productive value (PPV) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

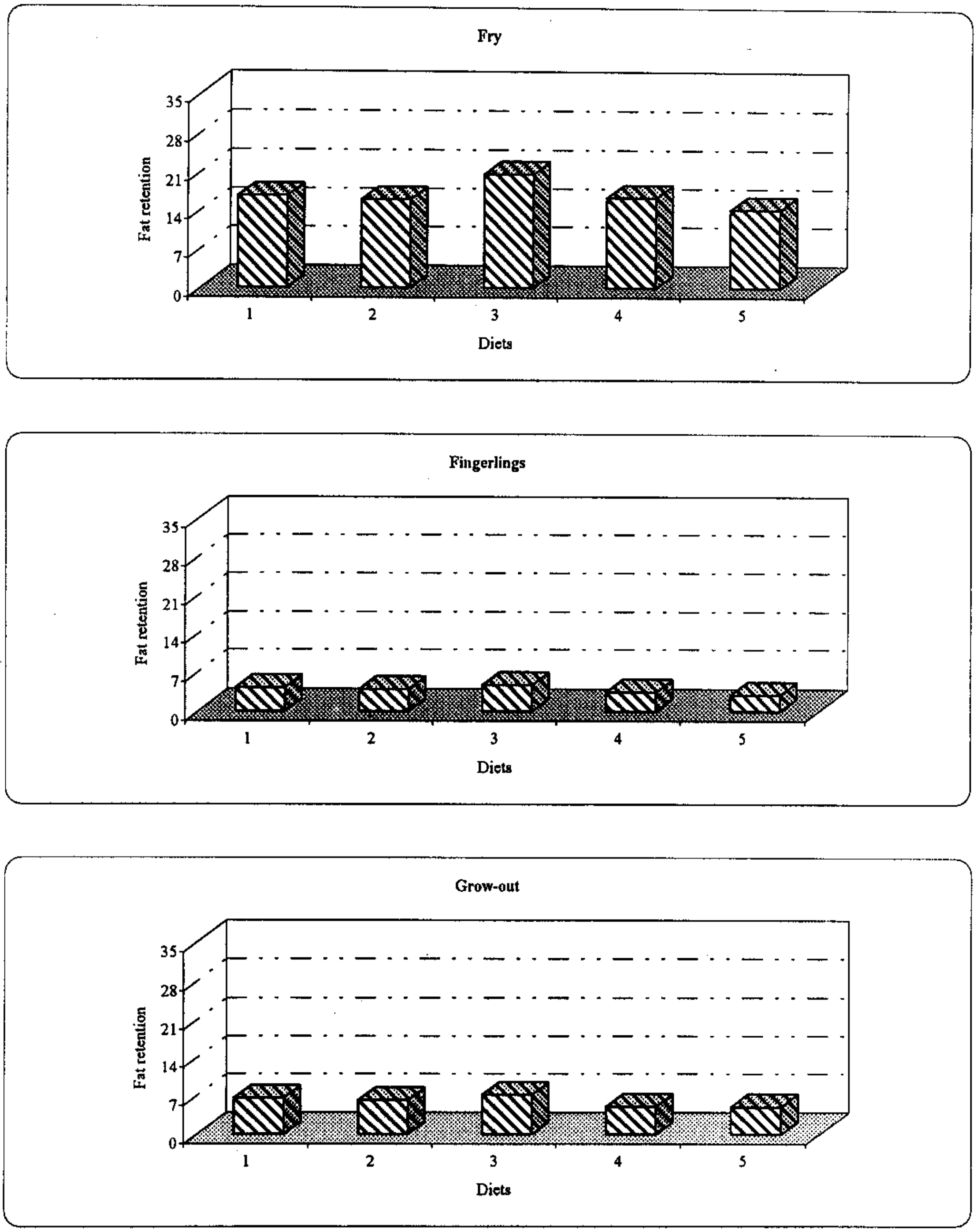



**Fig. (11) : Fat retention (FR) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

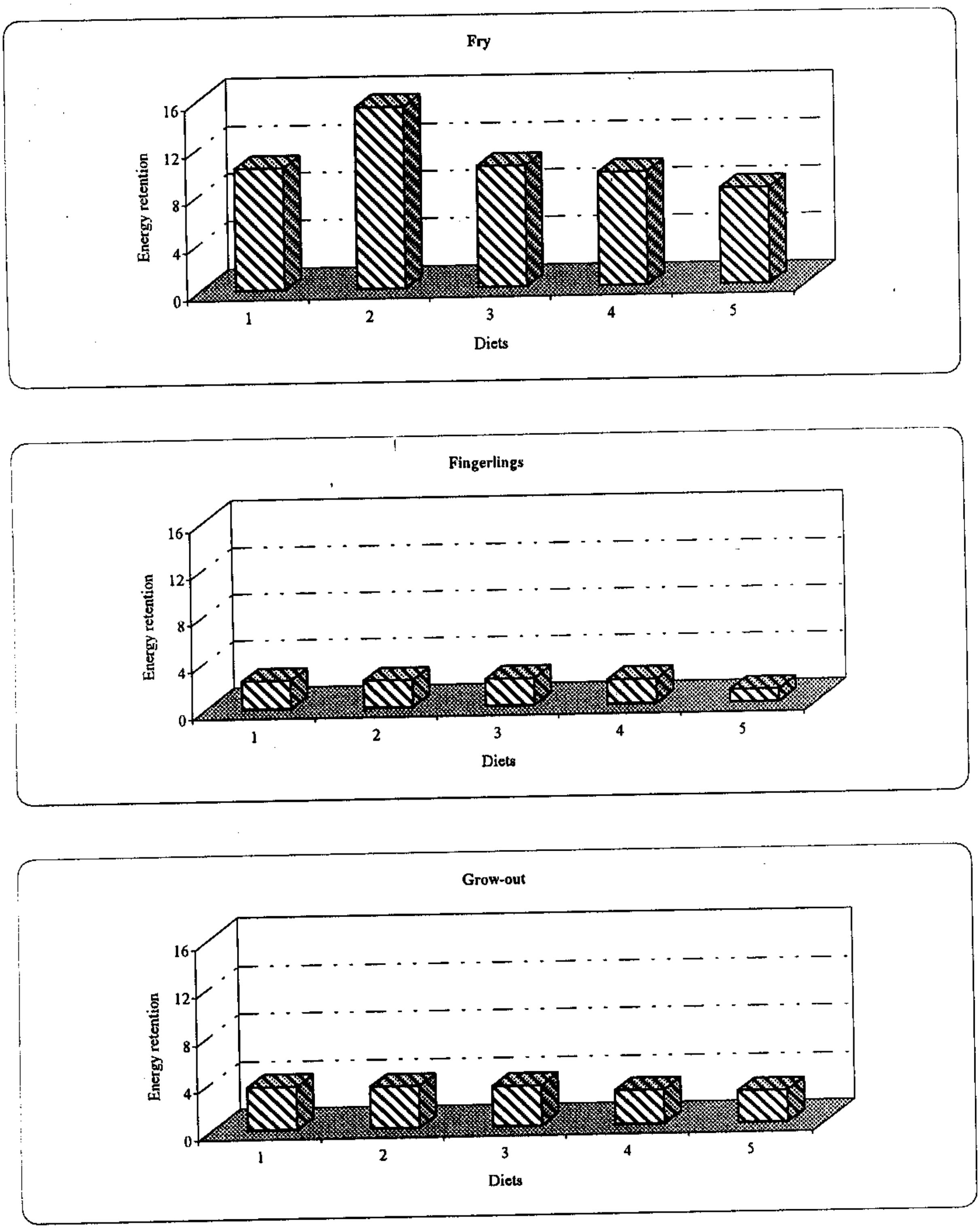



**Fig. (12): Energy retention (ER) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

### 1-3. Effect of FFS inclusion within diets on the biochemical composition of *O. niloticus* :

#### 1-3-1. *O. niloticus* fry :

Results of body composition (on dry weight basis) of *O. niloticus* fry fed the experimental diets are given in table (24). Fry fed the test diets showed a decreased trend for liver protein as well as liver glycogen along with further increase in FFS inclusion level (Figs 13 & 15). The lowest liver protein value (18.27g/100g tissue) was attained for fry fed diet 5 was significantly different ($p < 0.05$) as compared with the corresp-onding CTR group. On the other hand, the total hepatic lipids exhibited an opposite trend. Thus, the lowest value was given for fry fed diet 2, while the highest was that for fry fed diet 5. The highest value (12.3 g/ 100 g tissue) was tested to be significantly different as compared with the CTR group (Fig. 14).

Replacing FM by FFS inclusion levels had little effect on crude protein content of fry muscles fed diets 2 & 3, while protein content decreased significantly ($p < 0.05$) for fry fed diet 5 (56.17%) as compared with the corresponding for the CTR group (Table 24 & Fig. 16). On the other hand, total lipids values for fry fed diets 3, 4 & 5 were tested to be significantly different ($p < 0.05$) as compared with the control group fish fed diet 1.

As indicated from table (24), ash content values for fry fed diets 3 & 5 (18.79 & 22.00 respectively) were significantly different ($p < 0.05$) when compared with those of the CTR group. Moisture content high values (78.10 & 77.90) were recorded for fry fed diets 4 & 5 respectively with significant differences as compared with the control fish (diet 1).

**Table (24) : Liver and muscle composition of *O. niloticus* fry fed different levels of FFS-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 18.22 ± 0.79 | 20.18 ± 1.90 | 20.11 ± 1.64 | 19.84 ± 1.09 | 19.69 ± 1.10 | 18.27*± 0.94 |
| Total lipids | (g/100 g tissue) | 11.02 ± 0.90 | 10.67 ± 0.46 | 10.66 ± 0.46 | 10.98 ± 0.59 | 11.02 ± 0.71 | 12.30*± 0.86 |
| Glycogen | (g/100 g tissue) | 1.83 ± 0.07 | 2.20 ± 0.09 | 2.15 ± 0.07 | 2.12 ± 0.07 | 2.03 ± 0.06 | 1.90 ± 0.05 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 55.13 ± 2.17 | 61.90 ± 3.11 | 61.85 ± 2.98 | 61.07 ± 2.84 | 60.40 ± 2.06 | 56.17*± 2.11 |
| Total lipids | (%) | 16.16 ± 1.29 | 15.74 ± 1.27 | 16.16 ± 1.60 | 18.11*±1.92 | 18.90*± 1.68 | 18.94*± 2.01 |
| Ash | (%) | 21.34 ± 1.56 | 20.00 ± 1.42 | 19.28 ± 1.24 | 18.79*± 1.24 | 20.01 ± 1.62 | 22.00*± 1.93 |
| Moisture | (%) | 71.19 ± 3.11 | 75.10 ± 4.30 | 76.08 ± 4.02 | 76.00 ± 4.31 | 78.10*± 3.12 | 77.90*± 2.96 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 4642.12 | 4984.43 | 5021.62 | 5161.79 | 5198.65 | 4963.43 |
| Metabolizable energy | (K cal/Kg) | 3443.00 | 3669.20 | 3741.00 | 3831.00 | 3868.00 | 3706.20 |
| P/E ratio | | 118.76 | 124.19 | 123.17 | 118.31 | 116.18 | 113.17* |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

Generally, it seemed that the replacement of different levels of FFS-based diets had insignificant effect on energy content of *O. niloticus* fry as compared with the CTR fish group.

The P/E ratio values decreased along with the increase of FFS inclusion levels, the lowest value was significantly different as compared with the corresponding for the CTR group.

### 1-3-2. *O. niloticus* fingerlings :

Table (25) summarized the results of body composition of *O. niloticus* fingerlings fed the experimental diets for 18 weeks. The results of hepatic protein, lipids and glycogen exhibited the same trend of variation described for *O. niloticus* fry. Hepatic protein showed insignificant changes for fingerlings fed diets 2 & 3, while those fed diets 4 & 5 recorded significantly ($p < 0.05$) lower values (21.25 & 20.90 g/100 g tissue respectively) as compared with the corresponding for diet 1 (Fig. 13).

This was in contrast with the results of hepatic lipids, since the highest value (10.61g/100g tissue) was attained for fingerlings fed diet 5 which was tested to be significantly different as compared with that of the control fish (Fig. 14)

As shown in table (25) & fig. (15), glycogen content were insignificantly changed for fingerlings fed diets 2 & 3, but dropped to 2.66 & 2.49g/100g tissue for fish diets 4 & 5 exhibiting, thus, significant differences ($p<0.05$) as compared with the CTR fish.

**Table (25) : Liver and muscle composition of *O. niloticus* fingerlings fed different levels of FFS-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 19.91 ± 1.52 | 22.90 ± 2.14 | 22.90 ± 2.16 | 21.79 ± 1.82 | 21.25*±1.56 | 20.90*±1.61 |
| Total lipids | (g/100 g tissue) | 10.82 ± 0.50 | 9.59 ± 0.36 | 9.48 ± 0.42 | 9.80 ± 0.43 | 9.83 ± 0.44 | 10.61*± 0.50 |
| Glycogen | (g/100 g tissue) | 2.21 ± 0.10 | 2.86 ± 0.28 | 2.90 ± 0.29 | 2.72 ± 0.21 | 2.66*± 0.17 | 2.49*± 0.10 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 58.10 ± 3.71 | 64.26 ± 4.93 | 64.28 ± 4.66 | 63.47 ± 4.16 | 62.44 ± 3.92 | 60.07*± 3.78 |
| Total lipids | (%) | 23.05 ± 2.50 | 19.82 ± 2.17 | 19.66 ± 1.99 | 20.38 ± 2.45 | 20.60 ± 2.91 | 22.00*± 2.17 |
| Ash | (%) | 16.06 ± 1.92 | 14.36 ± 1.39 | 15.00 ± 1.76 | 15.00 ± 1.64 | 16.02*± 1.89 | 16.32*± 1.98 |
| Moisture | (%) | 76.62 ± 4.17 | 78.18 ± 5.84 | 75.91 ± 3.81 | 76.03 ± 4.50 | 77.60 ± 5.11 | 78.10 ± 5.92 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5460.82 | 5503.60 | 5489.70 | 5511.91 | 5474.70 | 5473.00 |
| Metabolizable energy | (K cal/Kg) | 4110.00 | 4092.00 | 4080.00 | 4105.40 | 4083.00 | 4103.00 |
| P/E ratio | | 106.39 | 116.76 | 117.09 | 115.15 | 114.05 | 109.76 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

In conclusion replacement of different levels of FFS-based diet did not affect crude protein and lipids in muscles of fingerlings fed diets 2, 3 & 4 but significantly affect those fed diet 5. Thus, the lowest crude protein value (60.07%) and the highest total lipids value (22.0%) were tested to be significantly different as compared with the corresponding for CTR (Fig. 16).

On the other hand, ash content of fingerlings fed diets 4 & 5 were significantly affected by FFS inclusion levels as compared with the CTR group. While moisture content seemed insignificantly affected by further increases in FFS inclusion level (Table 25).

Generally, replacement of different levels of FFS did not affect energy content of *O. niloticus* fingerlings, as shown in table (25).

In the mean time the P/E ratio attained insignificantly lower values as compared with the control group, i.e. P/E ratio was not significantly affected by FFS inclusion level within *O. niloticus* diets.

### 1-3-3. *O. niloticus* grow-out stage :

Table (26) summarized liver metabolites, carcass composition and energy content of *O. niloticus* grow-out stage. Hepatic protein, lipids and glycogen exhibited similar trend of variation shown before fry and fingerlings stages. Thus, the lowest hepatic protein value (21.0 g/100 g tissue) attained for grow-out fed diet 5, which was significantly different as compared with that of the CTR group (Fig. 13).

Also, hepatic lipid values (8.04, 9.00 & 10.50 g/ 100 g tissue) exerted for grow-up fish fed diets 3, 4 & 5 respectively were significantly different ($p<0.05$) as compared with that of the control fish. Similarly, glycogen values for grow-out fish fed diets 3, 4 & 5 were significantly variable as compared with those of the CRT group (Table 26 and Figs. 14 & 15).

Muscle protein value showed significant difference for fish fed diet 5 only as compared with CTR group (Fig 16). While total lipid values for grow-out fish fed diets 4 & 5 showed signified differences when compared with the corresponding for the CTR fish.

Ash content values of grow-out fish fed different levels of FFS (diets 2 to 5) were significantly different ($p<0.05$) when compared with that of the control fish fed diet 1 (Table 26).

Moisture content was highest for fish fed diet 2 (79.01%) as well as diet 5 (79.9%), but the latter value was significantly varied when compared with the corresponding value for the CTR fish.

In the mean time energy content values of grow-out fish fed different levels of FFS diets were insignificantly affected as compared with the control fish.

Despite of the apparent decreasing trend of P/E ratio values noted with further increase of FFS inclusion levels within the diets, values were insignificantly different as compared with those for the CTR fish.

Statistical analyses of body composition for different growth stages of *O. niloticus* fed different levels of FFS as compared with the CTR group are illustrated in tables (27 & 28).

**Table (26) : Liver and muscle composition of *O. niloticus* grow-out fed different levels of FFS-based diets for 18 weeks.**

| Items | | Initial | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 18.71 ± 1.12 | 24.27 ± 2.55 | 24.31 ± 2.62 | 23.38 ± 2.11 | 22.72 ± 1.92 | 21.00*± 1.81 |
| Total lipids | (g/100 g tissue) | 11.71 ± 0.94 | 7.66 ± 0.39 | 7.60 ± 0.41 | 8.04*± 0.60 | 9.00*± 0.63 | 10.50*± 0.96 |
| Glycogen | (g/100 g tissue) | 1.86 ± 0.09 | 4.10 ± 0.38 | 4.15 ± 0.41 | 3.69*± 0.22 | 3.16*± 0.18 | 2.55*± 0.16 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 53.17 ± 2.51 | 65.07 ± 4.99 | 65.18 ± 5.11 | 64.06 ± 4.23 | 63.83 ± 4.19 | 60.78*± 3.19 |
| Total lipids | (%) | 22.32 ± 2.17 | 20.09 ± 1.42 | 20.24 ± 1.39 | 20.85 ± 1.68 | 21.57*± 2.00 | 23.12*± 2.92 |
| Ash | (%) | 16.98 ± 1.16 | 13.07 ± 0.92 | 14.01*± 1.08 | 14.31*± 1.16 | 14.36*± 1.09 | 15.64*± 1.13 |
| Moisture | (%) | 78.01 ± 6.14 | 78.17 ± 5.13 | 79.01 ± 5.98 | 77.05 ± 5.12 | 75.10 ± 4.71 | 79.90*± 6.20 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5113.4 | 5575.00 | 5595.70 | 5589.63 | 5644.67 | 5618.84 |
| Metabolizable energy | (K cal/Kg) | 3859.60 | 4144.90 | 4161.20 | 4166.00 | 4214.60 | 4219.60 |
| P/E ratio | | 103.98 | 116.72 | 116.48 | 114.61 | 113.08 | 108.17 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (27) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of liver metabolites for fish fed different levels of fermented fish silage (FFS).**

| Different stages | Test diets | Hepatic Protein (HP) | Hepatic Lipid (HL) | Hepatic Glycogen (HG) |
|---|---|---|---|---|
| | | t-c | t-c | t-c |
| Fry | D2 | 0.084 | 0.046 | 1.316 |
| | D3 | 0.466 | -1.243 | 2.105 |
| | D4 | 0.670 | -1.241 | 4.715 |
| | D5 | 2.703* | -5.014* | 8.742 |
| Fingerlings | D2 | 0.000 | 0.597 | -0.298* |
| | D3 | 1.185 | -1.123 | 1.200 |
| | D4 | 1.869* | -1.266 | 1.832* |
| | D5 | 2.240* | -4.967* | 3.733* |
| Grow-out | D2 | -0.033 | 0.318 | -0.268 |
| | D3 | 0.807 | -1.593* | 2.801* |
| | D4 | 1.457 | -5.426* | 6.707* |
| | D5 | 3.137* | -8.222* | 11.278* |

* Significant at levels $P<0.05$.

**Table (28) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of growth performance for fish fed different levels of fermented fish silage (FFS).**

| Different stages | Test diets | Crude Protein (CP%) | Total Lipids (TL) | Ash Content (AC) | Moisture | Gross Energy (GE) | Metabolizable Energy (ME) | P/E ration |
|---|---|---|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.037 | -0.650 | 1.208 | -0.526 | -0.150 | -0.268 | -0.270 |
| | D3 | 0.623 | -3.256* | 2.030* | -0.467 | -0.691 | -0.603 | -0.842 |
| | D4 | 1.272 | -4.745* | -0.015 | -1.786* | -0.956 | -0.648 | -1.244 |
| | D5 | 4.821* | -4.256* | -2.640* | -1.696* | 0.095 | -0.109 | -1.682* |
| Fingerlings | D2 | -0.009 | 0.172 | -0.902 | 1.029 | 0.047 | 0.038 | 0.064 |
| | D3 | 0.387 | -0.541 | -0.941 | 0.922 | -0.027 | -0.044 | -0.311 |
| | D4 | 0.914 | -0.679 | -2.237* | 0.236 | 0.088 | 0.027 | -0.555 |
| | D5 | 2.133* | -2.246* | -2.562* | 0.030 | 0.087 | -0.032 | -4.449 |
| Grow-out | D2 | -0.049 | -0.239 | -2.095* | -0.337 | -0.062 | -0.081 | -0.068 |
| | D3 | 0.488 | -1.093 | -2.649* | 0.489 | -0.048 | -0.100 | -0.771 |
| | D4 | 0.602 | -1.908* | -2.860* | 1.394 | -0.327 | -0.343 | -1.255 |
| | D5 | 2.291* | -2.951* | -5.577* | -0.680 | -0.129 | -0.360 | -3.519* |

* Significant at levels P<0.05.

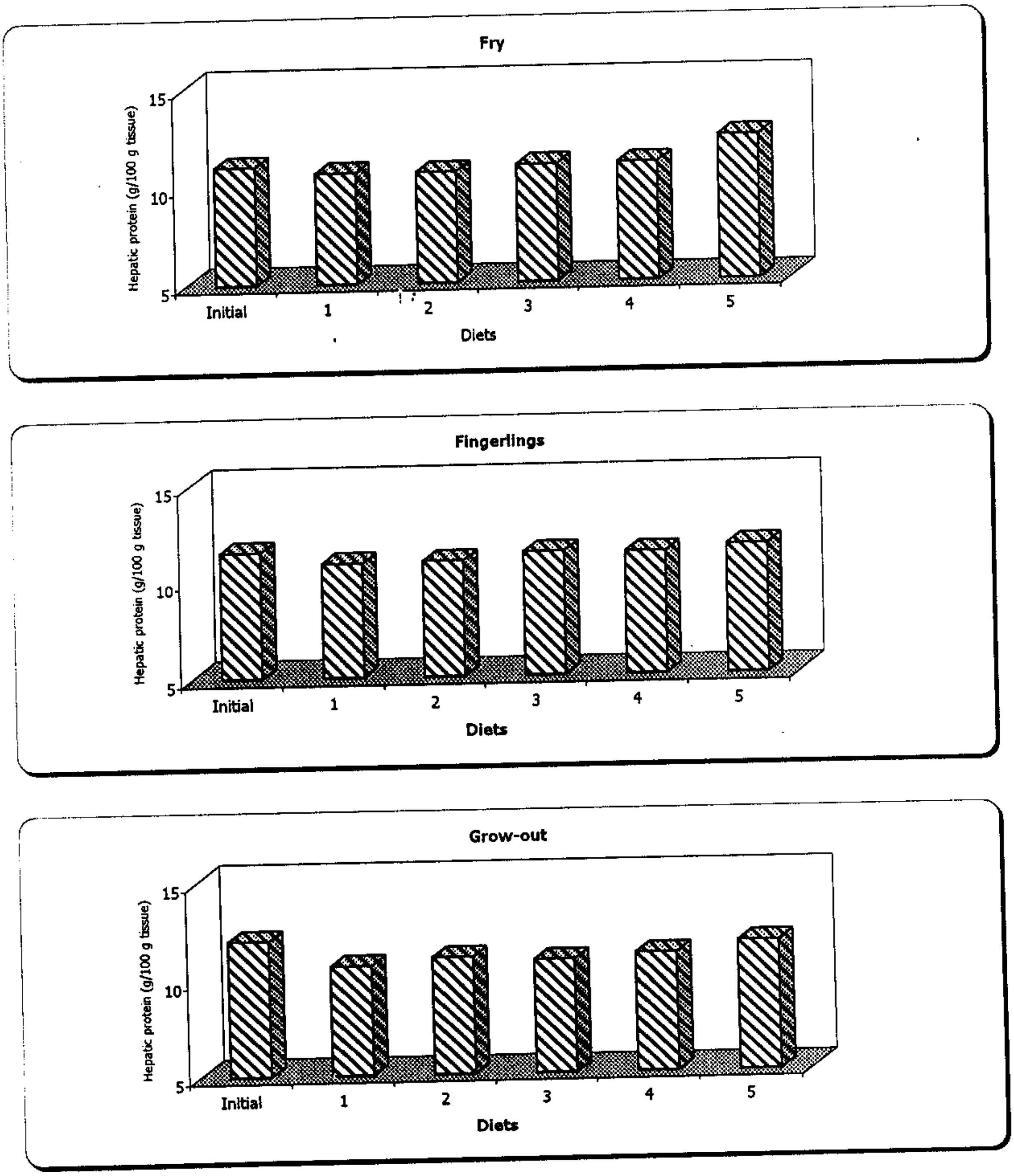



**Fig. (13): Hepatic protein (g/100 g tissue) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

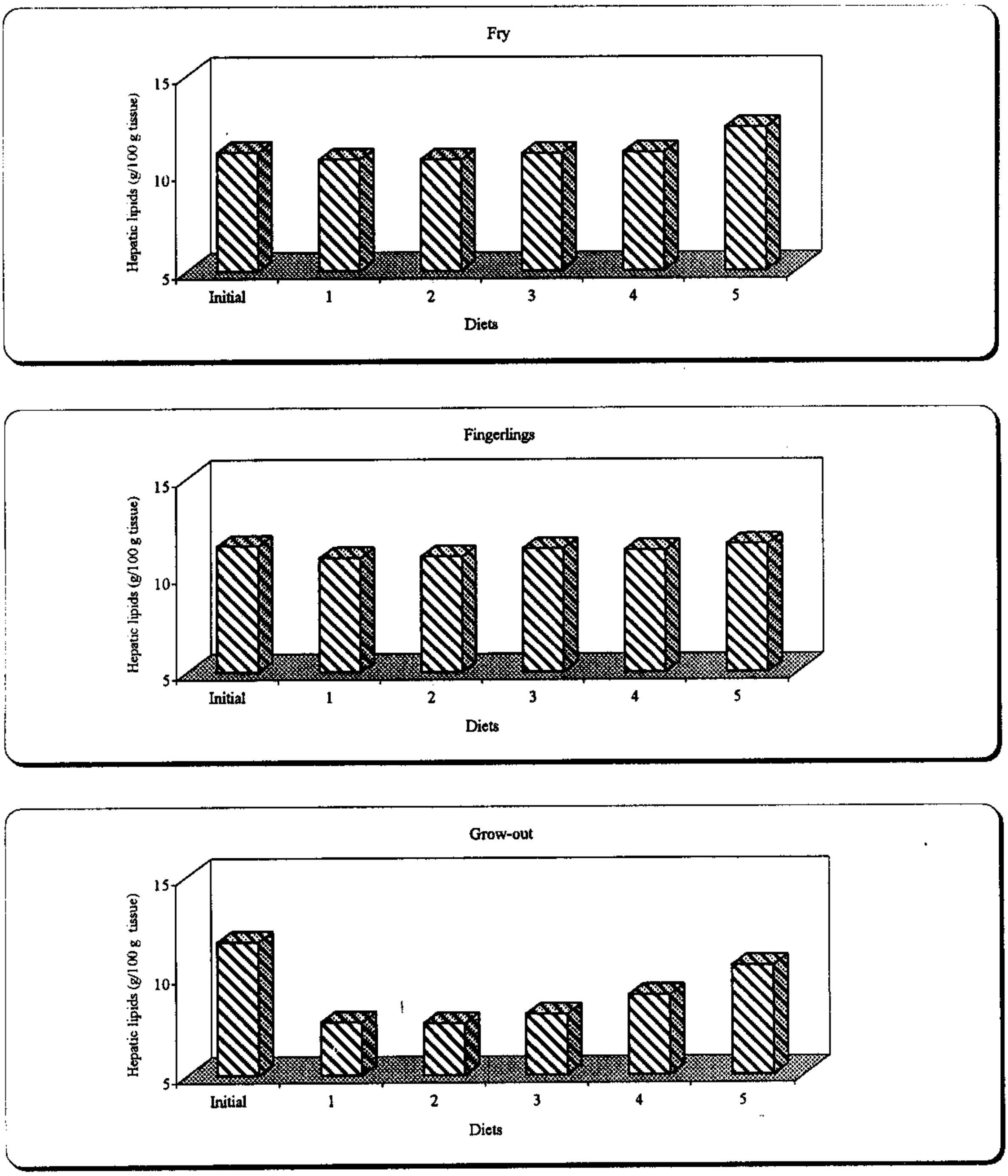



**Fig. (14): Hepatic lipids (g/100 g tissue) of *O. niloticus fed different levels* of fermented fish silage (FFS) for 18 weeks**

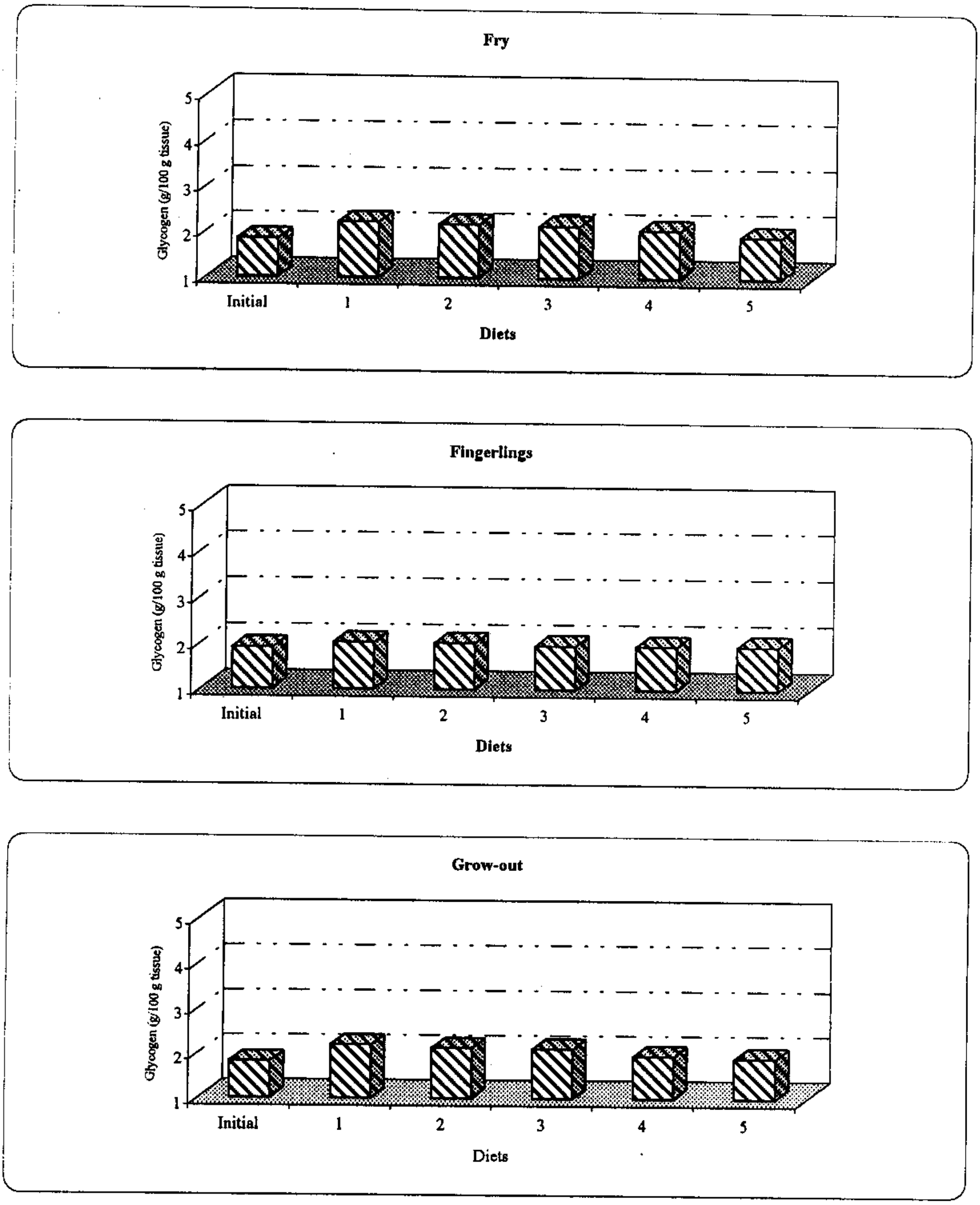



**Fig. (15) : Hepatic Glycogen (g/100 g tissue) of *O. niloticus* fed different levels of fermented fish silage (FFS) for 18 weeks**

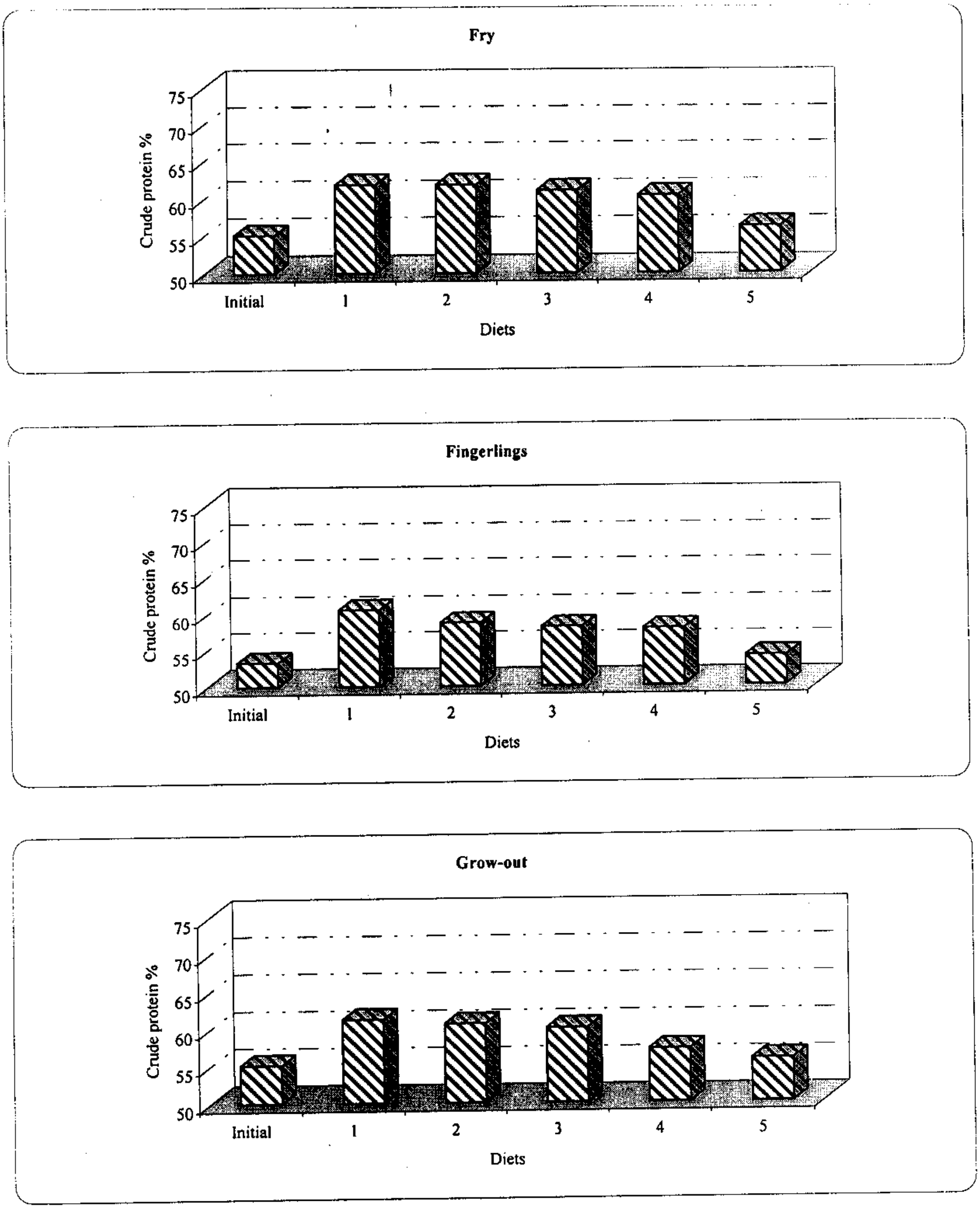



**Fig. (16): Crude protein content of *O. niloticus* fed different levels of fermented fish silage (FFS) diets for 18 weeks.**

## 1-4. Effect of fermented fish silage (FFS) inclusion within diets on *O. niloticus* biological characteristics :

### 1-4-1. *O. niloticus* fry :

At the end of feeding trials, hepatosomatic indices (H.S.I) showed significant differences for fry fed diets 4 & 5 as compared with those of the control fish. Whereas, values of gastrosomatic indices (Ga.S.I.) and gonadosomatic indices (G.S.I.) showed insignificant differences as compared with the control fish.

Fry fed diet 5 attained filling indices (F.I.) significant value as compared with the control fish, while all condition of fish flesh (C.F.F) values significantly varied for fry fed all test diets (from 2 to 5), as compared with those of the CTR fish as shown in table (29) and figs (17, 18 & 19).

### 1-4-2. *O. niloticus* fingerlings :

Likewise, the biological parameters measured for fingerlings fed the test diets are summarized in table (30) and illustrated in figs (17, 18 & 19).

Values of H.S.I. for fish fed diets 3, 4 & 5 were significantly different as compared with the CTR fish. The Ga.S.I. lowest value (7.15) attained for fish fed diet 5, was the only significant value when compared with that of control fish fed diet 1.

As for G.S.I., F.I. and C.F.F. values for fish fed all tested diet levels, were insignificantly different as compared with those of the corresponding fed diet 1.

### 1-4-3. *O. niloticus* grow-out :

Table (31) and figs. (17, 18 & 19) showed that fish fed diets 4 & 5 had H.S.I. values significantly different as compared with the corresponding for CTR fish, while grow-out fed diet 4 had Ga.S.I. values significantly different from the control fish.

Fish fed diet 5 had G.S.I. and F.I. values significantly different from that of the corresponding for CTR fish. Filling indices (F.I.) values were tested to be insignificantly different for fish fed all tested diets (2-5) as compared with the CTR fish. They were all lower than those of the control fish (Figs. 18 & 19).

Results of statistical analyses of the biological parameters for all stages fed the different FFS diets are summarized in table (32).

**Table (29) : Biological parameters of *O. niloticus* fry fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 9.96 ± 2.01 | 9.70 ± 1.96 | 9.59 ± 1.73 | 9.51 ± 1.78 | 8.60 ± 1.37 |
| Total weight (T. wt.) | (g) | 18.80 ± 5.06 | 15.58 ± 5.00 | 15.00 ± 4.46 | 13.00 ± 4.00 | 10.33 ± 3.79 |
| Gutted weight (G. wt.) | (g) | 15.31 ± 1.97 | 13.11 ± 1.39 | 12.39 ± 1.42 | 10.83 ± 1.09 | 8.58 ± 0.96 |
| Hepatosomatic index (H.S.I.) | (g) | 1.81 ± 0.26 | 1.81 ± 0.25 | 1.83 ± 0.26 | 1.54* ± 0.20 | 1.34* ± 0.13 |
| Gastrosomatic index (Ga.S.I.) | | 8.16 ± 2.03 | 8.23 ± 2.39 | 7.59 ± 2.06 | 7.13 ± 1.93 | 7.2 ± 1.82 |
| Gonadosomatic index (G.S.I.) | | 1.39 ± 0.96 | 1.42 ± 1.03 | 1.39 ± 0.86 | 1.31 ± 0.76 | 1.18 ± 0.81 |
| Filling index (F.I.) | | 2.16 ± 1.09 | 1.94 ± 1.11 | 1.92 ± 1.01 | 1.61 ± 0.87 | 1.05* ± 0.39 |
| Condition of fish flesh (C.F.F.) | | 1.55 ± 0.12 | 1.44* ± 0.11 | 1.40* ± 0.09 | 1.26* ± 0.08 | 1.35* ± 0.11 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (30) : Biological parameters of *O. niloticus* fingerlings fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 16.29 ± 4.69 | 16.71 ± 4.64 | 16.47 ± 5.01 | 15.84 ± 4.14 | 14.31 ± 3.32 |
| Total weight (T. wt.) | (g) | 77.00 ± 10.24 | 78.95 ± 10.36 | 75.00 ± 10.16 | 66.09 ± 9.17 | 47.78 ± 7.98 |
| Gutted weight (G. wt.) | (g) | 62.65 ± 6.78 | 64.34 ± 7.30 | 62.76 ± 7.02 | 56.95 ± 5.29 | 40.17 ± 5.13 |
| Hepatosomatic index (H.S.I.) | (g) | 1.94 ± 0.26 | 1.92 ± 0.25 | 1.76* ± 0.19 | 1.64* ± 0.19 | 1.42* ± 0.16 |
| Gastrosomatic index (Ga.S.I.) | | 9.32 ± 2.29 | 8.99 ± 2.12 | 8.67 ± 2.01 | 8.04 ± 1.82 | 7.15* ± 1.46 |
| Gonadosomatic index (G.S.I.) | | 1.42 ± 0.79 | 1.48 ± 0.82 | 1.24 ± 0.64 | 1.33 ± 0.56 | 1.16 ± 0.62 |
| Filling index (F.I.) | | 1.98 ± 0.80 | 1.94 ± 0.73 | 1.86 ± 0.68 | 1.61 ± 0.62 | 1.56 ± 0.53 |
| Condition of fish flesh (C.F.F.) | | 1.45 ± 0.20 | 1.38 ± 0.21 | 1.40 ± 0.22 | 1.43 ± 0.23 | 1.37 ± 0.12 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (31) : Biological parameters of *O. niloticus* grow-out fed different levels of FFS-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 21.85 ± 5.66 | 21.30 ± 5.09 | 20.96 ± 4.92 | 19.92 ± 4.83 | 18.51 ± 4.61 |
| Total weight (T. wt.) | (g) | 197.30 ± 26.23 | 184.80 ± 24.37 | 168.62 ± 26.17 | 143.20 ± 23.48 | 112.30 ± 21.37 |
| Gutted weight (G. wt.) | (g) | 167.40 ± 20.19 | 157.64 ± 18.86 | 139.54 ± 19.65 | 116.95 ± 15.11 | 89.68 ± 10.91 |
| Hepatosomatic index (H.S.I.) | (g) | 1.98 ± 0.26 | 1.96 ± 0.27 | 1.90 ± 0.22 | 1.76* ± 0.16 | 1.26* ± 0.06 |
| Gastrosomatic index (Ga.S.I.) | | 9.10 ± 2.08 | 8.96 ± 1.81 | 8.46 ± 1.72 | 7.79* ± 1.53 | 8.01 ± 1.59 |
| Gonadosomatic index (G.S.I.) | | 1.50 ± 0.41 | 1.50 ± 0.50 | 1.36 ± 0.36 | 1.40 ± 0.42 | 1.20* ± 0.31 |
| Filling index (F.I.) | | 2.14 ± 0.99 | 2.10 ± 1.07 | 1.89 ± 0.87 | 1.85 ± 0.79 | 1.71 ± 0.80 |
| Condition of fish flesh (C.F.F.) | | 1.60 ± 0.22 | 1.63 ± 0.26 | 1.52 ± 0.19 | 1.48 ± 0.18 | 1.41* ± 0.17 |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (32) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of biological condition for fish fed different levels of boiled soybean meal (BSM).**

| Different stages | Test diets | Hepatosomatic index (HIS) | Gonadosomatic index (GSI) | Gastrosomatic index (GaSI) | Filling index (FI) | Condition of fish flesh |
|---|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.000 | -0.064 | -0.067 | 0.424 | 2.027 |
| | D3 | -0.163 | 0.000 | 0.591 | 0.485 | 3.000* |
| | D4 | 2.469* | 0.196 | 1.103 | 1.183 | 6.032* |
| | D5 | 4.851* | 0.502 | 1.056 | 2.876* | 3.686* |
| Fingerlings | D2 | 0.166 | -0.158 | 0.317 | 0.111 | 0.724 |
| | D3 | 1.677* | 0.531 | 0.640 | 0.343 | 0.505 |
| | D4 | 2.795* | 0.279 | 1.313 | 1.097 | 0.197 |
| | D5 | 5.110* | 0.777 | 2.397* | 1.313 | 1.029 |
| Grow-out | D2 | 0.160 | 0.000 | 0.152 | 0.082 | -0.264 |
| | D3 | 0.705 | 0.770 | 0.711 | 0.569 | 0.826 |
| | D4 | 2.162* | 0.511 | 1.522* | 0.687 | 1.266 |
| | D5 | 8.095* | 1.751* | 1.249 | 1.013 | 2.050* |

* Significant at levels $P<0.05$.

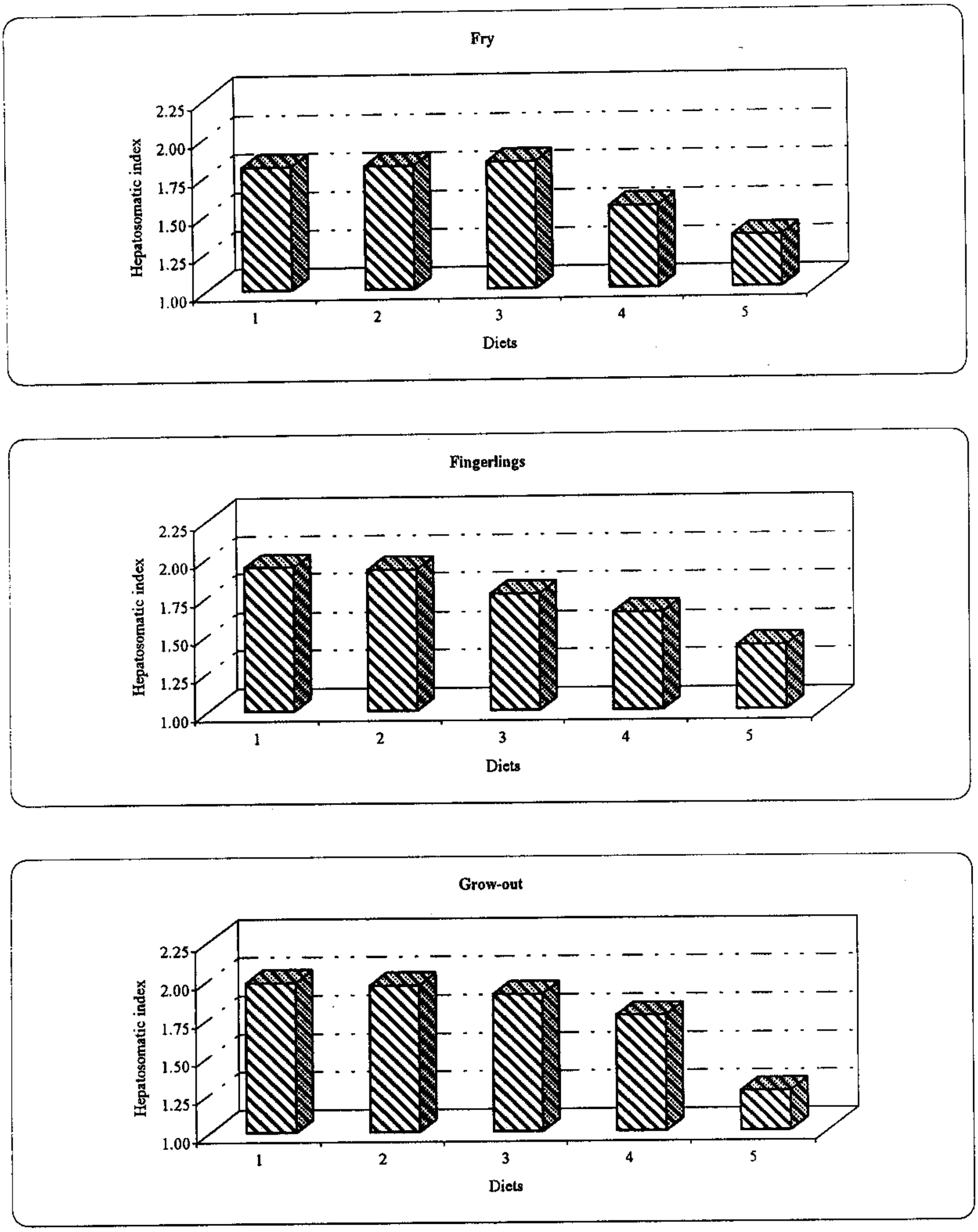



**Fig. (17): Hepatosomatic index (H.S.I) of *O. niloticus* fed different levels of fermented fish silage (FFS) diets for 18 weeks**

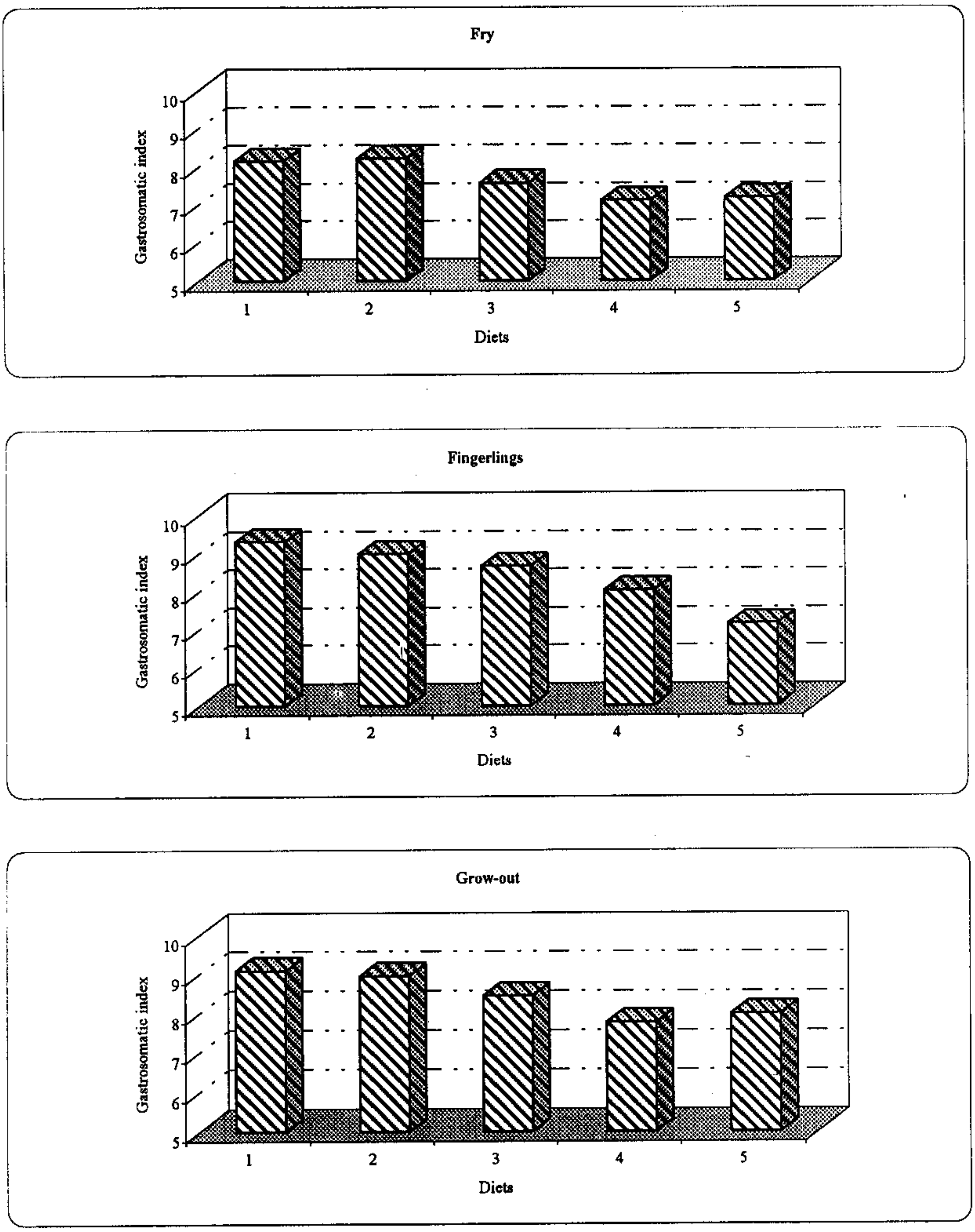



**Fig. (18): Gastrosomatic index (G.S.I) of *O. niloticus* fed different levels of fermented fish silage (FFS) diets for 18 weeks**

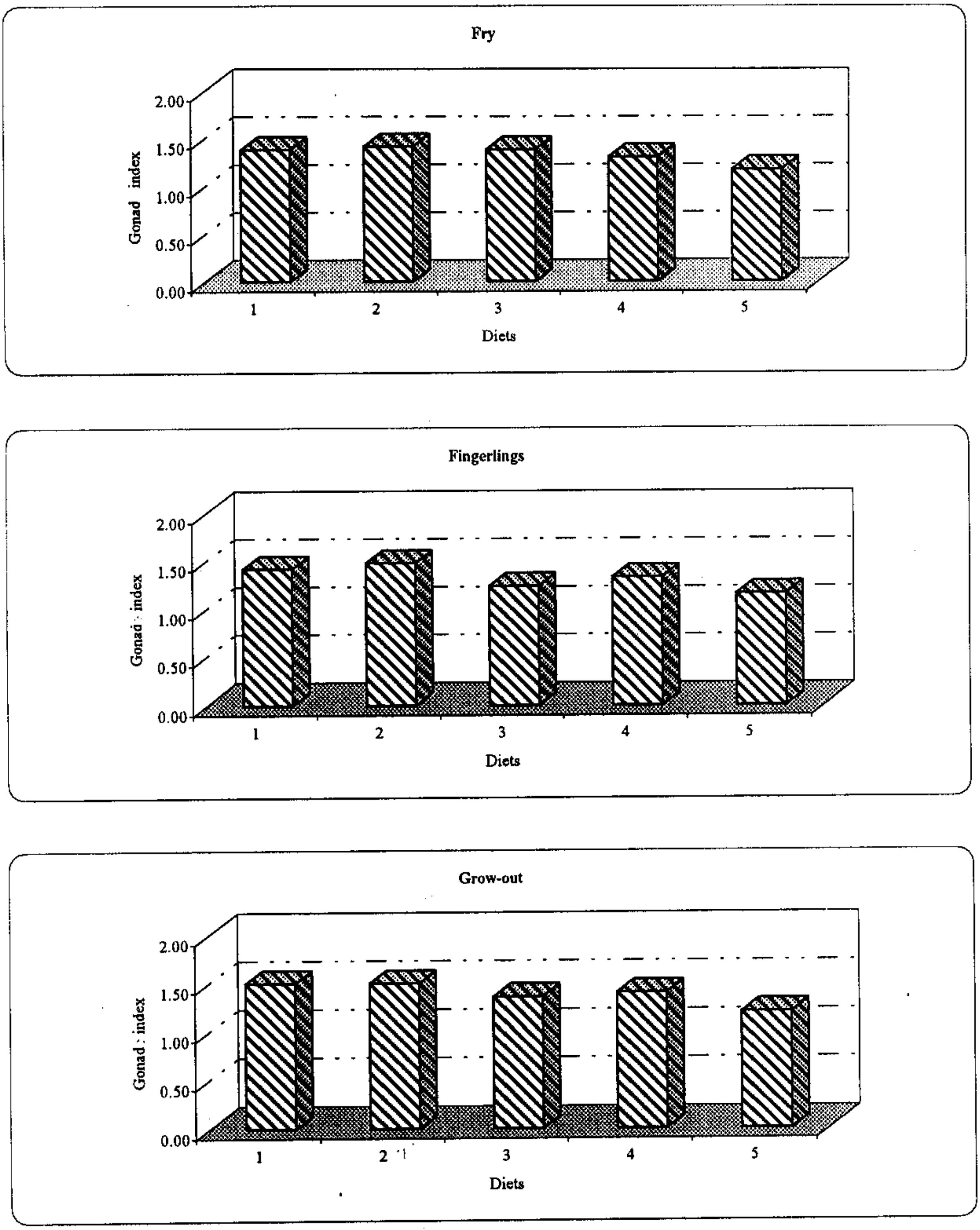



**Fig. (19) : Gonad index (G.I) of *O. niloticus* fed different levels of fermented fish silage (FFS) diets for 18 weeks**

# CHAPTER III

## Experiment 2 :

### 2. Effect of using boiled soybean meal (BSM) as a fish meal (FM) replacer in *O. niloticus* diets :

**Objective :**

Determination of optimum inclusion level of BSM as a FM replacer within *O. niloticus* diets fed to fry, fingerlings and grow-out stages.

#### 2-1. Effect of BSM inclusion on growth performance of *O. niloticus :*

##### 2-1-1. *O. niloticus* fry :

The mean final weights at biweekly intervals as well as total weight gain (TWG) for *O. niloticus* fry fed the test diets are illustrated in table (33) and graphically represented in fig. (20). The results indicated that, at the level of 25% BSM inclusion (diet 2), the total weight gain (TWG) reached a maximum value (15.7 g), followed by diet 3 (13.4g). Further increase in BSM inclusion level within the diets has led to a decrease in total weight gain (13.4, 10.4, & 9.16 g for fry fed diets 3, 4 & 5 respectively). According to t-test all the values of TWG were tested to be insignificantly different compared with the corresponding value for the control fish.

Similar trend was attained for the percentage weight gain (PWG) as shown in table (34) and fig. (21). Thus, the maximum value (38.39) was sustained for fry fed diet 2 followed by diet 3 (33.09). These values were tested to be insignificantly different compared with the value of the control group (diet 1). Further increase in BSM inclusion level within the diets has led to further decreases in PWG (30.43 & 28.67 for fry fed diets 4 & 5 respectively). These lowest values were tested to be significantly different ($p<0.05$) compared with the CTR fish.

The maximum DWG (0.12 g/fish/day) was also indicated for fry fed diet 2 followed by diet 3 (0.10 g/fish/day). Further increase in BSM inclusion levels within the diets has resulted into decreases in DWG values (Table 34 & Fig. 22). All the sustained DWG values for fry fed diets 2, 3, 4 & 5 were shown to be insignificantly different compared with the control fish.

Therefore, inclusion of BSM up to 50% did not significantly affect growth in weight of *O. niloticus* fry.

The highest specific growth rates (SGR) were achieved for fry fed diet 2 (2.33) followed by diet 3 (2.12). The SGR values decreased by further increase in BSM inclusion level attaining lowest values (1.84 & 1.73 for fry fed diets 4 & 5 respectively) which were tested to be significantly different ($p<0.05$) as compared with the CTR group (Table 34 & Fig. 23).

As shown in table (34) and illustrated in fig. (24), the total length gain (TLG) attained highest values (9.63 & 9.45 cm/ fish) for fry fed diets 2 & 3 respectively. Lowest values were sustained for fry fed diets 4 & 5. All the TLG values were tested to be insignificantly different compared with the CTR fish.

**Table (33) : Total weight gain (g) of *O. niloticus* fry fed different levels of BSM-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | $0.84 \pm 0.06$ | $0.84 \pm 0.06$ | $0.84 \pm 0.07$ | $0.84 \pm 0.06$ | $0.84 \pm 0.09$ |
| 2 | $1.08^{a} \pm 0.10$ | $1.08^{a} \pm 0.10$ | $1.06^{a} \pm 0.09$ | $0.98^{b} \pm 0.09$ | $0.95^{b} \pm 0.41$ |
| 4 | $1.43^{a} \pm 0.32$ | $1.43^{a} \pm 0.33$ | $1.37^{b} \pm 0.32$ | $1.30^{b} \pm 0.29$ | $1.25^{c} \pm 0.59$ |
| 6 | $2.26^{a} \pm 0.51$ | $2.18^{b} \pm 0.46$ | $2.05^{c} \pm 0.50$ | $1.80^{d} \pm 0.36$ | $1.70^{e} \pm 0.63$ |
| 8 | $3.70^{a} \pm 0.62$ | $3.40^{b} \pm 0.53$ | $3.28^{c} \pm 0.56$ | $2.70^{d} \pm 0.54$ | $2.50^{e} \pm 0.96$ |
| 10 | $6.17^{a} \pm 0.93$ | $6.04^{b} \pm 0.90$ | $5.20^{c} \pm 0.86$ | $3.76^{d} \pm 0.64$ | $3.50^{e} \pm 0.98$ |
| 12 | $8.50^{b} \pm 1.17$ | $8.46^{b} \pm 1.12$ | $8.80^{a} \pm 1.36$ | $6.91^{c} \pm 0.97$ | $6.55^{d} \pm 1.34$ |
| 14 | $11.33^{a} \pm 2.08$ | $11.02^{b} \pm 2.08$ | $10.00^{c} \pm 2.01$ | $8.40^{d} \pm 1.39$ | $7.60^{e} \pm 1.49$ |
| 16 | $14.50^{a} \pm 2.61$ | $13.78^{b} \pm 2.23$ | $11.50^{c} \pm 2.76$ | $9.10^{d} \pm 1.82$ | $8.10^{e} \pm 1.89$ |
| 18 (Final) | $18.10^{a} \pm 3.09$ | $16.50^{b} \pm 3.11$ | $14.20^{c} \pm 2.96$ | $11.20^{d} \pm 2.66$ | $10.00^{e} \pm 2.39$ |
| Total weight gain (g) | $17.26^{a}$ | $15.66^{b}$ | $13.36^{c}$ | $10.36^{d}$ | $9.16^{e}$ |

FM = Fish meal.
BSM = Boiled soybean meal.
SD = Standard deviation
$W_2$ = Mean weight (g)
Total weight gain = Final weight - Initial weight.
[a,b,c,d,e] Means followed by the same letters are not significantly different at levels $p<0.05$.

**Table (34) : Growth performance of *O. niloticus* fry fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| Final weight | (g/fish) | 19.10 | 16.50 | 14.20 | 11.20 | 10.00 |
| Total weight gain | (g/fish) | 17.26 | 15.66 | 13.36 | 10.36 | 9.16 |
| Percentage weight gain | (PWG) | 41.48 | 38.39 | 33.09 | 30.43* | 28.67* |
| Daily weight gain | (g/fish/day) | 0.13 | 0.12 | 0.10 | 0.08 | 0.07 |
| Specific growth rate | (SGR) | 2.27 | 2.23 | 2.12 | 1.94* | 1.73* |
| Initial length | (cm/fish) | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 |
| Total length gain | (cm/fish) | 10.20 | 9.63 | 9.45 | 8.52 | 8.55 |
| Condition factor | "K" (%) | 1.94 | 1.86 | 1.79 | 1.77 | 1.72* |

BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

Fry fed diet 2 showed the best condition factor (K), followed by diet 3 (1.86 & 1.79 respectively). The lowest "K" value (1.72) sustained for fry fed diet 5 was tested to be significantly different ($p<0.05$) compared with the corresponding control group (Table 34 & Fig. 25).

### 2-1-2. *O. niloticus* fingerlings :

Similarly, final weights at biweekly intervals as well as total weight gain (TWG) of *O. niloticus* fingerlings fed the test diets are summarized in table (35) and Figs (20) to (22). The results indicated that TWG reached a maximum (49.11g) for fingerlings fed diet 2 followed by those fed diet 3 (46.34g). The TWG values showed lowering trends along with further BSM inclusion levels attaining lowest values (37.4 & 34.26g) for fingerlings fed diets 4 & 5 respectively. All the recorded TWG values were tested to be insignificantly different as compared with the control fish.

Similar trend was observed for PWG and DWG as indicated for fry. Thus, the PWG attained highest values for fingerlings fed diet 2 followed by diet 3 (20.29 & 19.88 respectively). Such values decreased along with the increase in the BSM inclusion levels attaining lowest values for fingerlings fed diet 5 (16.47). All the PWG values were insignificantly different as compared with the CTR fish (Table 36).

Also, the DWG values were maximum for fingerlings fed diets 2 & 3 (0.36 & 0.34 g/fish/day respectively). Further increase in BSM inclusion level was accompanied by decreases in DWG values recording, thus, the lowest for fingerlings fed diet 5 (0.25 g/fish/day). All recorded DWG values were insignificantly different compared with the control fish.

The specific growth rate (SGR) sustained highest and same value for fingerlings fed both diets 1 & 2 (1.41). Lower values were observed for fingerlings fed diet 4 followed by diet 5 (1.08 & 0.99 respectively). Such values were tested to be significantly different ($p<0.05$) compared with the control fish (Fig. 23).

The total length gain (TLG) was maximum for fingerlings fed diet 2 followed by diet 3 (15.45 & 15.18 cm/ fish respectively). These values decreased along with the increases of BSM inclusion levels showing the lowest value (14.24 cm/ fish) for fingerlings fed diet 5. All the TLG values were shown to be insignificantly different compared with the CTR fish (Table 36 & Fig. 24).

Fingerlings fed diet 2 and 3 showed the best "K" factor (1.83 & 1.81 respectively), while those fed diets 4 and 5 showed the least "K" factor values (1.75 & 1.67) which were significantly different compared with the CTR fish (Table 36 & Fig. 25).

**2-1-3. *O. niloticus* grow-out stage :**

Similarly, final weights at biweekly intervals as well as total weight gain of *O. niloticus* grow-out stage fed the test diets are summarized in table (37) and graphically illustrated in figs. (20 to 22). The total weight gain (TWG) was maximum for grow-out stage fed diet 2 (107.3g). Further increase in BSM inclusion levels has led to decreases in TWG values (89.88, 83.05 & 74.87g) for grow-out fed diets 3, 4 & 5 respectively. All values were insignificantly different as compared with the control fish.

**Table (35) : Total weight gain (g) of *O. niloticus* fingerlings fed different levels of BSM-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | 11.74 ± 3.13 | 11.74 ± 3.01 | 11.74 ± 2.29 | 11.74 ± 2.87 | 11.74 ± 2.43 |
| 2 | $16.18^{a} \pm 4.22$ | $16.22^{b} \pm 4.18$ | $16.82^{a} \pm 3.65$ | $13.86^{c} \pm 3.15$ | $13.88^{d} \pm 3.00$ |
| 4 | $19.81^{b} \pm 5.32$ | $19.83^{b} \pm 5.24$ | $20.47^{a} \pm 5.31$ | $17.81^{c} \pm 4.16$ | $16.30^{d} \pm 3.86$ |
| 6 | $22.79^{a} \pm 6.08$ | $22.79^{b} \pm 5.94$ | $22.28^{b} \pm 6.20$ | $19.50^{c} \pm 5.26$ | $17.99^{d} \pm 4.18$ |
| 8 | $24.84^{a} \pm 6.89$ | $24.82^{a} \pm 6.68$ | $24.13^{b} \pm 6.83$ | $22.05^{c} \pm 5.93$ | $20.89^{d} \pm 5.31$ |
| 10 | 28.26 ± 7.33 | 28.23 ± 7.36 | 27.11 ± 7.08 | 24.45 ± 6.49 | 23.00 ± 6.14 |
| 12 | $35.03^{a} \pm 8.32$ | $34.52^{b} \pm 8.28$ | $32.14^{c} \pm 7.97$ | $27.24^{d} \pm 7.18$ | $25.90^{d} \pm 6.72$ |
| 14 | $43.50^{a} \pm 10.14$ | 41.95 ± 9.96 | 39.20 ± 9.26 | 33.60 ± 8.08 | 32.00 ± 7.21 |
| 16 | $52.67^{a} \pm 13.61$ | 51.00 ± 13.07 | $48.90^{c} \pm 10.36$ | $40.00^{d} \pm 8.96$ | $39.20^{e} \pm 7.94$ |
| 18 (Final) | $63.90^{a} \pm 16.71$ | $60.85^{b} \pm 15.83$ | $58.08^{c} \pm 13.28$ | $49.14^{d} \pm 10.12$ | $46.00^{e} \pm 8.80$ |
| Total weight gain (g) | $52.16^{a}$ | $49.11^{b}$ | $46.34^{c}$ | $37.40^{d}$ | $34.26^{e}$ |

FM = Fish meal.
BSM = Boiled soybean meal.
Total weight gain = Final weight – Initial weight.
[a,b,c,d,e] Means followed by the same letters are not significantly different at levels $p<0.05$.

SD = Standard deviation
$W_2$ = Mean weight (g)

**Table (36) : Growth performance of *O. niloticus* fingerlings fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 11.74 | 11.74 | 11.74 | 11.74 | 11.74 |
| Final weight | (g/fish) | 63.90 | 60.85 | 58.08 | 49.14 | 46.00 |
| Total weight gain | (g/fish) | 52.16 | 49.11 | 46.34 | 37.40 | 34.26 |
| Percentage weight gain | (PWG) | 20.95 | 20.29 | 19.88 | 17.36 | 16.47 |
| Daily weight gain | (g/fish/day) | 0.39 | 0.36 | 0.34 | 0.28 | 0.25 |
| Specific growth rate | (SGR) | 1.42 | 1.41 | 1.41 | 1.08* | 0.99* |
| Initial length | (cm/fish) | 8.38 | 8,38 | 8,38 | 8,38 | 8,38 |
| Total length gain | (cm/fish) | 15.31 | 15.45 | 15.18 | 14.45 | 14.25 |
| Condition factor | "K" (%) | 1.88 | 1.83 | 1.81 | 1.75* | 1.67* |

BSM = Boiled soybean meal
* Significant at levels $P<0.05$.

The percentage weight gain (PWG) was highest for grow-out fed diet 2 (20.7), but decreased with further increases in BSM inclusion levels attaining lowest value (16.97) for fish fed diet 5. Such lowest value (16.97) was tested to be significantly different ($p < 0.05$) compared with the corresponding control fish.

Similarly, the DWG recorded the maximum value for fish fed diet 2 (0.80 g/fish/day). Further increases in BSM inclusion level has led to decreased DWG values attaining the lowest value for fish fed diet 5 (0.56 g/fish/day). All the DWG records were insignificantly different as compared with the CTR fish.

The highest SGR value was achieved for fish fed diet 2 (1.33), but further increases in BSM inclusion levels resulted into further decrease in SGR values (1.19, 1.12 & 0.97 for fish fed diets 3, 4 & 5 respectively). All sustained values (from diet 2 to 5) were tested to be significantly different ($p < 0.05$) as compared with control diet 1 (Table 38 & Fig. 23).

The total length gain (TLG) values was highest for fish fed diet 2 (19.03 cm/ fish), but closely similar values were sustained for fish fed diet 3, 4 & 5 (18.55, 18.54 & 18.37 cm/ fish respectively). All the TLG values showed insignificant differences when compared with the CTR fish (Table 38 & Fig. 24).

The condition factor "K" sustained the highest value for fish fed diet 2 (1.86) with a lowering trend along with further increases in BSM inclusion levels (1.8, 1.71 & 1.66 for grow-out fed diets 3, 4 & 5 respectively). All sustained values of "K" factor were tested to be significantly different ($p < 0.05$) as compared with the CTR group (Table 38 & Fig. 25).

Statistical analyses of the results of growth performance parameters for all treatments as compared with the corresponding control group are given in table (39).

**Table (37) : Total weight gain (g) of *O. niloticus* grow-out fed different levels of BSM-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | 24.30 ± 4.91 | 24.30 ± 4.80 | 24.30 ± 4.66 | 24.30 ± 5.03 | 24.30 ± 4.81 |
| 2 | $29.80^{a} \pm 6.76$ | $29.71^{a} \pm 6.36$ | $28.90^{b} \pm 5.86$ | $27.90^{c} \pm 5.69$ | $26.85^{d} \pm 5.63$ |
| 4 | $36.70^{a} \pm 10.11$ | $36.05^{b} \pm 9.39$ | $34.00^{c} \pm 7.90$ | $33.00^{d} \pm 7.87$ | $30.70^{e} \pm 6.48$ |
| 6 | $46.00^{a} \pm 13.14$ | $45.10^{b} \pm 12.41$ | $42.90^{a} \pm 10.75$ | $40.87^{d} \pm 9.83$ | $37.10^{e} \pm 9.10$ |
| 8 | $61.50^{a} \pm 16.53$ | $56.00^{b} \pm 15.70$ | $52.13^{c} \pm 13.64$ | $50.90^{d} \pm 12.64$ | $47.00^{e} \pm 11.72$ |
| 10 | $76.00^{a} \pm 18.21$ | $69.20^{b} \pm 17.69$ | $63.70^{c} \pm 15.64$ | $60.61^{d} \pm 14.61$ | $56.46^{e} \pm 13.73$ |
| 12 | $90.00^{a} \pm 19.90$ | $82.00^{b} \pm 18.86$ | $71.17^{c} \pm 17.57$ | $67.23^{d} \pm 16.43$ | $62.18^{e} \pm 15.37$ |
| 14 | $106.00^{a} \pm 22.19$ | $96.60^{b} \pm 20.97$ | $80.23^{c} \pm 18.32$ | $75.15^{a} \pm 18.22$ | $69.35^{e} \pm 17.44$ |
| 16 | $119.00^{a} \pm 23.77$ | $108.30^{b} \pm 22.33$ | $90.41^{a} \pm 19.61$ | $84.94^{a} \pm 19.57$ | $79.24^{e} \pm 18.84$ |
| 18 (Final) | $143.10^{a} \pm 26.01$ | $131.60^{b} \pm 24.62$ | $114.11^{c} \pm 22.07$ | $107.31^{d} \pm 22.09$ | $99.17^{e} \pm 20.93$ |
| Total weight gain (g) | $118.80^{a}$ | $107.30^{b}$ | $89.88^{c}$ | $83.05^{d}$ | $74.87^{e}$ |

FM = Fish meal.
BSM = Boiled soybean meal.
Total weight gain = Final weight – Initial weight.
$^{a,b,c,d,e}$ Means followed by the same letters are not significantly different at levels $p<0.05$.

SD = Standard deviation
$W_2$ = Mean weight (g)

**Table (38) : Growth performance of *O. niloticus* grow-out fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 24.30 | 24.30 | 24.30 | 24.30 | 24.30 |
| Final weight | (g/fish) | 143.10 | 131.60 | 114.18 | 107.35 | 99.17 |
| Total weight gain | (g/fish) | 118.80 | 107.30 | 89.88 | 83.05 | 74.87 |
| Percentage weight gain | (PWG) | 21.90 | 20.70 | 18.87 | 18.07 | 16.97* |
| Daily weight gain | (g/fish/day) | 0.88 | 0.80 | 0.67 | 0.62 | 0.56 |
| Specific growth rate | (SGR) | 1.41 | 1.33* | 1.19* | 1.12* | 0.97* |
| Initial length | (cm/fish) | 10.85 | 10.85 | 10.85 | 10.85 | 10.85 |
| Total length gain | (cm/fish) | 19.34 | 19.03 | 18.55 | 18.54 | 18.37 |
| Condition factor | "K" (%) | 1.92 | 1.86* | 1.80* | 1.71* | 2.66* |

BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (39) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of growth performance for fish fed different levels of boiled soybean meals (BSM).**

| Different stages | Test diets | Total Weight Gain (TWG) | Percentage Weight Gain (PWG) | Specific Growth Rate (SGR) | Condition Factor (CF) |
|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.114 | 0.363 | 0.265 | 0.680 |
| | D3 | 0.367 | 1.063 | 0.917 | 1.021 |
| | D4 | 0.867 | 1.537* | 2.467* | 1.353 |
| | D5 | 1.064 | 1.743* | 2.917* | 1.652* |
| Fingerlings | D2 | 0.088 | 0.170 | 0.070 | 0.634 |
| | D3 | 0.240 | 0.251 | 0.066 | 1.229 |
| | D4 | 0.865 | 1.020 | 2.878* | 2.339* |
| | D5 | 1.065 | 1.417 | 3.788* | 4.208* |
| Grow-out | D2 | 0.296 | 0.500 | 2.425* | 2.563* |
| | D3 | 0.783 | 1.109 | 6.204* | 4.620* |
| | D4 | 0.986 | 1.382 | 7.252* | 6.302* |
| | D5 | 1.263 | 1.714* | 7.818* | 6.045* |

* Significant at levels $P<0.05$.

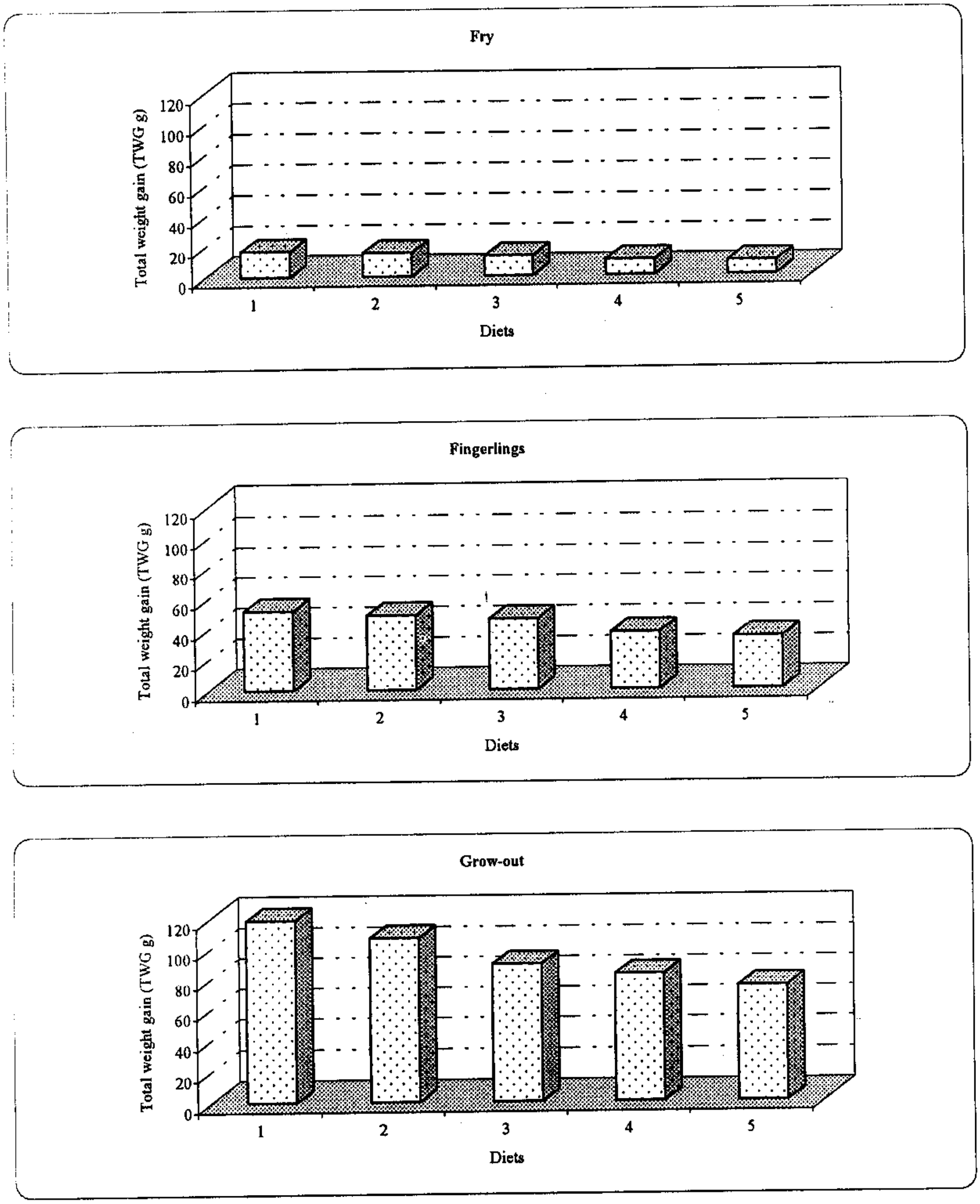



**Fig. (20): Total weight gain (TWG g) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

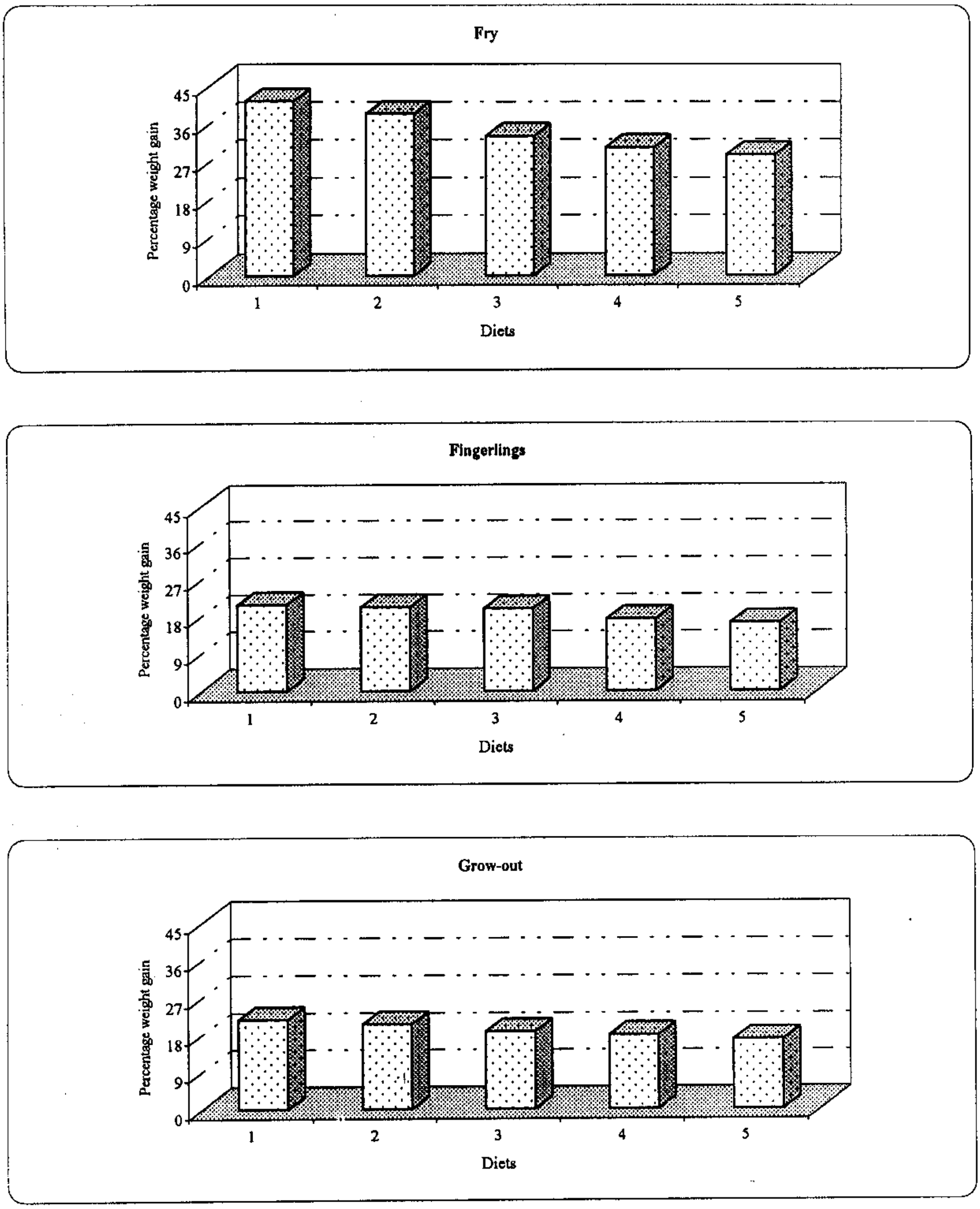



**Fig. (21) : Percentage weight gain (PWG) for *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

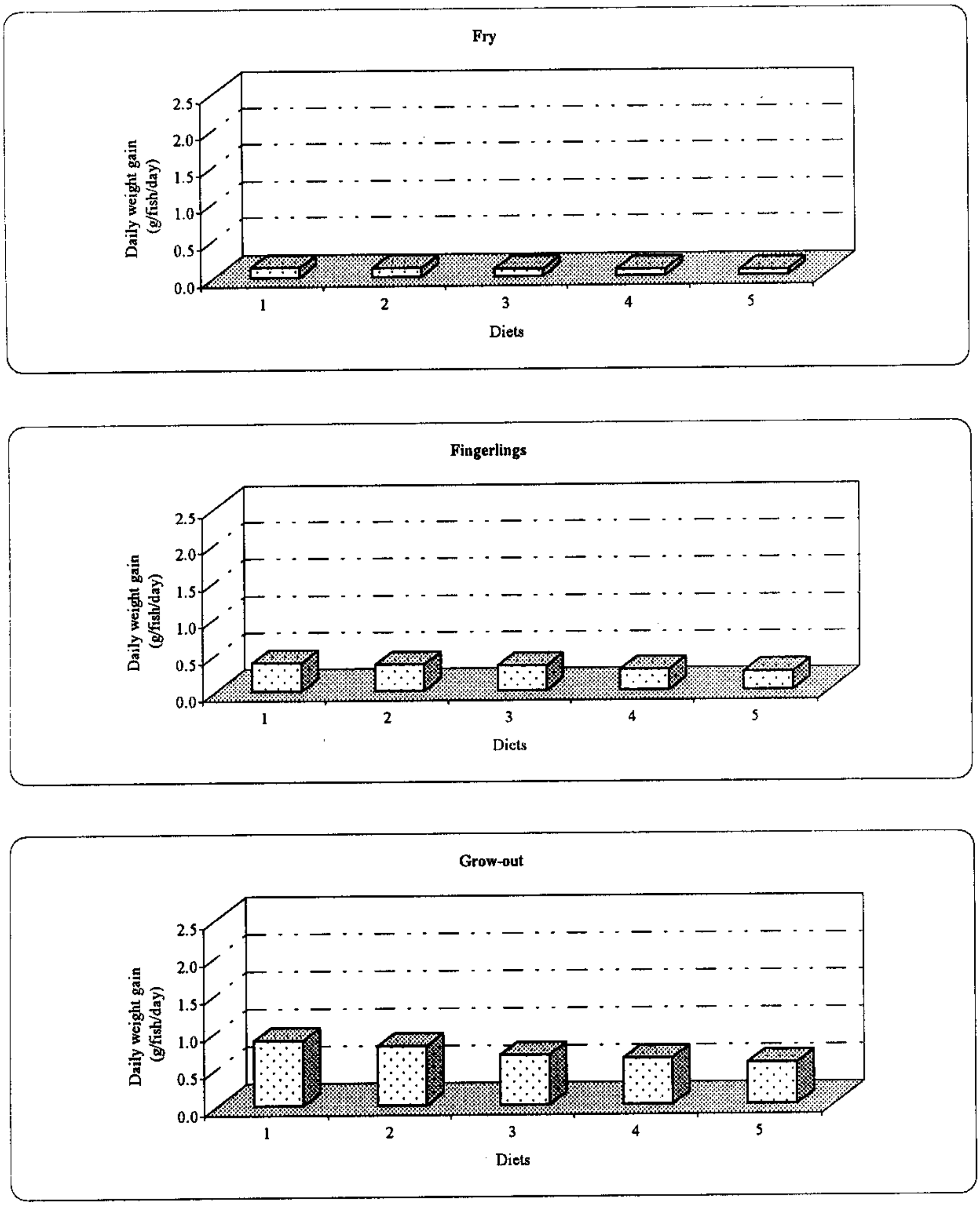



**Fig. (22): Daily weight gain (g/fish/day) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

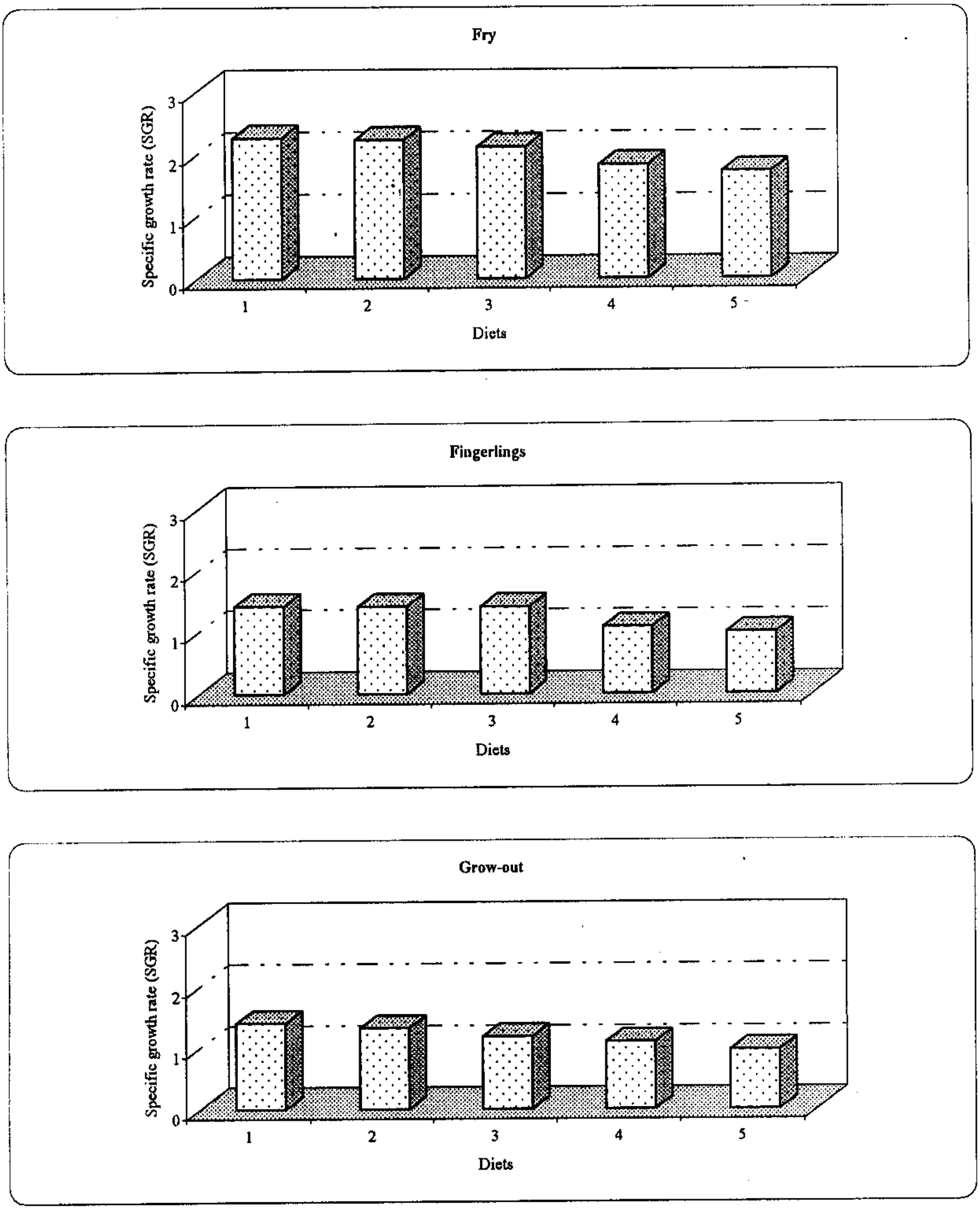



**Fig. (23) : Specific growth rate (SGR) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

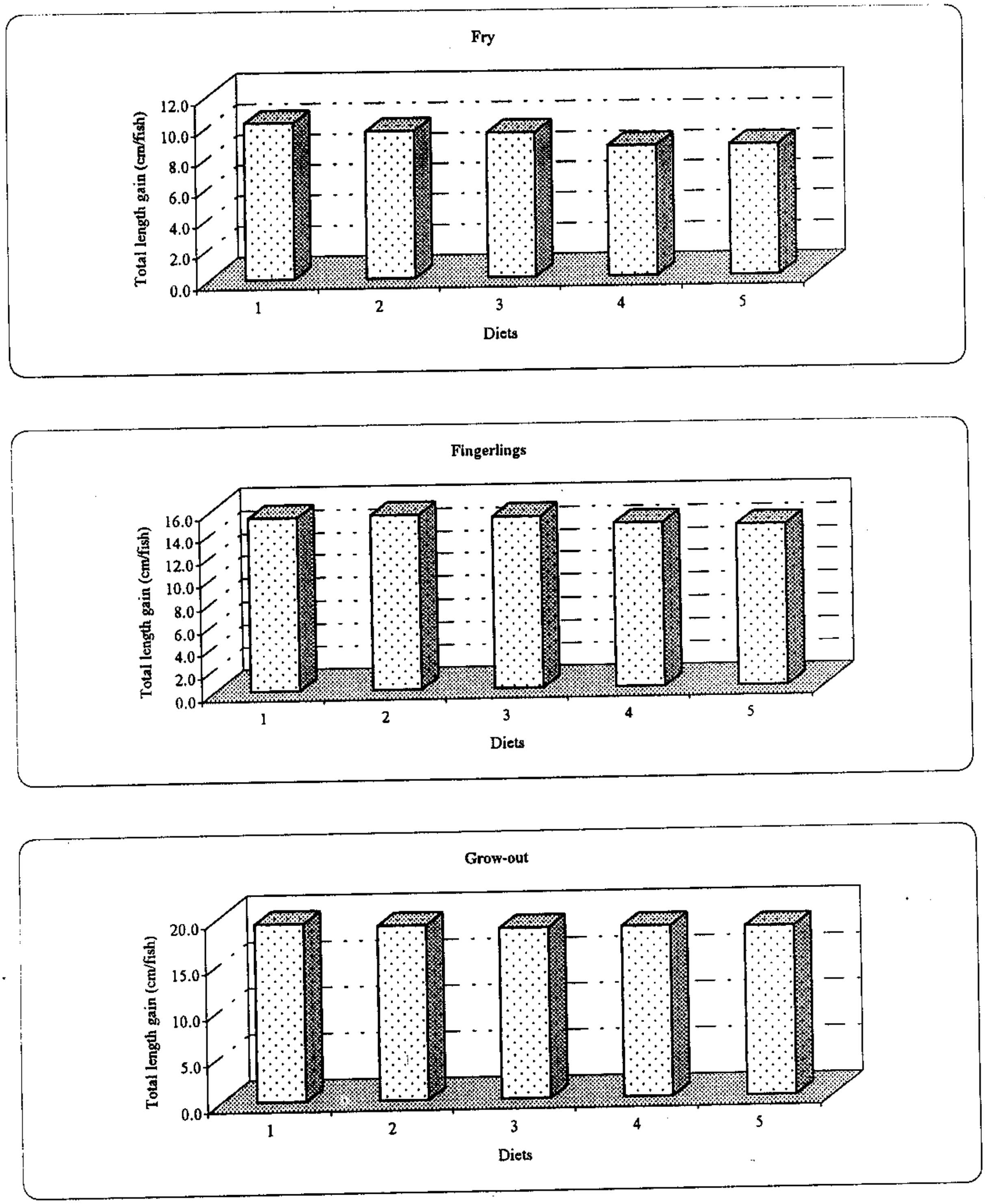



**Fig. (24) : Total length gain (TLG cm/fish) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

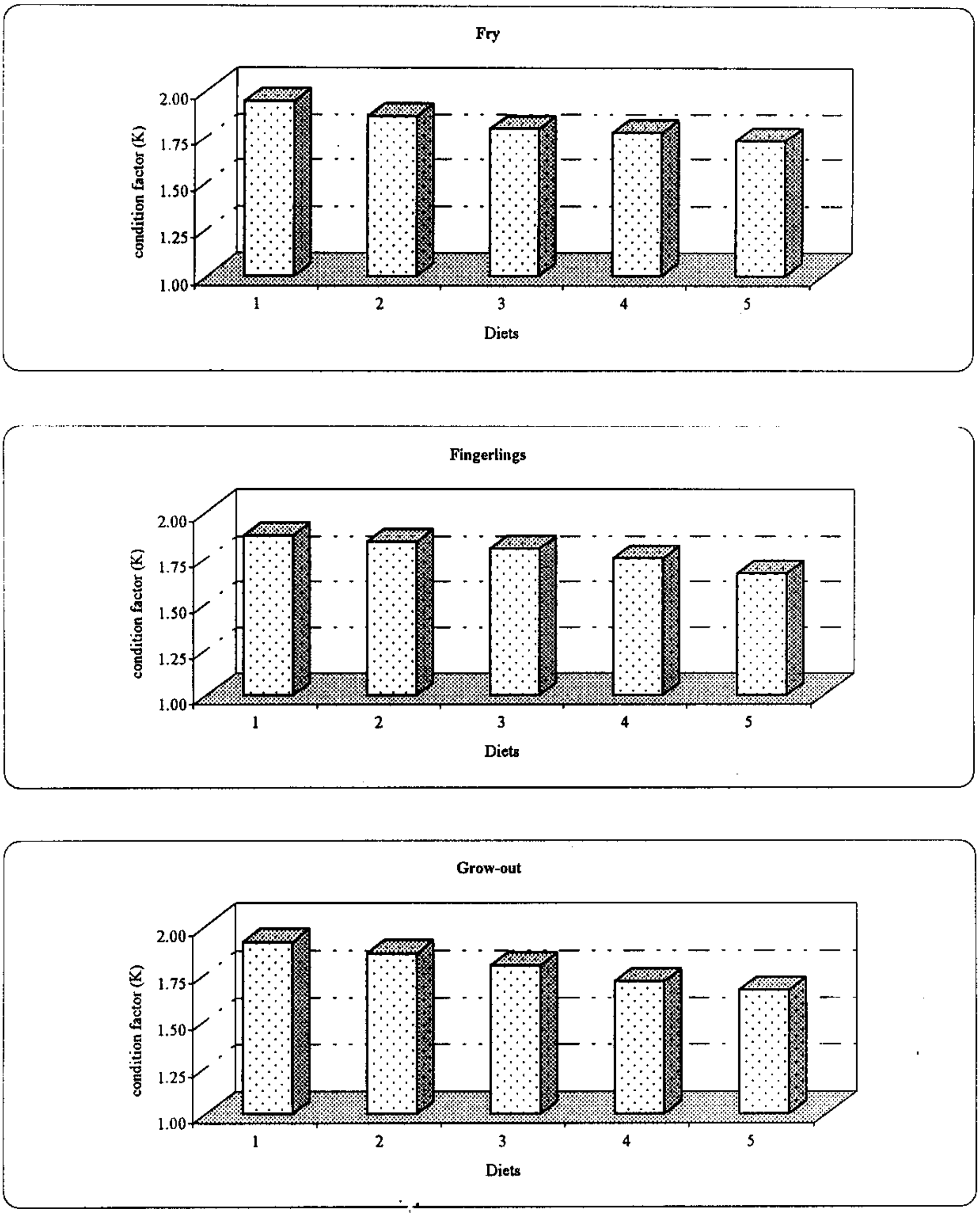



**Fig. (25): Condition factor (K) for *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks.**

## 2-2. Effect of using BSM as a FM replacer on feed utilization parameters of *O. niloticus.*

### 2-2-1. *O. niloticus* fry :

The effect of using different levels of BSM on feed utilization of *O. niloticus* fry are summarized in table (40). The lowest FCR (1.41) was indicated for fry fed ,diet 2. The increase in BSM inclusion levels resulted into higher FCR (1.67, 1.79 & 2.31 for fry fed diets 3, 4 & 5 respectively). All values of FCR were insignificantly different from the corresponding control group (Fig. 26).

The PER value was maximum for fry fed diet 2 (3.08) but decreased along with further increase in BSM inclusion levels attaining a lowest of 2.46 for fry fed diet 5. All PER values were insignificantly different compared with CTR group (Fig. 27).

The DFI values attended similar trend, thus, the highest was recorded for fry fed diet 2 (0.16 g/fish/day) with a decreasing trend accompanied by further increase in BSM inclusion levels, without significant differences when compared with the CTR group (Fig. 28).

The PPV of *O. niloticus* fry fish was highest for those fed diet 2 (10.89). The PPV decreased consequently along with consequent increase in BSM inclusion levels attaining a lowest of 9.25 for fry fed diet 5. Differences among PPV values were insignificant as compared with the CTR group (Fig. 29).

The highest FR value (34.42) was recorded for fry fish fed diet 5, whereas the lowest (22.32) was that for fry fed diet 2, followed by that for diet 3 (24.1). All the FR values were insignificantly different as compared with the corresponding for the control fish (Table 40 & Fig. 30).

No significant ER effects appeared for *O. niloticus* fry fish fed the test diets (Table 40 & Fig. 31).

**Table (40) : Nutritional parameters of *O. niloticus* fry fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% BSM | Diet 3<br>50% FM<br>50% BSM | Diet 4<br>25% FM<br>75% BSM | Diet 5<br>100% BSM |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 1.23 | 1.41 | 1.67 | 1.79 | 2.31 |
| Protein efficiency ratio | (PER) | 3.26 | 3.08 | 2.88 | 2.55 | 2.46 |
| Daily feed intake | (g/fish/day) | 0.17 | 0.16 | 0.15 | 0.12 | 0.11 |
| Protein productive value | | 11.07 | 10.89 | 9.76 | 9.71 | 9.25 |
| Fat retention | | 23.52 | 22.32 | 24.10 | 32.48 | 34.42 |
| Energy retention | | 13.39 | 12.52 | 12.30 | 13.44 | 12.74 |

BSM = Boiled soybean meal

### 2-2-2. *O. niloticus* fingerlings :

The effect of using different levels of BSM on feed utilization of *O. niloticus* fingerlings are summarized in table (41). The lowest FCR (2.56) was recorded for fingerlings fed diet 2. Further increase in BSM inclusion levels has led to increases in FCR for fingerlings fed diets 3 and 4, while FCR value decreased slightly for fish fed diet 5. All FCR values were tested to be insignificantly different as compared with the control fish (Fig. 26).

The PER was maximum for fingerlings fed both diets 2 & 3 (1.63), but showed a tendency to decrease by further increases in BSM inclusion levels recording the lowest value at using diet 5 (1.41). All recorded PER values were insignificantly different as compared with the CTR fish (Fig. 27).

The DFI values showed same tendency as described for *O. niloticus* fry. Thus, the highest DFI value (0.84 g/fish/day), followed by consequent lowering values accompanied by further increases in BSM inclusion levels fig. (28). The sustained DFI values were insignificantly different as compared with the CTR group.

Similarly, The PPV was highest (1.78) for fingerlings fed diet 2 followed by diet 3 (1.77), with a lowering trend accompanied by further increases in BSM inclusion levels as illustrated in fig. (29). All PPV values were also insignificantly different as compared with control group.

**Table (41) : Nutritional parameters of *O. niloticus* fingerlings fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 2.54 | 2.56 | 2.88 | 2.98 | 2.86 |
| Protein efficiency ratio | (PER) | 1.65 | 1.63 | 1.63 | 1.46 | 1.41 |
| Daily feed intake | (g/fish/day) | 0.85 | 0.83 | 0.81 | 0.70 | 0.67 |
| Protein productive value | | 1.95 | 1.78 | 1.77 | 1.62 | 1.55 |
| Fat retention | | 3.53 | 3.57 | 3.73 | 5.97 | 5.27 |
| Energy retention | | 2.24 | 2.09 | 2.10 | 2.12 | 2.12 |

BSM = Boiled soybean meal

Maximum FR values were recorded for fish fed diet 4 (5.97) followed by diet 5 (5.27) which were insignificantly different as compared with CTR fish (Fig. 30).

Similarly the maximum ER value was recorded for fish fed both diets 4 & 5 (2.12) which was insignificantly different as compared with the CTR group (Fig. 31).

**2-2-3. *O. niloticus* grow-out :**

The effect of using different levels of BSM on feed utilization of *O. niloticus* grow-out are summarized in table (42). The lowest FCR (2.27) was achieved for fish fed diet 2. Further increase in BSM inclusion levels has led to decreased FCR, the lowest of which was recorded for fish fed diet 5 (2.98) and was tested to be significantly different from the control group (Fig. 26).

The highest PER, DFI and PPV values were recorded for fish fed diet 2. Generally, a decreasing trend of PER, DFI and PPV values was noticed with the increase in BSM inclusion levels to reach minimum values for fish fed diet 5 (1.46, 1.44 & 1.95 respectively) without significant effects as compared with the CTR fish (Figs. 27, 28 & 29).

No significant FR and ER effects appeared for *O. niloticus* grow-out stage fed the test diets (Figs 30 & 31).

Results of statistical analyses among all treatments as compared with control group are shown in table (43).

**Table (42) : Nutritional parameters of *O. niloticus* grow-out fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% BSM | Diet 3<br>50% FM<br>50% BSM | Diet 4<br>25% FM<br>75% BSM | Diet 5<br>100% BSM |
|---|---|---|---|---|---|---|
| Feed conversion ratio | (FCR) | 2.20 | 2.27 | 2.60 | 2.74 | 2.98* |
| Protein efficiency ratio | (PER) | 1.72 | 1.66 | 1.55 | 1.52 | 1.46 |
| Daily feed intake | (g/fish/day) | 1.96 | 1.82 | 1.62 | 1.55 | 1.44 |
| Protein productive value | | 2.51 | 2.53 | 2.23 | 2.12 | 1.95 |
| Fat retention | | 5.19 | 6.24 | 8.05 | 7.80 | 8.72 |
| Energy retention | | 3.00 | 3.14 | 3.24 | 3.11 | 3.07 |

BSM = Boiled soybean meal

**Table (43) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of nutritional parameters for fish fed different levels of boiled soybean meals (BSM).**

| Different stages | Test diets | Feed Conversion Ratio (FCR) | Protein Efficiency Ratio (PER) | Daily Feed Intake (DFI) |
|---|---|---|---|---|
| | | t-c | t-c | t-c |
| Fry | D2 | -0.751 | 0.259 | 0.078 |
| | D3 | -1.272 | 0.576 | 0.293 |
| | D4 | -1.508 | 1.219 | 0.786 |
| | D5 | -1.658 | 1.327 | 0.973 |
| Fingerlings | D2 | -0.133 | 0.055 | 0.066 |
| | D3 | -0.622 | 0.049 | 0.228 |
| | D4 | -0.890 | 0.664 | 0.921 |
| | D5 | -1.014 | 0.485 | 1.125 |
| Grow-out | D2 | -0.241 | 0.305 | 0.307 |
| | D3 | -1.130 | 0.785 | 0.814 |
| | D4 | -1.453 | 0.913 | 1.022 |
| | D5 | -2.035* | 1.077 | 1.314 |

* Significant at levels $P<0.05$.

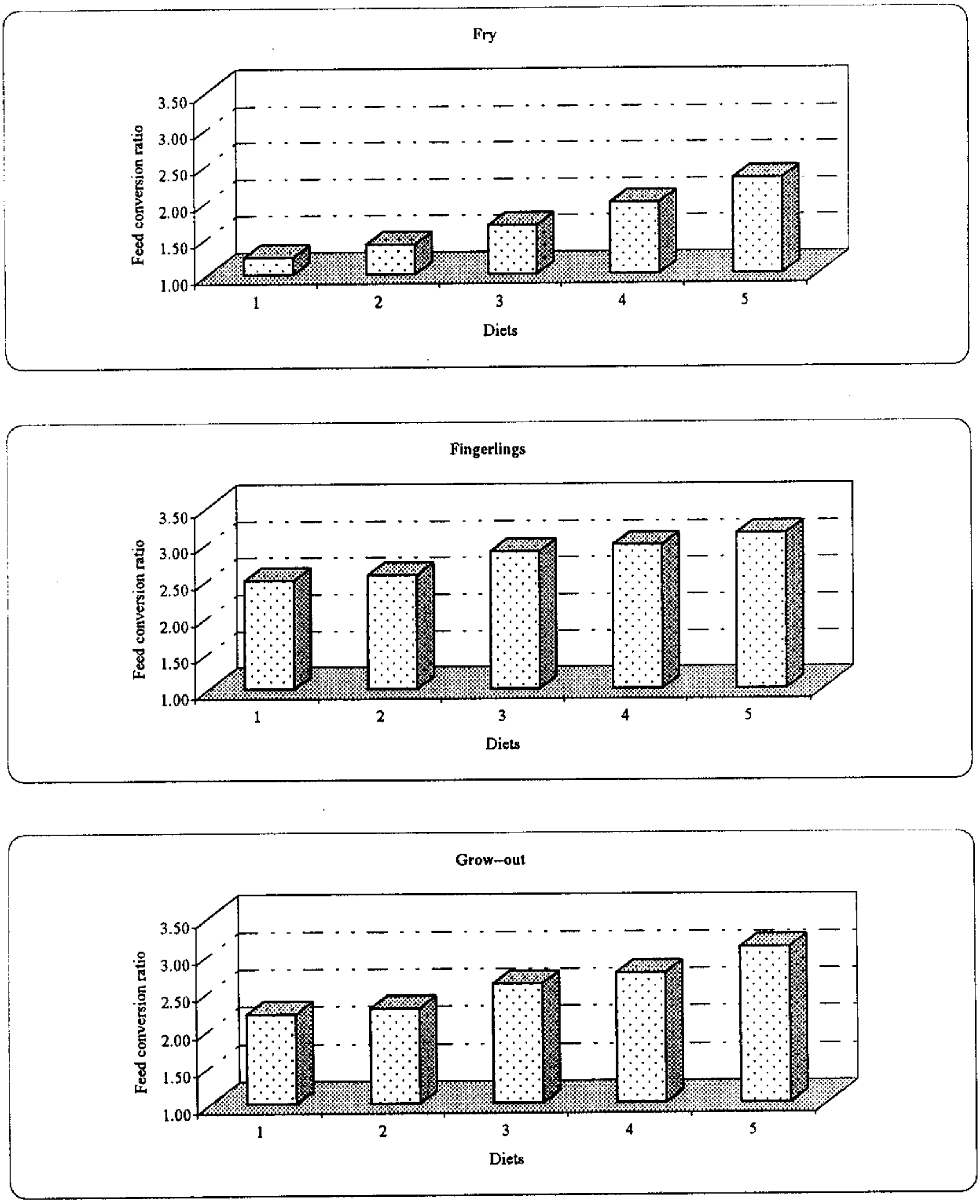



**Fig. (26): Feed conversion ratio (FCR) for *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks.**

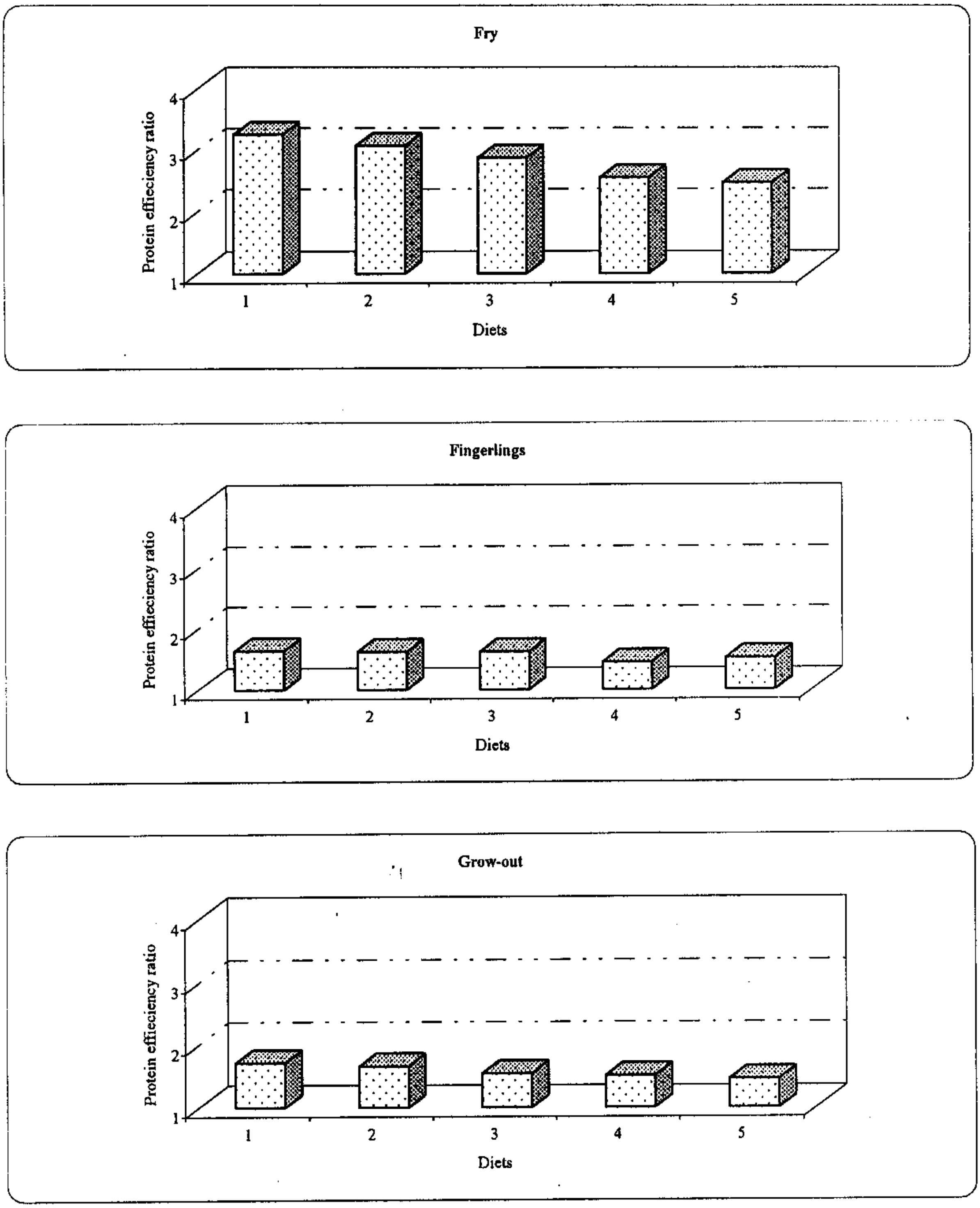



**Fig. (27) : Protein effieciency ratio (PER) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

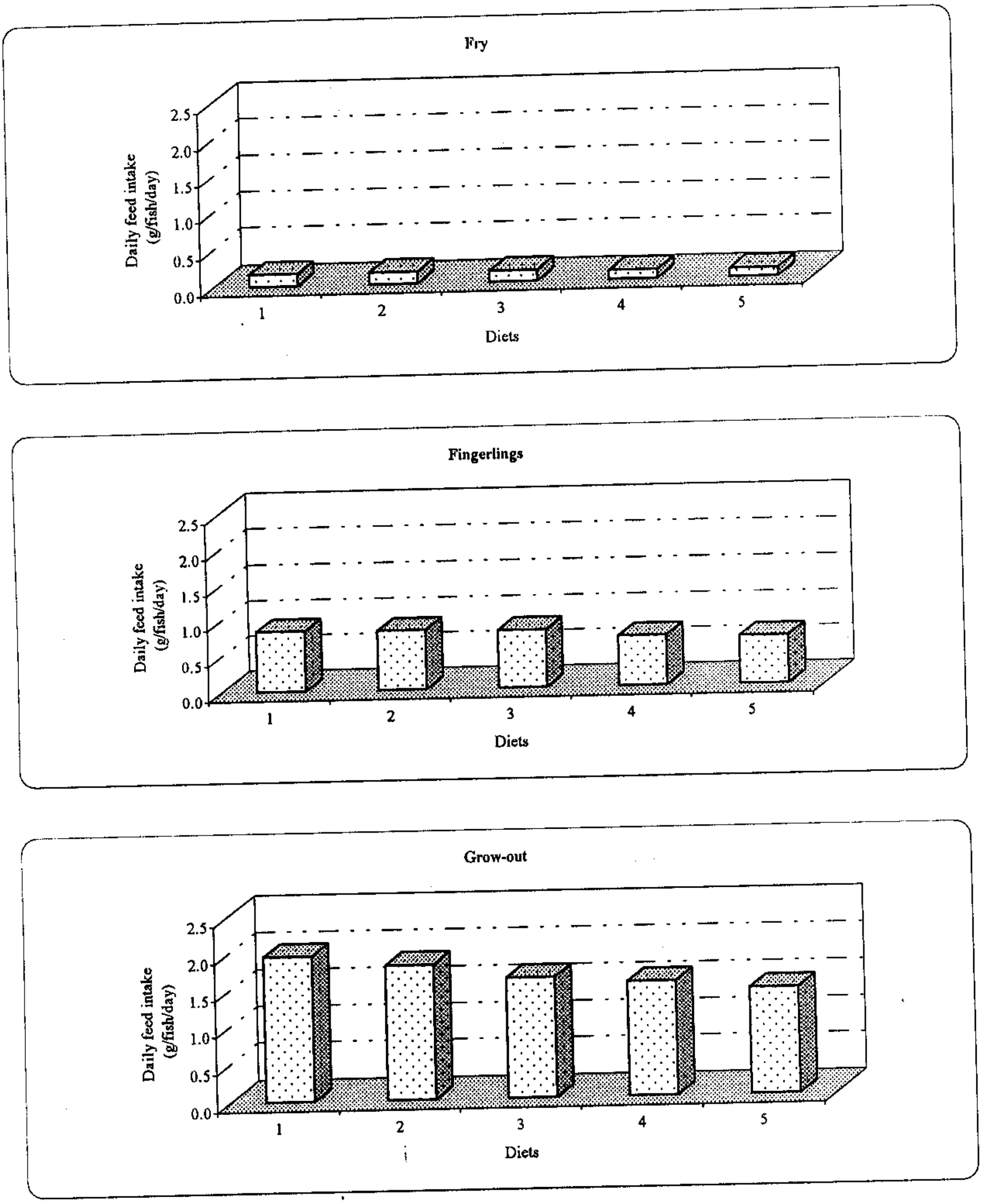



**Fig. (28): Daily feed intake (DFI g/fish/day) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

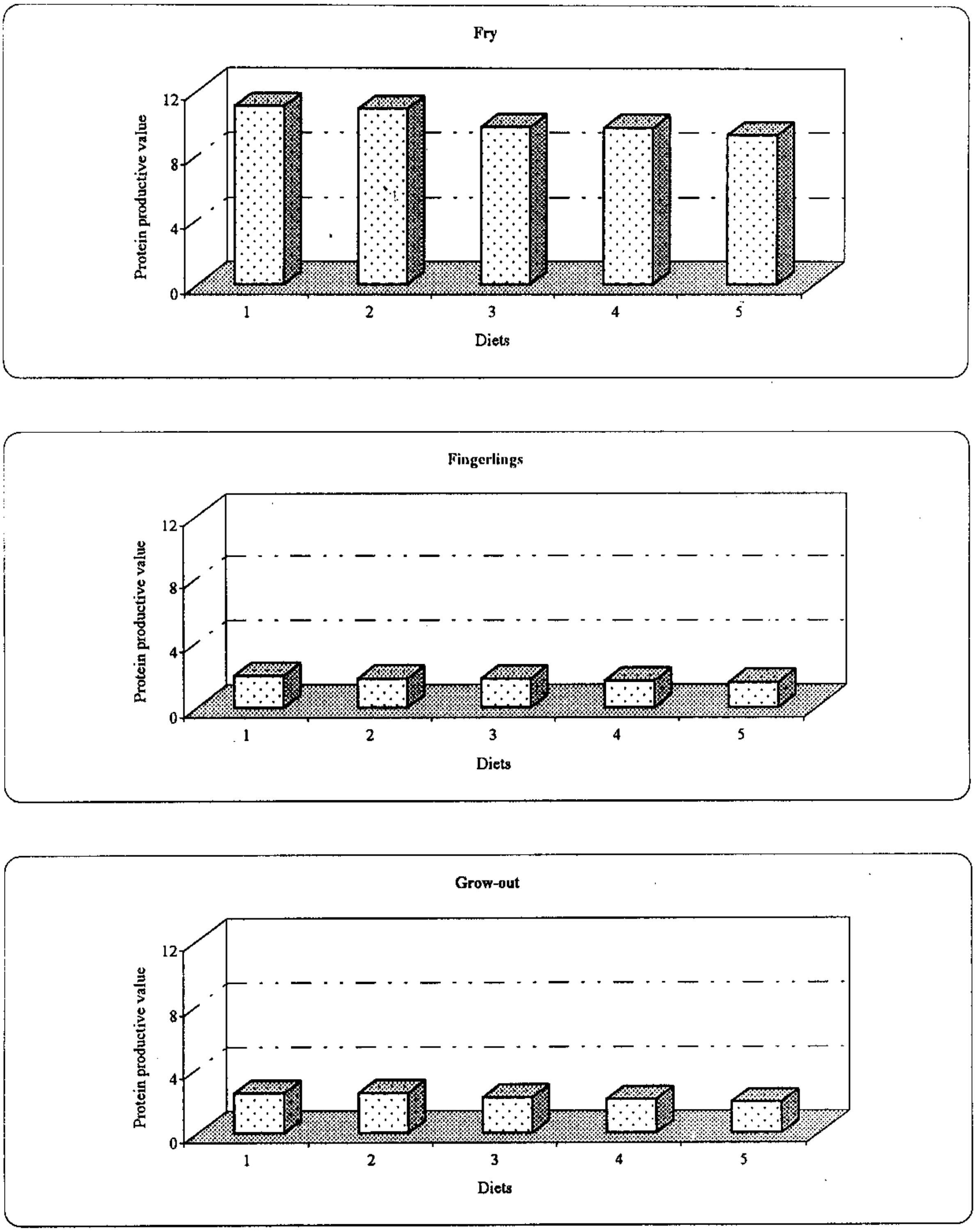



**Fig. (29) : Protein productive value (PPV) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

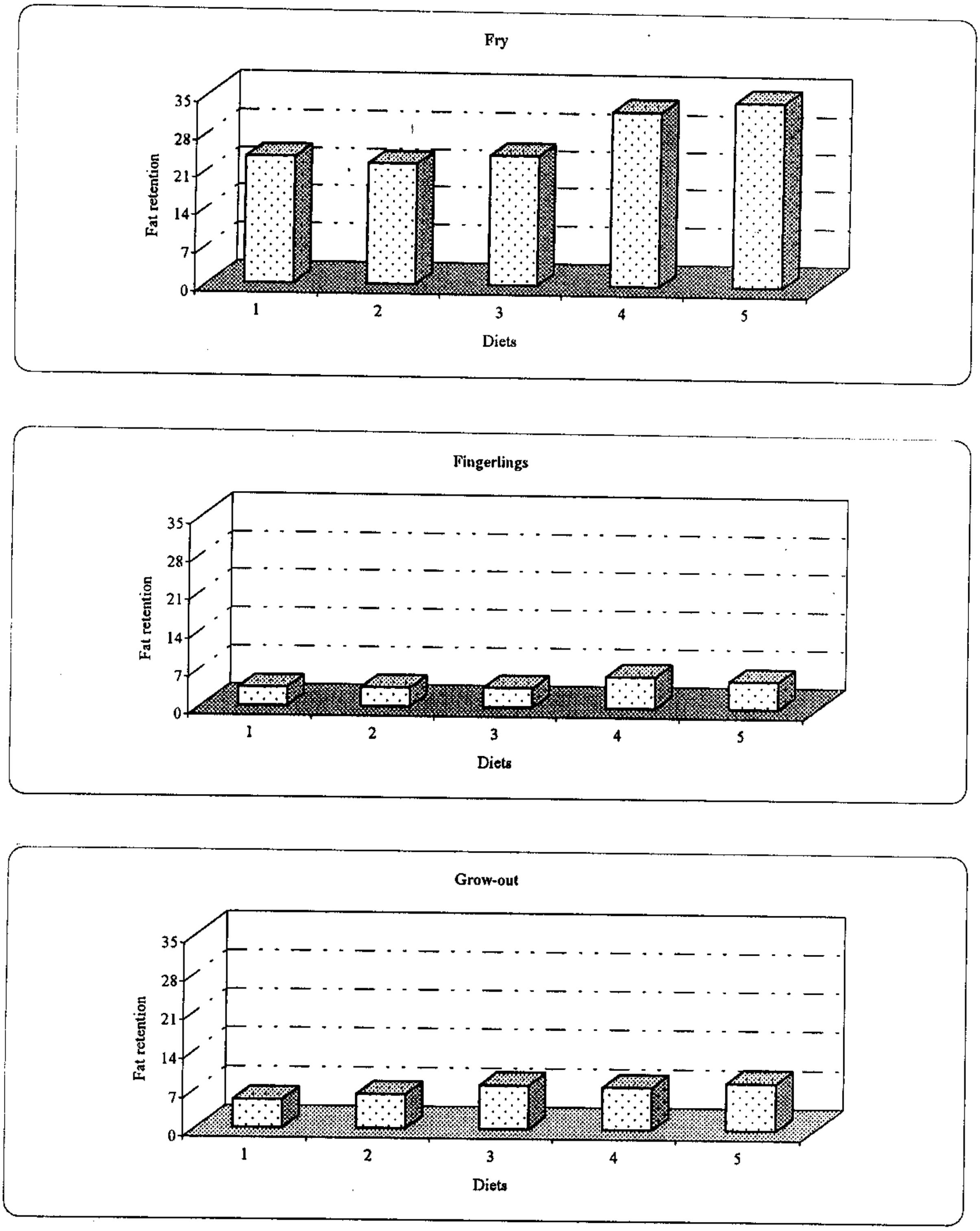



**Fig. (30) : Fat retention (FR) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

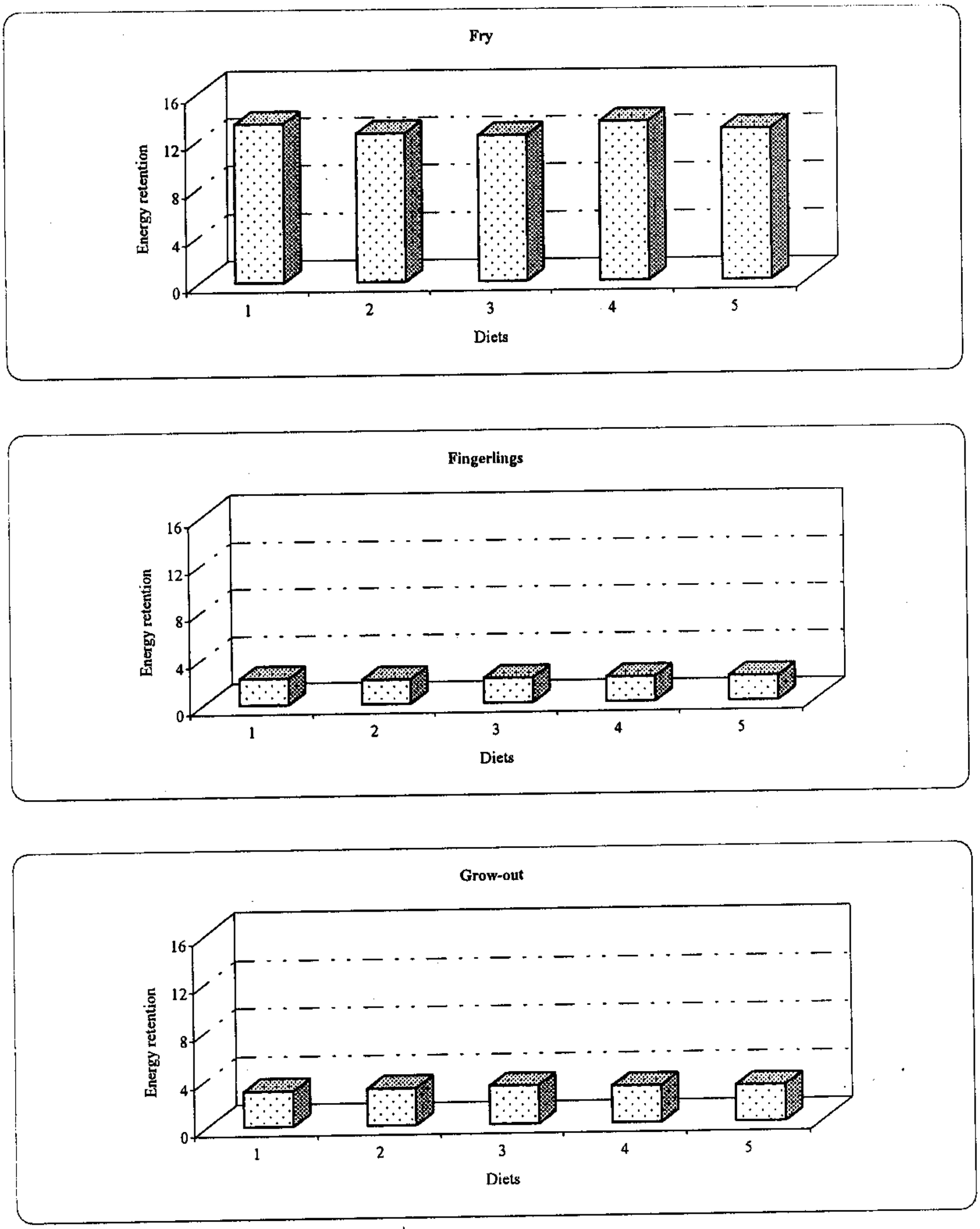



**Fig. (31): Energy retention (ER) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

## 2-3. Effect of BSM inclusion within diets on the biochemical composition of *O. niloticus* :

### 2-3-1. *O. niloticus* fry :

Results of body composition analyses (on dry weight basis) at the end of the feeding trials of fry fed the test diets are given in table (44) and illustrated in figs. (32, 33, 34 & 35).

With the consequent increase of BSM inclusion level a tendency of subsequent decrease in liver protein as well as glycogen, or an increase in total lipids was noticeable. Significant differences of liver protein were shown for fry fed diets 4 and 5 as compared with the corresponding for fish fed diet 1 (CTR fish).

Also, a significant difference of liver total lipids was shown for fry fed diet 5 as compared with the corresponding CTR fish. At the mean time, replacing FM by BSM had a significant effect on crude protein (for fry fed diets 4 & 5), on muscle total lipids (for fry fed diets 2, 4 & 5) and on ash content (for fry fed diets 2, 3 & 5) as compared with the corresponding for fish fed diet 1 (CTR fish).

Values of energy content (gross energy and metabolizable energy showed fluctuations for fry fed the test diets. On the other hand, P/E ratio increased steadily with the increase in BSM inclusion levels, attaining the highest values for fry fed diets 4 & 5 (69.90 & 73.02) which were tested to be significantly different as compared with the CTR fish.

**Table (44) : Liver and muscle composition of *O. niloticus* fry fed different levels of BSM-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 17.17 ± 0.40 | 18.71 ± 0.90 | 18.52 ± 0.82 | 18.32 ± 0.79 | 17.91*± 0.65 | 17.32*± 0.59 |
| Total lipids | (g/100 g tissue) | 11.50 ± 0.91 | 10.89 ± 0.80 | 10.96 ± 0.82 | 11.35 ± 0.90 | 11.29 ± 0.89 | 11.61*± 0.98 |
| Glycogen | (g/100 g tissue) | 1.90 ± 0.06 | 2.01 ± 0.19 | 2.00 ± 0.19 | 1.95 ± 0.12 | 1.94 ± 0.08 | 1.95 ± 0.10 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 53.34 ± 3.12 | 60.60 ± 3.89 | 58.80 ± 3.79 | 58.19 ± 3.50 | 57.89*± 3.09 | 54.07*± 3.14 |
| Total lipids | (%) | 24.00 ± 2.60 | 17.72 ± 1.71 | 16.40*± 1.59 | 17.80 ± 1.81 | 22.36*± 2.09 | 22.98*± 2.43 |
| Ash | (%) | 18.00 ± 2.15 | 22.60 ± 2.94 | 20.20*± 2.34 | 19.28*± 2.40 | 21.68 ± 2.56 | 19.18*± 2.50 |
| Moisture | (%) | 73.80 ± 3.94 | 74.04 ± 4.12 | 74.91 ± 4.26 | 75.34 ± 5.11 | 76.54 ± 4.96 | 77.98 ± 5.17 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5282.00 | 5098.50 | 4872.00 | 4971.10 | 5384.00 | 5226.61 |
| Metabolizable energy | (K cal/Kg) | 4000.30 | 3781.00 | 3605.20 | 3694.00 | 4046.80 | 3948.40 |
| P/E ratio | | 74.99 | 62.40 | 61.31 | 63.50 | 69.90* | 73.02* |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

### 2-3-2. *O. niloticus* fingerlings :

As shown in table (45) and illustrated in figs. (32, 33, 34 and (35) liver protein, lipids and glycogen showed similar trend of variations as previously mentioned for *O. niloticus* fry.

Replacing FM by BSM had significant effects on crude protein and ash for fingerlings fed all the test diets as compared with the corresponding CTR fish. While total lipids and moisture values for fish fed diets 4 & 5 were significantly different as compared with the control fish.

On the other hand, further increase in BSM inclusion level within the diets had led to increases in gross energy, metabolizable energy and P/E ratio. The P/E values achieved for fish fed diets 4 & 5 were significantly different as compared with the CTR fish.

### 2-3-3. *O. niloticus* grow-out :

Results of *O. niloticus* grow-out liver protein, lipids and glycogen showed similar tendency as previously mentioned for fry and fingerlings. On the other hand, replacing FM by BSM had significant effects on crude protein, total lipids and ash for fish fed all the experimental diets as compared with the control fish fed diet 1 (Table 46 and Figs. 32, 33, 34 & 35).

Values of energy content (gross energy, metabolizable energy and P/E ratio) showed fluctuations for grow-out fed the test diets (Table 46).

The statistical analyses of the body composition parameters for all treatments as compared with the corresponding for the control group are given in Tables (47 & 48).

**Table (45) : Liver and muscle composition of *O. niloticus* fingerlings fed different levels of BSM-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% FFS |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 20.68 ± 1.31 | 22.23 ± 1.95 | 21.96 ± 1.76 | 21.60 ± 1.51 | 20.92*± 1.28 | 20.58*± 1.09 |
| Total lipids | (g/100 g tissue) | 10.39 ± 0.51 | 8.40 ± 0.40 | 7.94*± 0.30 | 8.65 ± 0.40 | 10.03*± 0.50 | 10.51*± 0.50 |
| Glycogen | (g/100 g tissue) | 2.11 ± 0.16 | 3.41 ± 0.28 | 2.69 ± 0.20 | 2.41*± 0.20 | 2.33*± 0.16 | 2.10*± 0.17 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 64.08 ± 2.65 | 71.11 ± 0.79 | 67.20*± 1.47 | 66.97*± 1.40 | 64.87*± 2.65 | 63.49*± 2.28 |
| Total lipids | (%) | 19.94 ± 1.40 | 18.11 ± 1.98 | 17.75 ± 0.76 | 17.92 ± 0.32 | 20.68*± 1.57 | 22.48*± 2.13 |
| Ash | (%) | 14.71 ± 2.01 | 10.78 ± 0.98 | 15.05*± 0.74 | 15.11*± 1.07 | 14.45*± 1.08 | 12.83*± 0.91 |
| Moisture | (%) | 76.18 ± 4.43 | 74.70 ± 3.98 | 73.93 ± 3.28 | 75.20 ± 4.69 | 75.29*± 4.70 | 78.15* ± 5.17 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5505.30 | 5729.40 | 5474.40 | 5477.40 | 5619.26 | 5711.36 |
| Metabolizable energy | (K cal/Kg) | 4095.20 | 4222.10 | 4041.60 | 4045.60 | 4184.40 | 4274.40 |
| P/E ratio | | 63.91 | 59.40 | 60.13 | 60.41 | 64.50* | 67.32* |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (46) : Liver and muscle composition of *O. niloticus* grow-out fed different levels of BSM-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% FFS |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 20.96 ± 1.81 | 23.39 ± 2.70 | 23.06 ± 2.81 | 22.05 ± 2.17 | 21.24*± 1.91 | 20.90*± 1.78 |
| Total lipids | (g/100 g tissue) | 10.93 ± 0.60 | 8.00 ± 0.29 | 8.14 ± 0.31 | 8.75*± 0.31 | 10.14*± 0.56 | 10.91*± 0.60 |
| Glycogen | (g/100 g tissue) | 2.38 ± 0.10 | 4.10 ± 1.31 | 3.82 ± 1.16 | 3.20*± 0.09 | 2.80*± 0.09 | 2.39*± 0.09 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 57.28 ± 3.70 | 62.20 ± 4.49 | 62.06*± 4.33 | 59.08*± 4.10 | 57.84*± 3.68 | 55.67*± 2.96 |
| Total lipids | (%) | 21.78 ± 2.29 | 18.32 ± 1.58 | 20.36*± 2.13 | 25.05*± 3.39 | 23.18*± 2.42 | 24.53*± 3.17 |
| Ash | (%) | 18.26 ± 1.95 | 17.05 ± 1.56 | 15.46*± 1.44 | 14.76*± 1.34 | 15.12*± 1.40 | 18.32*± 2.10 |
| Moisture | (%) | 76.48 ± 4.18 | 76.53 ± 4.88 | 76.68 ± 4.67 | 74.32 ± 4.10 | 75.40 ± 4.60 | 77.56 ± 5.21 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5294.51 | 5245.24 | 5430.02 | 570523* | 5458.50 | 5463.10 |
| Metabolizable energy | (K cal/Kg) | 3976.40 | 3891.60 | 4048.80 | 4308.00 | 4110.40 | 4133.40 |
| P/E ratio | | 69.42 | 62.57 | 65.24* | 72.92* | 71.07* | 74.25* |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (47) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of liver metabolites for fish fed different levels of boiled soybean meal (BSM).**

| Different stages | Test diets | Hepatic Protein (HP) | Hepatic Lipid (HL) | Hepatic Glycogen (HG) |
|---|---|---|---|---|
| | | t-c | t-c | t-c |
| Fry | D2 | 0.468 | -0.183 | 0.113 |
| | D3 | 0.977 | -1.146 | 0.816 |
| | D4 | 2.162* | -1.003 | 1.042 |
| | D5 | 3.875* | -1.707* | 0.856 |
| Fingerlings | D2 | 0.308 | 2.760* | 6.277* |
| | D3 | 0.766 | -1.326 | 8.719* |
| | D4 | 1.685* | -7.637* | 10.047* |
| | D5 | 2.216* | -9.886* | 11.998* |
| Grow-out | D2 | 0.254 | -0.989 | 0.480 |
| | D3 | 1.161 | -5.300* | 2.056* |
| | D4 | 1.950* | -10.180* | 2.970* |
| | D5 | 2.310* | -13.100* | 3.907* |

* Significant at levels $P<0.05$.

**Table (48) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of body composition and energy content for fish fed different levels of boiled soybean meal (BSM).**

| Different stages | Test diets | Crude Protein (CP%) | Total Lipids (TL) | Ash Content (AC) | Moisture | Gross Energy (GE) | Metabolizable Energy (ME) | P/E ratio |
|---|---|---|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c | t-c | t-c | t-c |
| Fry | D2 | 1.048 | 1.788* | 2.020* | -0.464 | 0.906 | 0.329 | 0.224 |
| | D3 | 1.456 | -0.102 | 2.766* | -0.626 | 0.460 | 0.161 | -0.229 |
| | D4 | 1.725* | -5.434* | 0.746 | -1.226 | -1.050 | -0.479 | -1.545* |
| | D5 | 4.131* | -5.598* | 2.802* | -1.885* | -0.460 | -0.305 | -2.127* |
| Fingerlings | D2 | 7.409* | 0.537 | -10.996* | 0.472 | 1.173 | 1.035 | -0.328 |
| | D3 | 8.144* | 0.300 | -9.437* | -0.257 | 0.972 | 0.855 | -0.392 |
| | D4 | 7.136* | -3.216* | -7.958* | -0.303* | 0.424 | 0.182 | -2.151* |
| | D5 | 9.986* | -4.752* | -4.847* | -1.672* | 0.066 | -0.275 | -3.859* |
| Grow-out | D2 | 0.071 | -2.432* | 2.368* | -0.070 | -0.649 | -0.520 | -0.889 |
| | D3 | 1.623* | -5.690* | 3.521* | 1.096 | -1.712* | -1.423 | -4.109* |
| | D4 | 2.375* | -5.318* | 2.912* | 0.533 | -0.754 | -0.734 | -3.827* |
| | D5 | 3.840* | -5.544* | -1.535 | -0.456 | -0.724 | -0.650 | -5.896* |

* Significant at levels $P<0.05$.

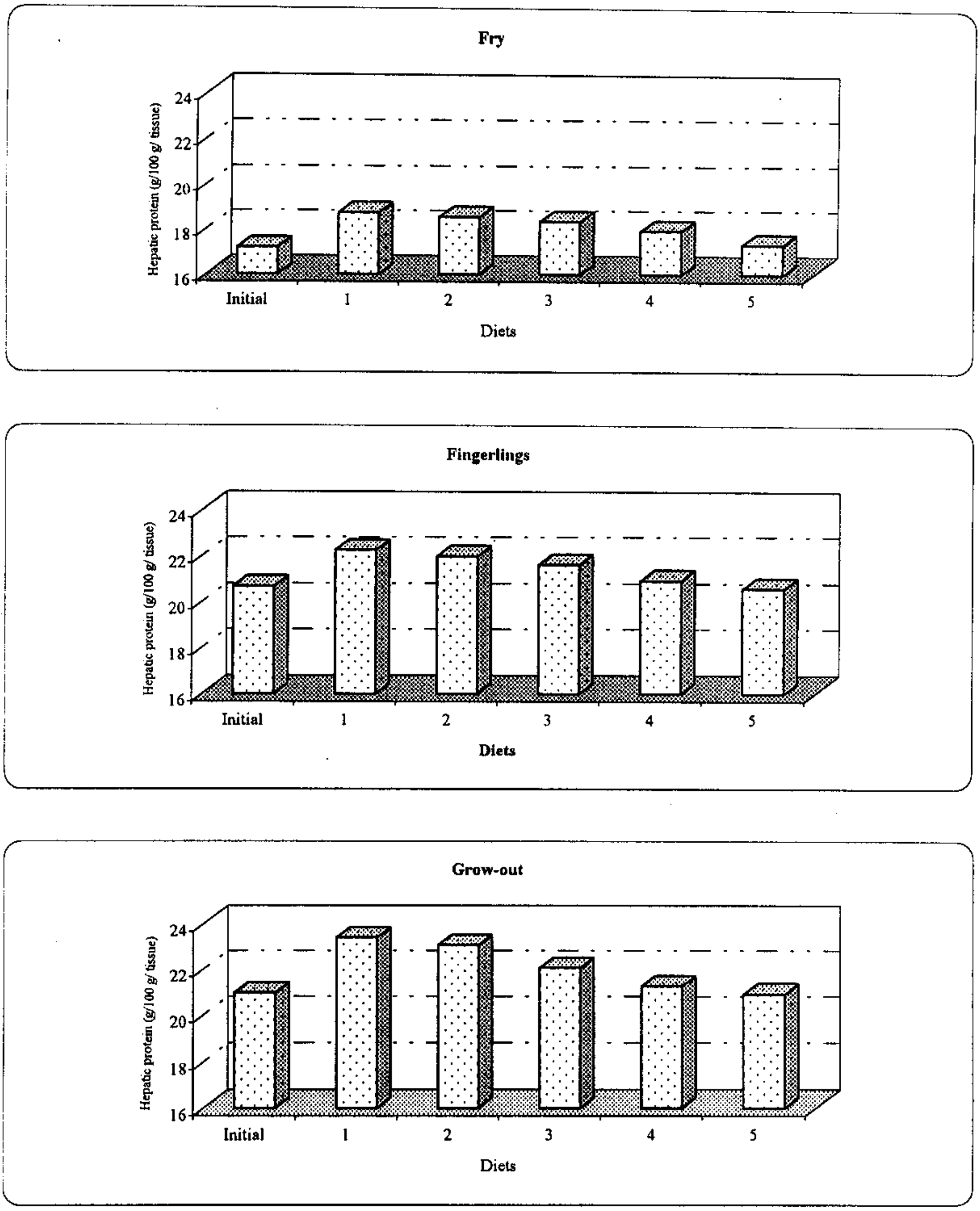



**Fig. (32) : Hepatic protein (g/100 g tissue) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

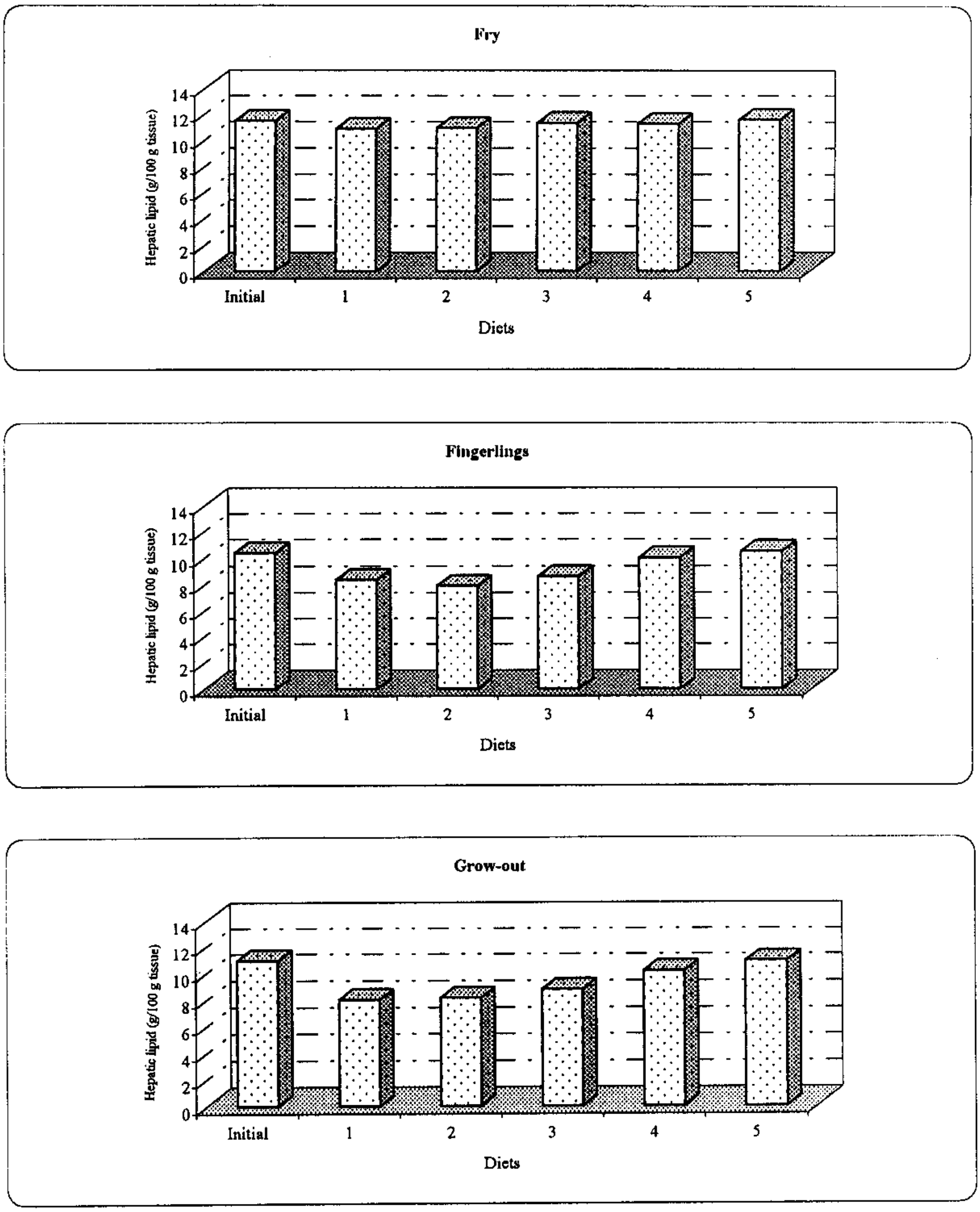



**Fig. (33): Hepatic lipids (g/100 g tissue) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

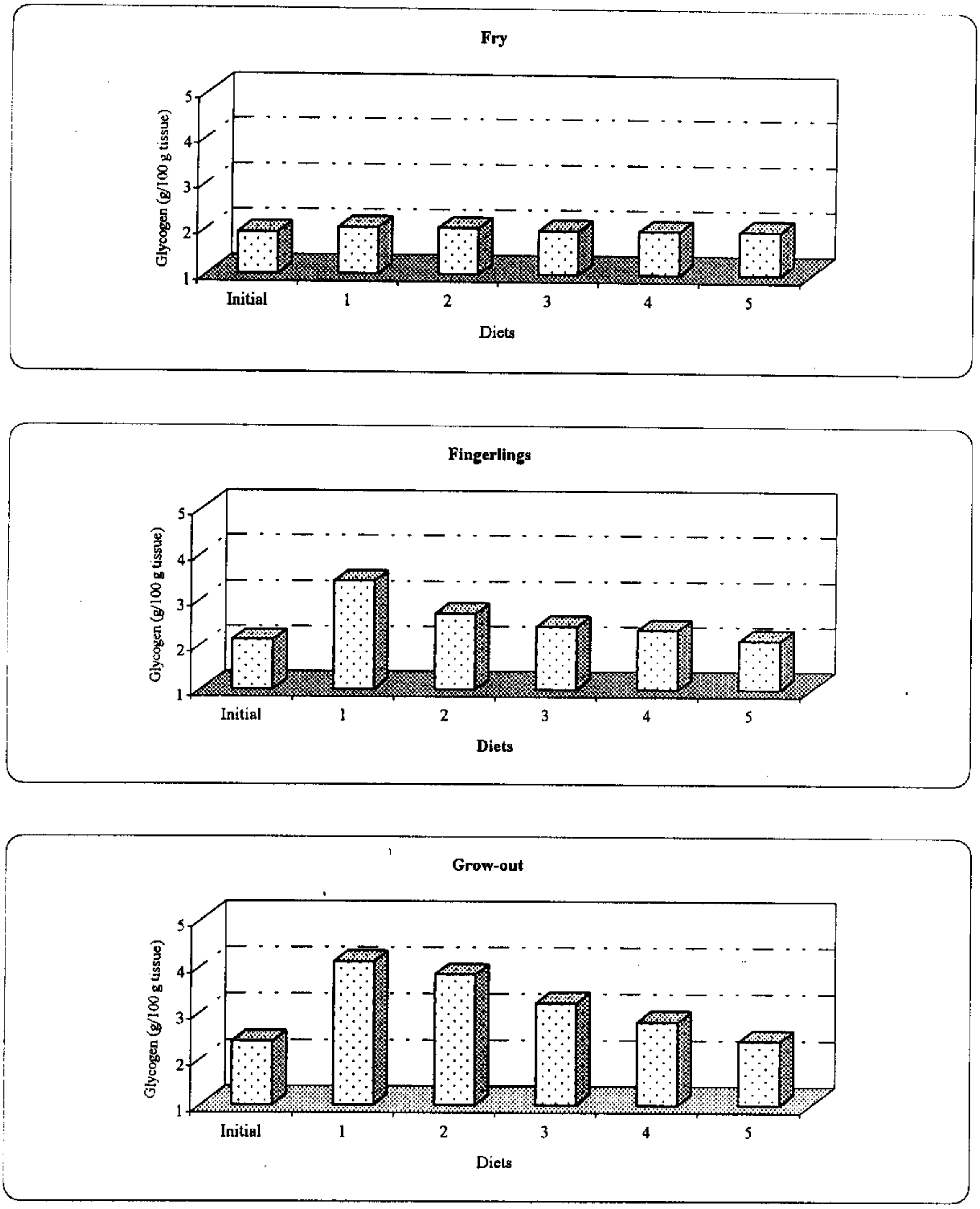



**Fig. (34) : Hepatic Glycogen (g/100 g tissue) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

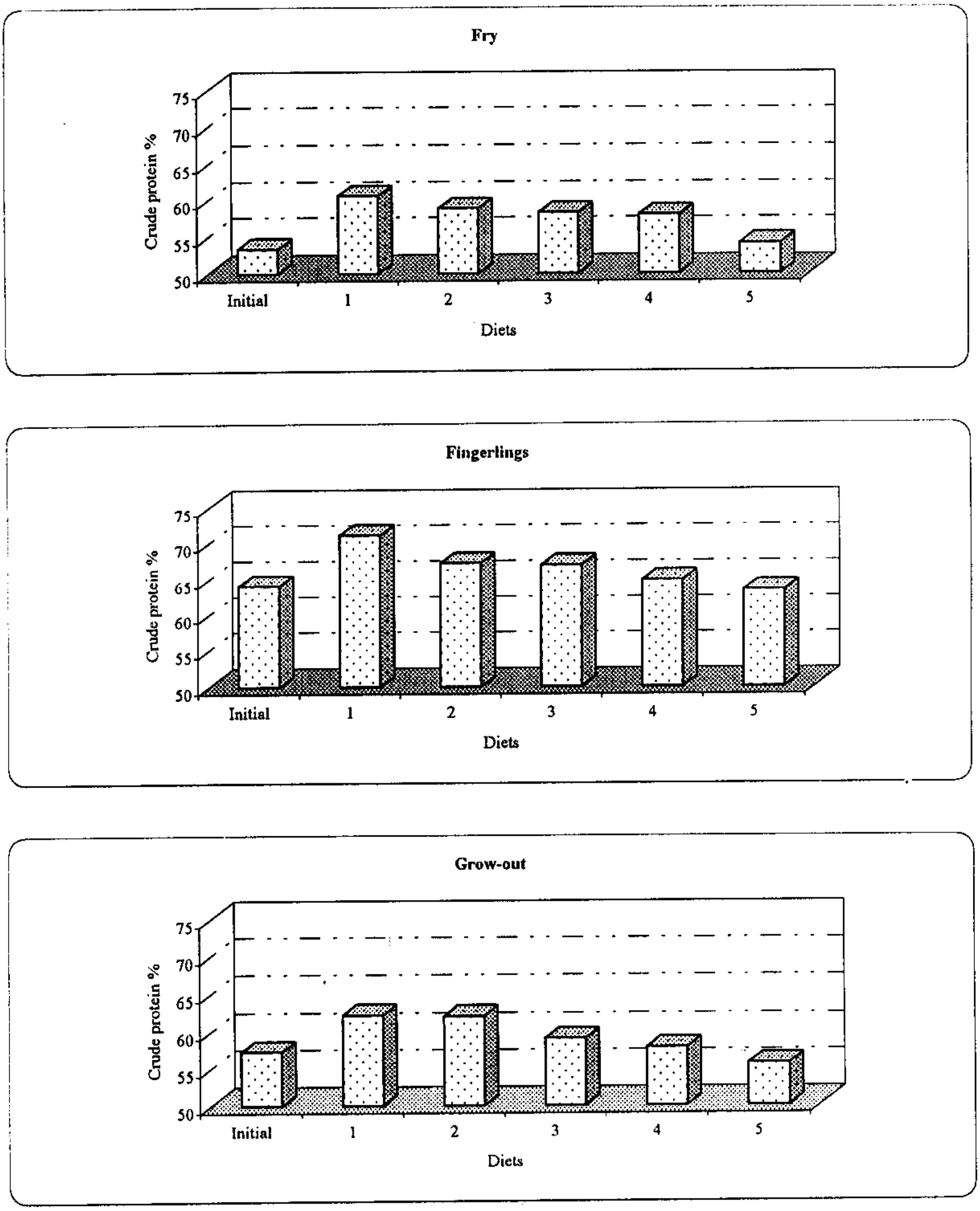



**Fig. (35): Crude protein content of *O. niloticus* fed different levels of boiled soybean meal (BSM) diets for 18 weeks.**

## 2-4. Effect of boiled soybean meal (BSM) as a Fish meal (FM) replacer on *O. niloticus* biological characteristics :

### 2-4-1. *O. niloticus* fry :

At the end of the feeding trials, hepatosomatic indices (H.S.I.) showed significant differences for fry fed diets 2, 4 & 5 as compared with those of the control fish. Whereas values of gastrosomatic indices (Ga.S.I.) and gonadosomatic indices (G.S.I.) showed insignificant differences as compared with the control fish (Table 49 and Figs. 36, 37 & 38).

Fry fed diet 5 attained filling indices (F.I.) as well as condition of fish flesh (C.F.F.) values significantly different as compared with those of the corresponding CTR fish as shown in table (49).

### 2-4-2. *O. niloticus* fingerlings :

Likewise, the biological parameters measured for fingerlings fed the test diets are summarized in table (50) and illustrated in figs. (36, 37 & 38).

Values of H.S.I. for fish fed diets 3 & 5 were significantly different as compared with the CTR fish. The Ga.S.I. and G.S.I. lowest values (7.09 and 0.96 respectively) attained for fish fed diet 5 were the only significant values when compared with that of the control fish fed diet 1.

As for F.I. values for fish fed all tested diet levels were insignificantly different as compared with those fed diet 1.

Fingerlings fed diets 4 & 5 recorded C.F.F. values significantly different as compared with the CTR fish fed diet 1.

### 2-4-3. *O. niloticus* grow-out :

Table (51) and fig. (36) showed that fish fed diets 3, 4 & 5 had H.S.I. values lower and significantly different as compared with the CTR fish fed diet 1. Fish fed all test diets recorded Ga.S.I. and F.I. values which were insignificantly different as compared with the corresponding CTR fish (Fig. 37).

Fish fed diet 5 recorded G.S.I. value significantly different as compared with the CTR fish (Fig. 38), while fish fed diets 4 & 5 recorded C.F.F. values lower and also significantly different from the control fish fed diet 1.

Results of statistical analyses of the biological parameters for all stages fed the different BSM diets are summarized in table (52).

**Table (49) : Biological parameters of *O. niloticus* fry fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 10.20 ± 1.97 | 9.63 ± 1.95 | 9.45 ± 1.90 | 8.52 ± 1.79 | 8.55 ± 1.90 |
| Total weight (T. wt.) | (g) | 18.10 ± 3.09 | 16.50 ± 3.11 | 14.20 ± 2.96 | 11.20 ± 2.66 | 10.00 ± 2.39 |
| Gutted weight (G. wt.) | (g) | 15.07 ± 1.86 | 13.01 ± 1.73 | 11.31 ± 1.22 | 9.36 ± 1.23 | 7.80 ± 0.83 |
| Hepatosomatic index (H.S.I.) | (g) | 1.79 ± 0.19 | 1.99*± 0.22 | 1.78 ± 0.17 | 1.46*± 0.13 | 1.17*± 0.08 |
| Gastrosomatic index (Ga.S.I.) | | 7.87 ± 1.86 | 8.13 ± 2.13 | 7.64 ± 1.63 | 7.09 ± 1.35 | 6.94 ± 1.08 |
| Gonadosomatic index (G.S.I.) | | 1.41 ± 1.06 | 1.36 ± 1.12 | 1.41 ± 1.09 | 1.23 ± 1.11 | 1.26 ± 1.17 |
| Filling index (F.I.) | | 1.96 ± 0.87 | 1.90 ± 0.80 | 1.77 ± 0.69 | 1.61 ± 0.51 | 1.06*± 0.50 |
| Condition of fish flesh (C.F.F.) | | 1.42 ± 0.20 | 1.46 ± 0.20 | 1.34 ± 0.18 | 1.51 ± 0.14 | 1.25*± 0.11 |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (50) : Biological parameters of *O. niloticus* fingerlings fed the test BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 15.31 ± 4.53 | 15.45 ± 4.91 | 15.18 ± 4.44 | 14.45 ± 4.36 | 14.25 ± 3.98 |
| Total weight (T. wt.) | (g) | 63.90 ± 16.71 | 60.85 ± 15.83 | 58.08 ± 13.28 | 49.14 ± 10.12 | 46.00 ± 8.80 |
| Gutted weight (G. wt.) | (g) | 50.98 ± 12.77 | 49.20 ± 10.81 | 45.87 ± 9.32 | 39.84 ± 6.17 | 37.18 ± 4.77 |
| Hepatosomatic index (H.S.I.) | (g) | 1.86 ± 0.20 | 1.81 ± 0.21 | 1.71*± 0.17 | 1.50 ± 0.14 | 1.30*± 0.07 |
| Gastrosomatic index (Ga.S.I.) | | 9.06 ± 2.19 | 9.01 ± 2.08 | 8.19 ± 2.06 | 7.81 ± 1.98 | 7.09*± 1.62 |
| Gonadosomatic index (G.S.I.) | | 1.36 ± 0.54 | 1.45 ± 0.45 | 1.04 ± 0.61 | 1.11 ± 0.52 | 0.96*± 0.36 |
| Filling index (F.I.) | | 2.00 ± 0.95 | 1.91 ± 0.91 | 1.80 ± 0.91 | 1.54 ± 0.85 | 1.57 ± 0.58 |
| Condition of fish flesh (C.F.F.) | | 1.42 ± 0.19 | 1.33 ± 0.18 | 1.31 ± 0.12 | 1.32*± 0.16 | 1.28*± 0.11 |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (51) : Biological parameters of *O. niloticus* grow-out fed different levels of BSM-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 19.34 ± 6.11 | 19.03 ± 5.92 | 18.55 ± 5.09 | 18.53 ± 4.86 | 18.37 ± 4.73 |
| Total weight (T. wt.) | (g) | 143.10 ± 26.01 | 131.60 ± 24.62 | 114.18 ± 22.07 | 107.35 ± 22.09 | 99.17 ± 20.93 |
| Gutted weight (G. wt.) | (g) | 117.82 ± 18.66 | 107.40 ± 16.46 | 97.80 ± 13.78 | 87.52 ± 11.81 | 83.20 ± 8.76 |
| Hepatosomatic index (H.S.I.) | (g) | 2.09 ± 0.30 | 2.06 ± 0.30 | 1.89* ± 0.20 | 1.76* ± 0.13 | 1.20*± 0.05 |
| Gastrosomatic index (Ga.S.I.) | | 8.49 ± 1.88 | 8.61 ± 1.90 | 7.96 ± 1.84 | 8.01 ± 1.80 | 7.63 ± 1.69 |
| Gonadosomatic index (G.S.I.) | | 1.34 ± 0.62 | 1.41 ± 0.72 | 1.09 ± 0.50 | 1.11 ± 0.33 | 0.99*± .09 |
| Filling index (F.I.) | | 2.00 ± 1.01 | 1.86 ± 0.79 | 1.91 ± 0.82 | 1.84 ± 0.73 | 1.62 ± 0.52 |
| Condition of fish flesh (C.F.F.) | | 1.63 ± 0.23 | 1.56 ± 0.21 | 1.53 ± 0.20 | 1.38*± 0.19 | 1.34*± 0.16 |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (52) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of biological condition for fish fed different levels of boiled soybean meal (BSM).**

| Different stag | Test diets | Hepatosomatic index (HIS) | Gonadosomatic index (GSI) | Gastrosomatic index (GaSI) | Filling index (FI) | Condition of fish flesh |
|---|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c | t-c |
| Fry | D2 | -2.064* | 0.097 | -0.255 | 0.152 | -0.424 |
| | D3 | 0.118 | 0.000 | 0.303 | 0.513 | 0.892 |
| | D4 | 4.300* | 0.352 | 1.044 | 1.041 | -1.106 |
| | D5 | 9.022* | 0.285 | 1.325 | 2.691* | 2.234* |
| Fingerlings | D2 | 0.517 | -0.384 | 0.050 | 0.205 | 1.032 |
| | D3 | 1.714* | 1.178 | 0.868 | 0.456 | 1.468 |
| | D4 | 4.424* | 1.000 | 1.270 | 1.083 | 1.208* |
| | D5 | 7.928* | 1.849* | 2.170* | 1.159 | 1.913* |
| Grow-out | D2 | 0.212 | -0.221 | -0.135 | 0.328 | 0.674 |
| | D3 | 1.664* | 0.942 | 0.604 | 0.208 | 0.984 |
| | D4 | 3.028* | 0.982 | 0.553 | 0.385 | 2.51*4 |
| | D5 | 8.779* | 1.676* | 1.021 | 1.004 | 3.105* |

* Significant at levels $P<0.05$.

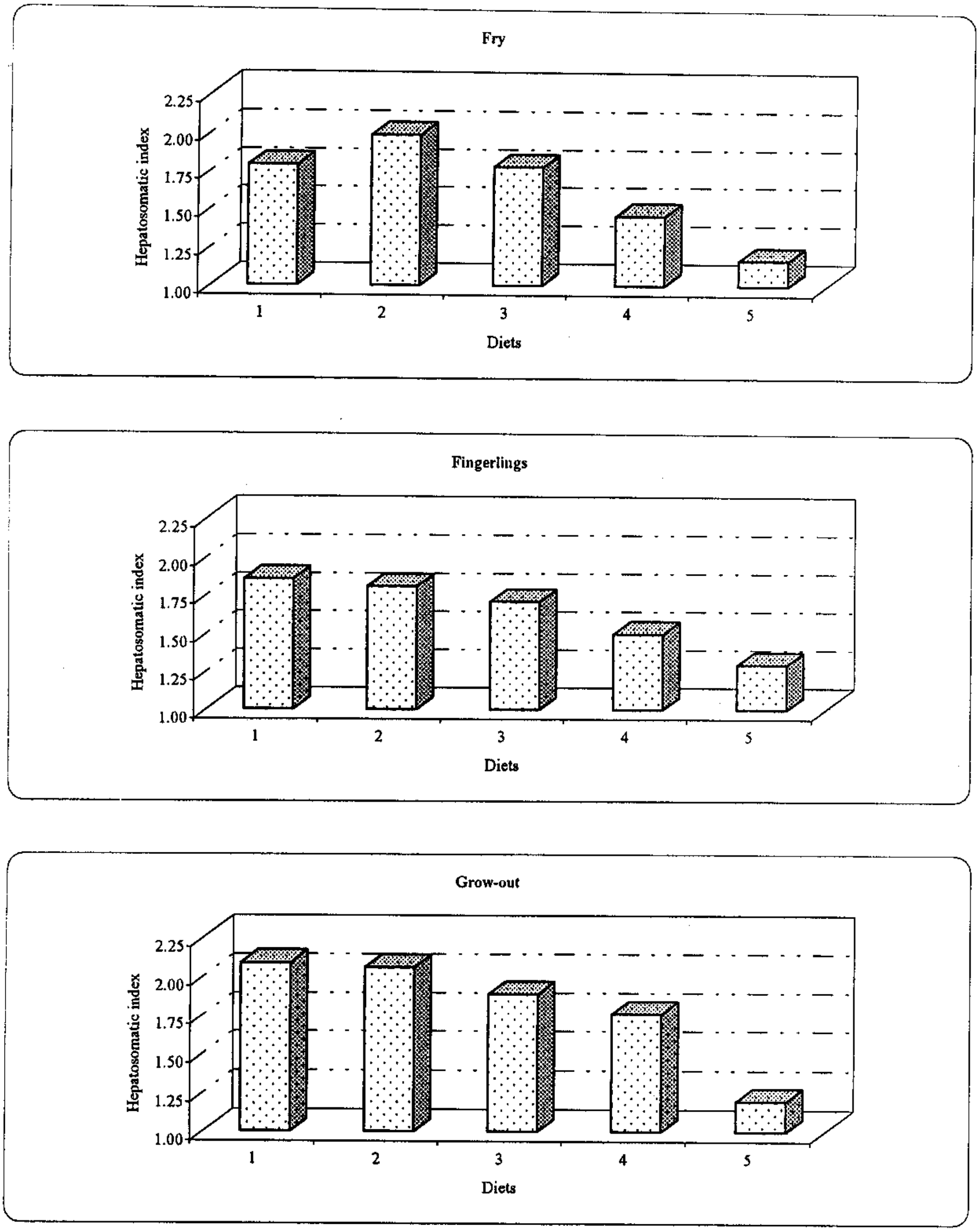



**Fig. (36) : Hepatosomatic index (H.I.S) of *O. niloticus* fed different levels of boiled soybean meal (BSM) diets for 18 weeks**

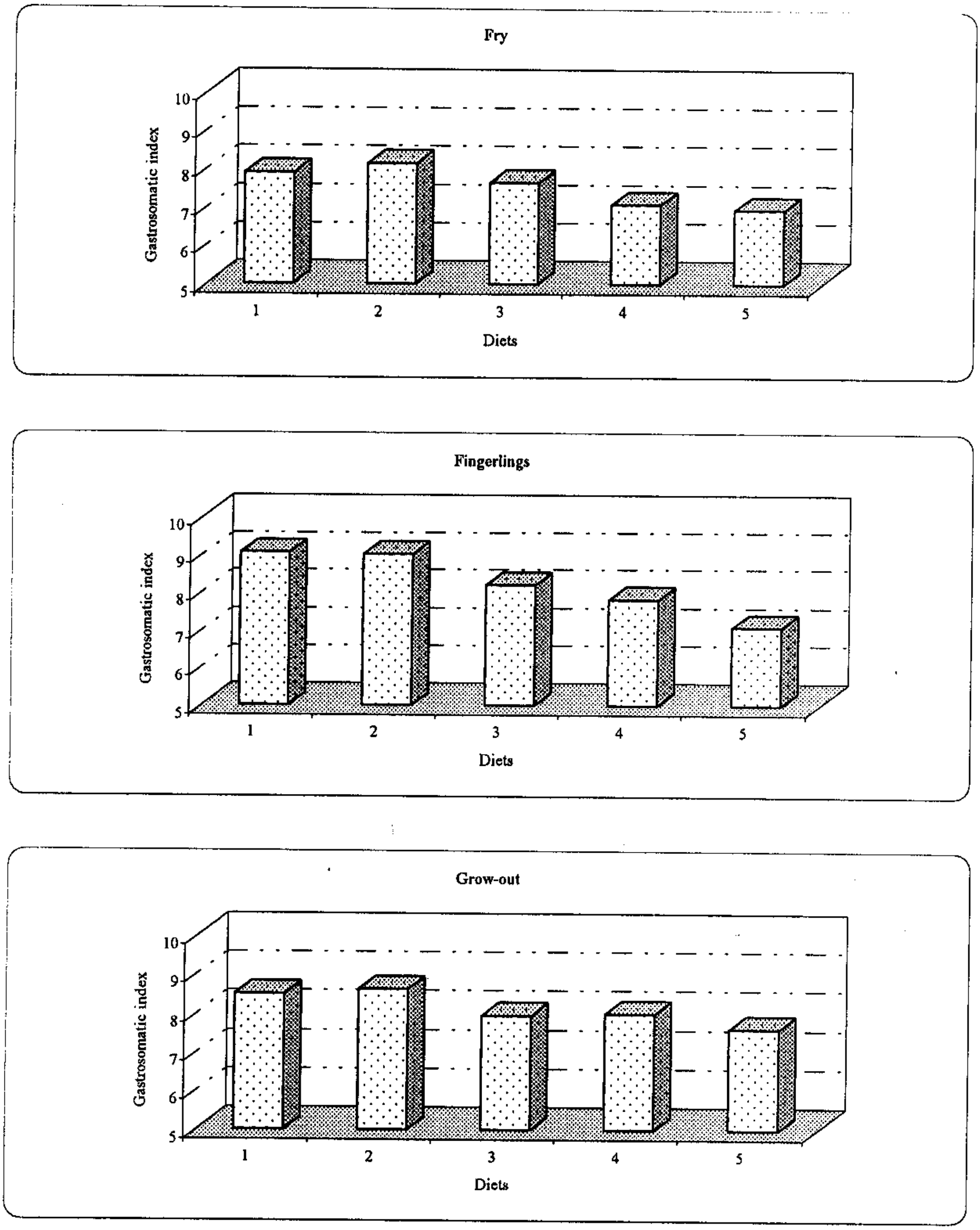



**Fig. (37): Gastrosomatic index (G.S.I) of *O. niloticus* fed different levels of boiled soybean meal (BSM) diets for 18 weeks**

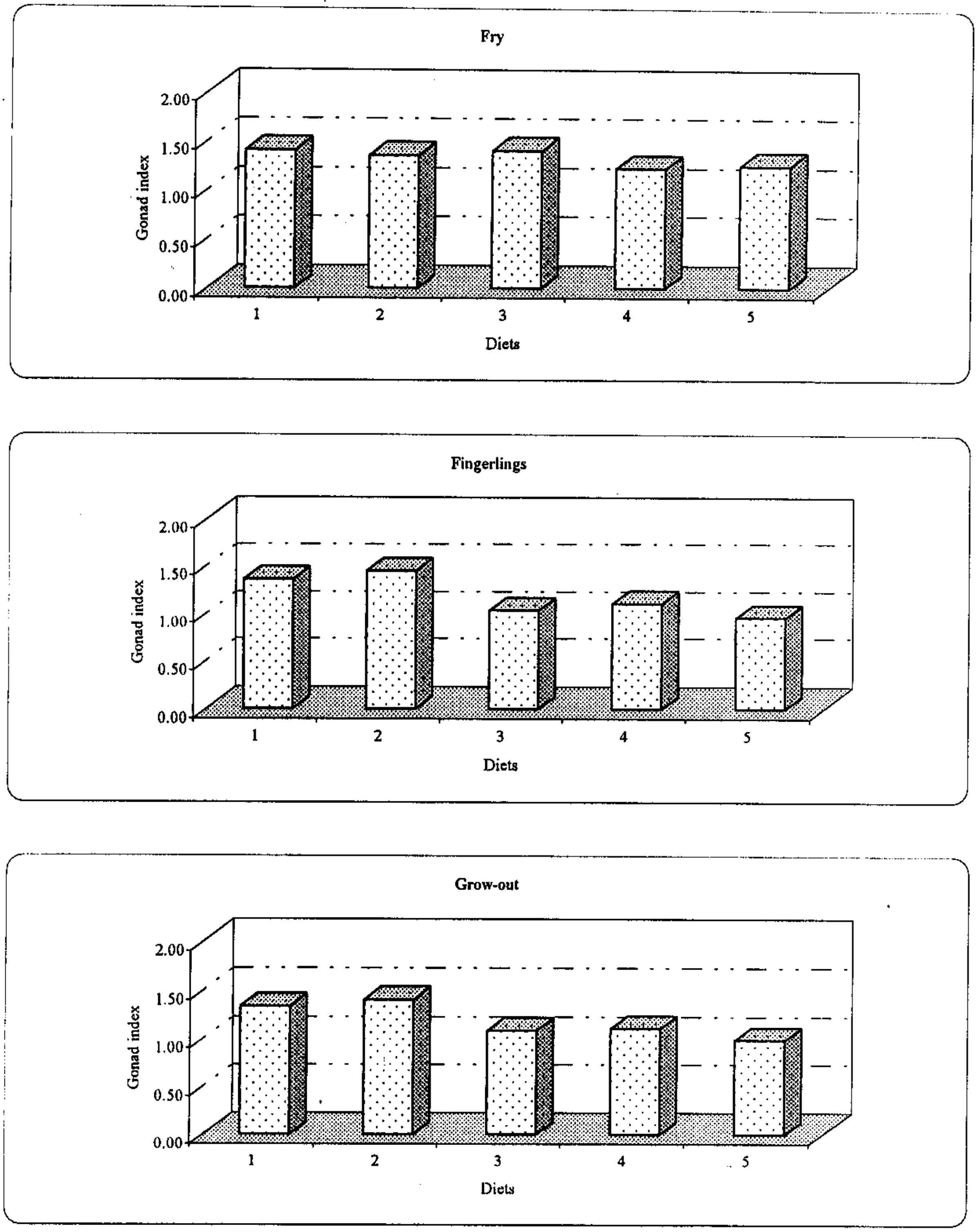



**Fig. (38): Gonad index (G I) of *O. niloticus* fed different levels of boiled soybean meal (BSM) for 18 weeks**

# CHAPTER IV

## Experiment 3

## 3. Effect of using a mixture of both FFS and BSM (MIX) as FM replacer in *O. niloticus* diets :

**Objective :**

Determination of the optimum inclusion level of MIX as a FM replacer within *O. niloticus* diets fed to fry, fingerlings and grow-out stages.

### 3-1. Effect of MIX on growth performance of *O. niloticus*

#### 3-1-1. *O. niloticus* fry

The results of growth monitoring at the biweekly intervals for *O. niloticus* fry fed the test diets are give in table (53). The present experiment indicated that at the level of 25% MIX inclusion (diet 2), the total weight (TWG) reached a relatively highest value (17.53 g), followed by that for diet 3 (15.42g). Such values were in significantly (P>0.05) different as compared with control fish fed diet 1 (20.04g).

Further increase in MIX inclusion level within the test diets has led to decreased TWG (12.69 & 10.17g for fry fed diets 4 & 5 respectively). Such lowest values were also insignificantly different as compared with the control fish fed diet 1 (Fig. 39).

Similar trend was attained for percentage weight gain (PWG) and daily weight gain (DWG) as shown in table (54). Thus maximum PWG and DWG values were recorded for fry fed diet 2 (41.39 & 0.13 g/ fish/ day respectively). Further increase in MIX inclusion levels within the test diets has led to a decrease in PWG and DWG reaching the lowest values for fry fed diet 5 (33.49 & 0.08g/ fish/ day). All PWG and DWG values recorded for fish fed the test diets were insignificantly different as compared with CTR fish fed diet 1 (Figs. 40 & 41).

Therefore fish meal could be safely replaced by a MIX at the level of 25% inclusion or a maximum of 50% within fry *O. niloticus* diets, without significant effects on growth rates.

The highest specific growth rates (SGR) were achieved for fry fed diet 2 (2.57) followed by diet 3 (2.45). The SGR values decreased by further increase in MIX inclusion level recording minimum values for fry fed diets 4 & 5 (2.10 & 1.92 respectively), which were tested to be significantly different ($P< 0.05$) as compared with the CTR fish (Table 54 & Fig. 42).

As shown in table (54) and illustrated in fig. (43), the total length gain (TWG) was maximum for fry fed diet 2 (10.02cm/ fish) with a decreasing trend along with further increase in MIX inclusion level, attaining values which were insignificantly different as compared with the control fish.

Similarly, condition factor "K" was best for fry fed diet 2 (1.86) with a slight decreasing trend accompanied by further increase in MIX inclusion level. The lowest "k" value was reached for fry fed diet 5 (1.71) which was significantly different as compared with the CTR fish fed diet 1 (Fig. 44).

**3-1-2. *O. niloticus* fingerlings :**

Similarly, final weights at biweekly intervals as well as total weight gain (TWG) of *O. niloticus* fingerlings fed the test diets are summarized in table (55) and figs. (39 to 41).

The results indicated that TWG reached a maximum (53.51g) for fish fed diet 2 followed by fish fed diet 3 (50.43g). Further increase in MIX inclusion level within the test diets has led to decreased TWG without significant effect on growth rate compared with the control fish.

The results of PWG and DWG showed similar trend as TWG (Table 56). Thus the highest PWG and DWG were observed for fish fed diet 2 (22.67 & 0.40 g/ fish/ day respectively). The lowest PWG (16.55g) was reached for fish fed diet 5 and was tested to be significantly different (P<0.05) as compared with fish fed diet 1 (CTR fish).

Inclusion of different levels of MIX within the diets of *O. niloticus* fingerlings had insignificant effects on DWG values.

The values of SGR were highest for fish fed diet 2 (1.58g) followed by diet 3 (1.52g). They decreased with further increase in MIX inclusion level within the diets attaining lowest values (1.37 & 1.18g) for fish fed diets 4 & 5 respectively, which were significantly different as compared with the CTR fish fed diet 1 (Fig. 42).

Total length gain was highest for fish fed diet 2 (15.58 cm/ fish) followed by diet 3 (15.35 cm/ fish). Its values dropped by further increase in MIX inclusion level within the diets attaining values of 14.53 & 13.37 cm/ fish for fish fed diets 4 & 5 respectively. All TLG values were insignificantly different as compared with control fish (Fig. 43).

**Table (56) : Growth performance of *O. niloticus* fignerlings fed different levels of MIX-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 10.35 | 10.35 | 10.35 | 10.35 | 10.35 |
| Final weight | (g/fish) | 66.75 | 63.86 | 60.78 | 52.77 | 40.38 |
| Total weight gain | (g/fish) | 56.05 | 53.51 | 50.43 | 42.42 | 30.03 |
| Percentage weight gain | (PWG) | 23.26 | 22.67 | 22.05 | 19.98 | 16.55* |
| Daily weight gain | (g/fish/day) | 0.42 | 0.40 | 0.37 | 0.31 | 0.22 |
| Specific growth rate | (SGR) | 1.61 | 1.58 | 1.52 | 1.37* | 1.18* |
| Initial length | (cm/fish) | 7.60 | 7.60 | 7.60 | 7.60 | 7.60 |
| Total length gain | (cm/fish) | 15.65 | 15.58 | 15.35 | 14.53 | 13.37 |
| Condition factor | "K" (%) | 1.98 | 1.89 | 1.82 | 1.77* | 1.74* |

MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, w/w).
* Significant at levels $P<0.05$.

Fingerlings fed diets 2 & 3 showed the best "K" values (1.89 & 1.82g respectively), while that fed diet 4 & 5 attained lower values (1.77 & 1.74 g respectively) which were significantly different ($P<0.05$) as compared with control fish (Fig. 44).

### 3-1-3. *O. niloticus* grow-out :

Similarly, final weights at biweekly intervals as well as TWG of *O. niloticus* grow-out stage fed the test diets are summarized in table (57) and graphically represented in figs (39 to 41). The TWG values showed same tendency as described previously for fry and fingerlings showing highest value for fish fed diet 2 (122.81g) then followed by a decreasing trend along with the increase in MIX inclusion level within the diets without significant differences as compared with the control fish.

Similar observation was noticed for PWG results, but the lowest value (1.69) attained for fish fed diet 5 was tested to be significantly different as compared with CTR fish.

Also, results of DWG showed same tendency as for TWG and PWG without significant differences when compared with CTR fish fed diet 1.

Fish fed all MIX diets (from 2 to 5) showed SGR values lower and significantly different if compared with fish fed diet 1 (Fig. 42).

The highest TLG value was achieved for fish fed diet 2 (20.37 cm/ fish), but decreased consequently along with the increase in MIX inclusion levels attaining lowest value (17.29 cm/ fish) for that fed diet 5. Inclusion of MIX had insignificant effects on TLG for fish fed all test diets (Fig. 43).

**Table (57) : Total weight gain (g) of *O. niloticus* grow-out fed different levels of MIX-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|
| | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ | $W_2 \pm SD$ |
| 0 (Initial) | 23.45 ± 5.32 | 23.45 ± 5.39 | 23.45 ± 6.08 | 23.45 ± 5.14 | 23.45 ± 6.36 |
| 2 | $28.80^{a}$ ±. 7.14 | $28.70^{a}$ ± 7.09 | $27.91^{b}$ ± 7.15 | $27.00^{c}$ ± 6.36 | $26.00^{d}$ ± 6.94 |
| 4 | $35.97^{a}$ ± 8.21 | $34.67^{b}$ ± 7.83 | $32.00^{c}$ ± 7.92 | $32.00^{c}$ ± 7.34 | $30.30^{d}$ ± 7.56 |
| 6 | $45.23^{a}$ ± 11.26 | $43.00^{b}$ ± 10.51 | $40.90^{c}$ ± 9.67 | $39.00^{d}$ ± 9.13 | $37.06^{e}$ ± 8.69 |
| 8 | $61.00^{a}$ ± 12.11 | $59.16^{b}$ ± 10.98 | $56.12^{c}$ ± 10.93 | $50.90^{d}$ ± 10.40 | $46.26^{e}$ ± 9.99 |
| 10 | $75.17^{a}$ ± 14.69 | $73.75^{b}$ ± 13.42 | $71.00^{c}$ ± 12.95 | $63.01^{d}$ ± 12.78 | $55.10^{e}$ ± 10.88 |
| 12 | $90.60^{a}$ ± 16.21 | $88.94^{a}$ ± 15.97 | $84.00^{b}$ ± 14.66 | $69.10^{c}$ ± 12.88 | $62.23^{d}$ ± 12.09 |
| 14 | $108.11^{a}$ ± 18.60 | $107.67^{a}$ ± 17.67 | $93.00^{b}$ ± 16.55 | $79.20^{c}$ ± 14.70 | $68.42^{d}$ ± 12.86 |
| 16 | $122.60^{a}$ ± 19.99 | $122.00^{a}$ ± 19.11 | $115.90^{b}$ ± 18.79 | $89.60^{c}$ ± 15.93 | $78.91^{d}$ ± 14.73 |
| 18 (Final) | $147.74^{a}$ ± 21.17 | $146.26^{a}$ ± 20.58 | $133.01^{b}$ ± 19.92 | $106.51^{c}$ ± 17.51 | $85.84^{d}$ ± 15.86 |
| Total weight gain (g) | $124.29^{a}$ | $122.81^{b}$ | $109.56^{c}$ | $83.11^{d}$ | $62.39^{e}$ |

SD = Standard deviation
$W_2$ = Mean weight (g)

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
Total weight gain = Final weight – Initial weight.
a,b,c,d,e Means followed by the same letters are not significantly different at levels $p<0.05$.

**Table (58) : Growth performance of *O. niloticus* grow-out fed different levels of MIX diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| Initial weight | (g/fish) | 23.45 | 23.45 | 23.45 | 23.45 | 23.45 |
| Final weight | (g/fish) | 147.74 | 146.26 | 133.01 | 106.56 | 85.84 |
| Total weight gain | (g/fish) | 124.29 | 122.81 | 109.56 | 83.11 | 62.29 |
| Percentage weight gain | (PWG) | 22.76 | 22.73 | 21.52 | 18.47 | 15.63* |
| Daily weight gain | (g/fish/day) | 0.92 | 0.91 | 0.81 | 0.62 | 0.46 |
| Specific growth rate | (SGR) | 1.52 | 1.43* | 1.31* | 1.15* | 1.00* |
| Initial length | (cm/fish) | 10.19 | 10.19 | 10.19 | 10.19 | 10.19 |
| Total length gain | (cm/fish) | 20.25 | 20.37 | 19.48 | 18.78 | 17.29 |
| Condition factor | "K" (%) | 1.85 | 1.82 | 1.80 | 1.73 | 1.69* |

MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, w/w).
* Significant at levels $P<0.05$.

**Table (59) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of growth performance for fish fed different levels of mixture of both FFS and BSM (1:1, W/W).**

| Different stages | Test diets | Total Weight Gain (WG) | Percentage Weight Gain (PWG) | Specific Growth Rate (SGR) | Condition Factor (CF) |
|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.183 | 0.114 | 0.627 | 0.117 |
| | D3 | 0.420 | 0.252 | 1.210 | 0.629 |
| | D4 | 1.108 | 0.600 | 3.501* | 1.398 |
| | D5 | 1.375 | 0.756 | 4.067* | 2.634* |
| Fingerlings | D2 | 0.134 | 0.145 | 0.185 | 0.561 |
| | D3 | 0.292 | 0.289 | 0.573 | 1.177 |
| | D4 | 0.666 | 0.942 | 1.745* | 1.549* |
| | D5 | 1.251 | 1.784* | 3.569* | 1.685* |
| Grow-out | D2 | 0.055 | -0.060 | 1.692* | 0.409 |
| | D3 | 0.322 | 0.302 | 3.146* | 0.544 |
| | D4 | 0.933 | 1.393 | 6.033* | 1.426 |
| | D5 | 1.406 | 2.497* | 7.879* | 1.778* |

* Significant at levels $P<0.05$.

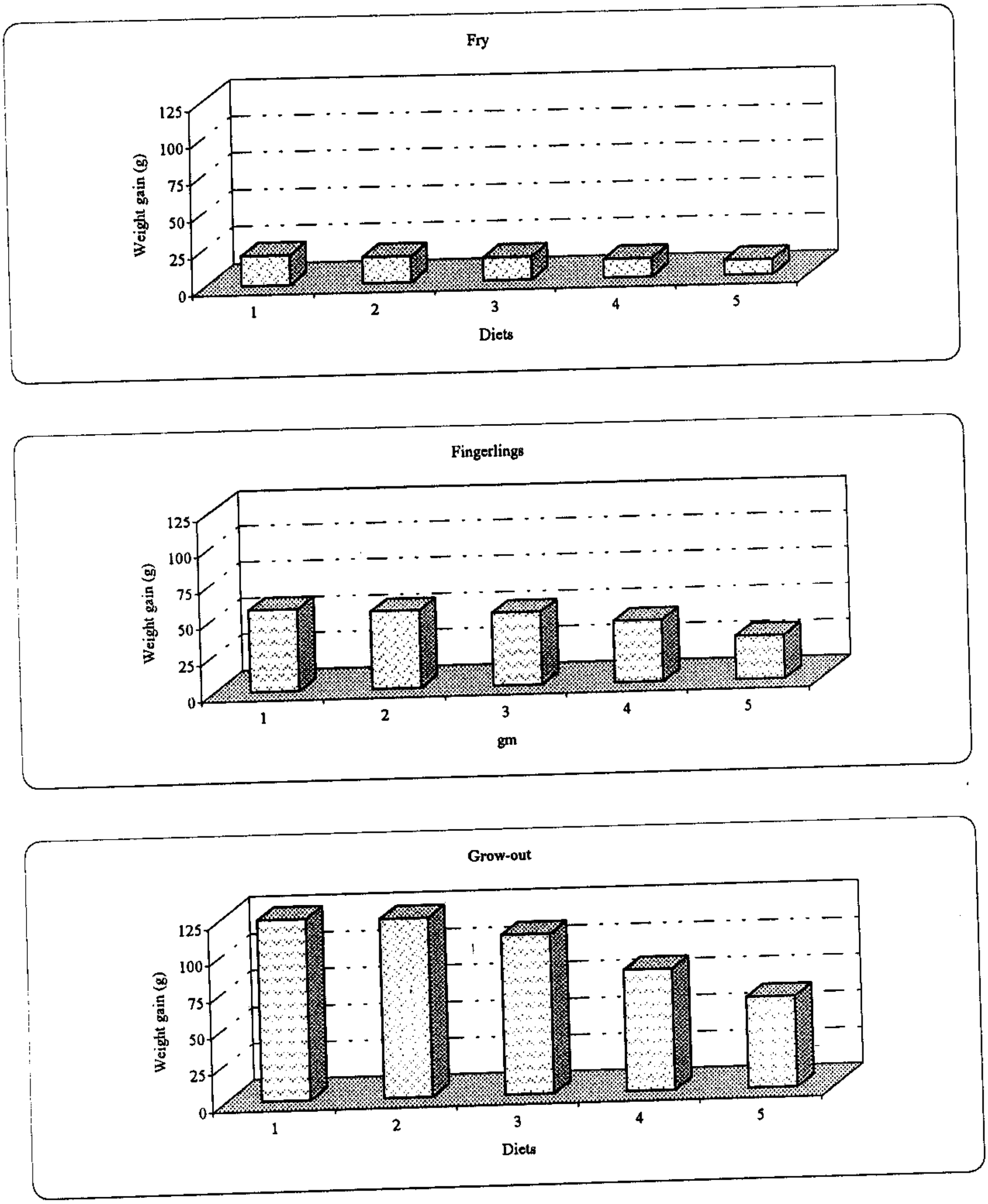



**Fig. (39) : Total weight gain (g) of *O. niloticus* fed different levels of mixture of FFS & BSM (1:1, W/W) for 18 weeks**

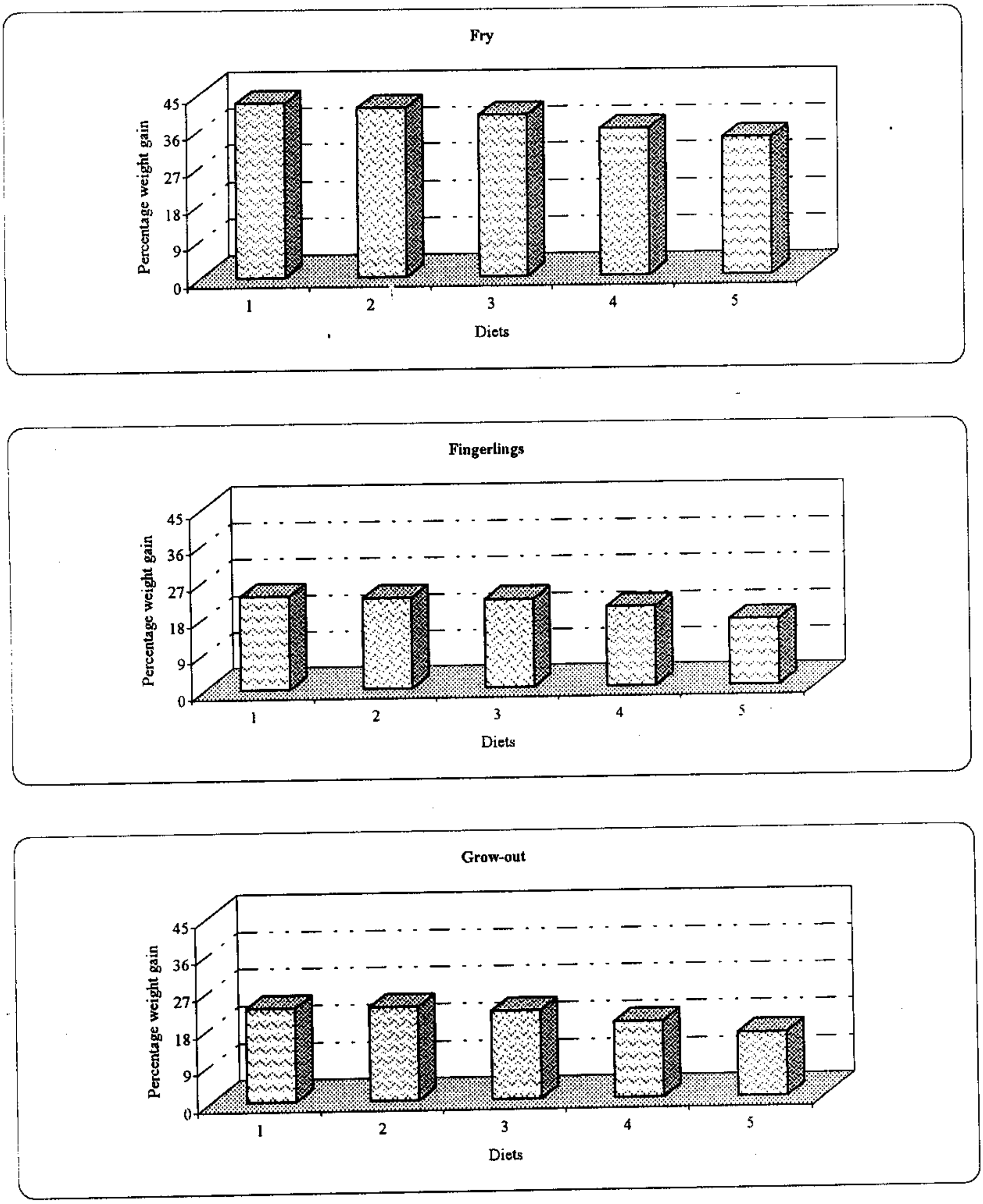



**Fig. (40): Percentage weight gain (PWG) for *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

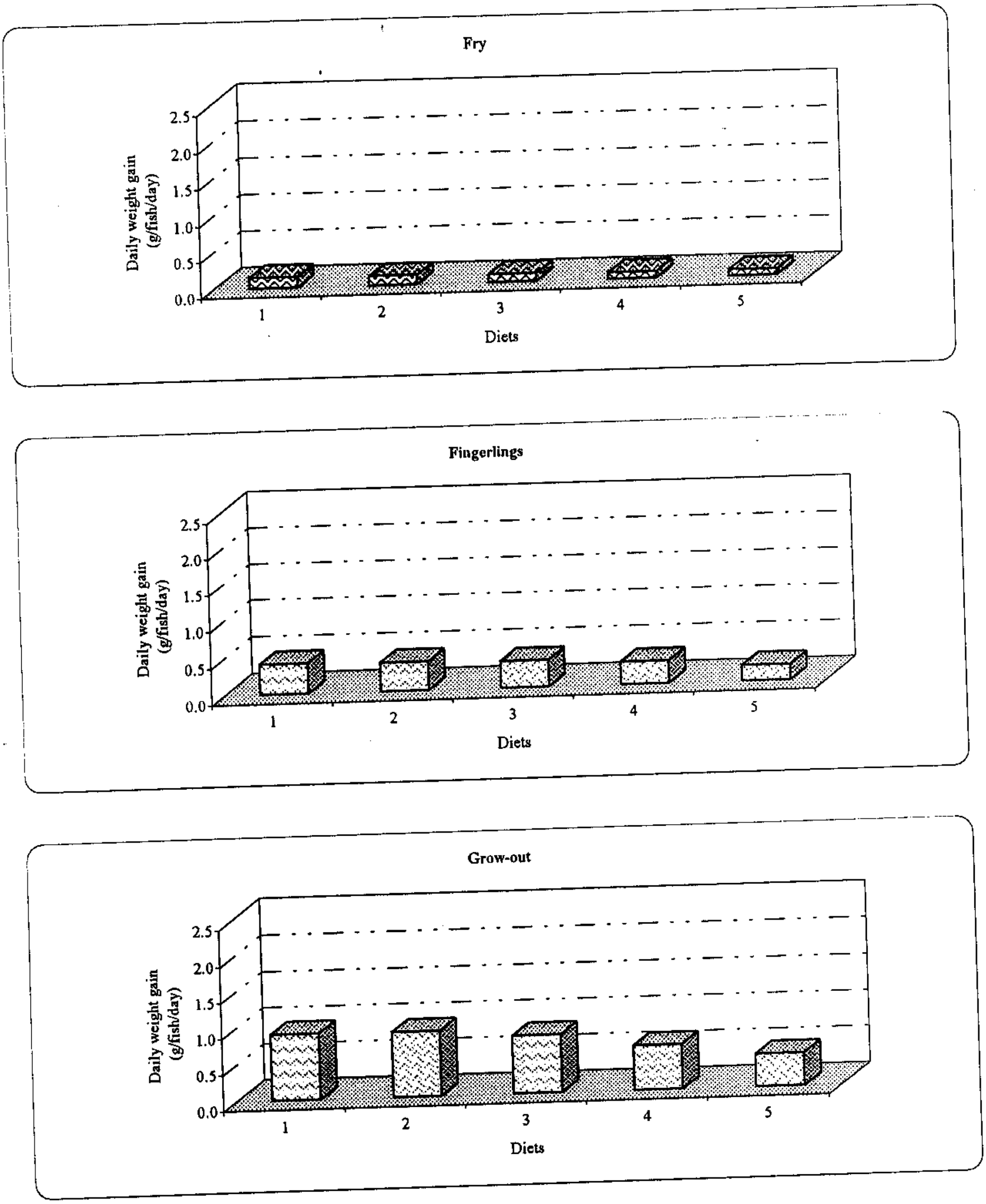



**Fig. (41): Daily weight gain (g/fish/day) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1 W/W) for 18 weeks**

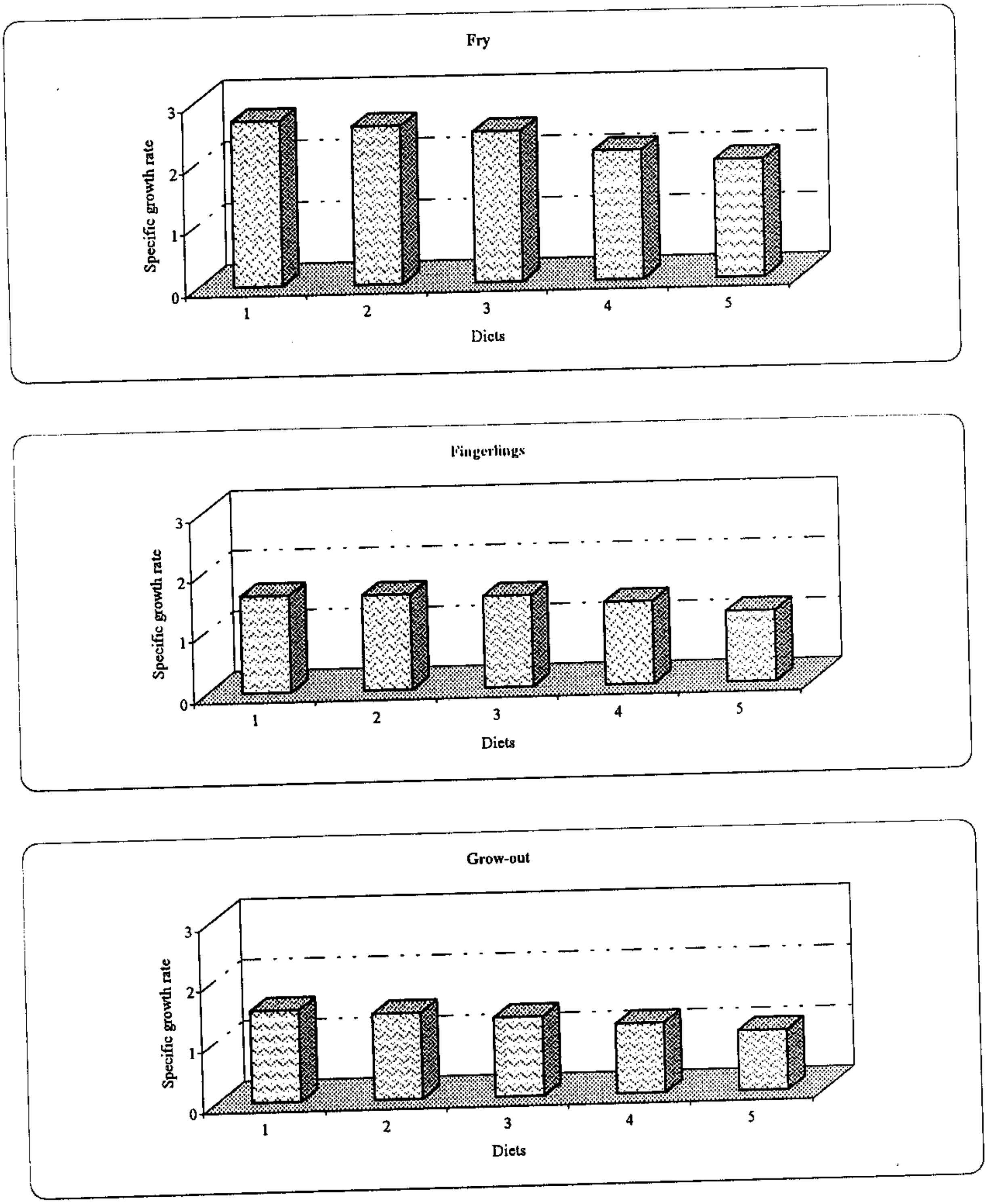



**Fig. (42): Specific growth rate of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

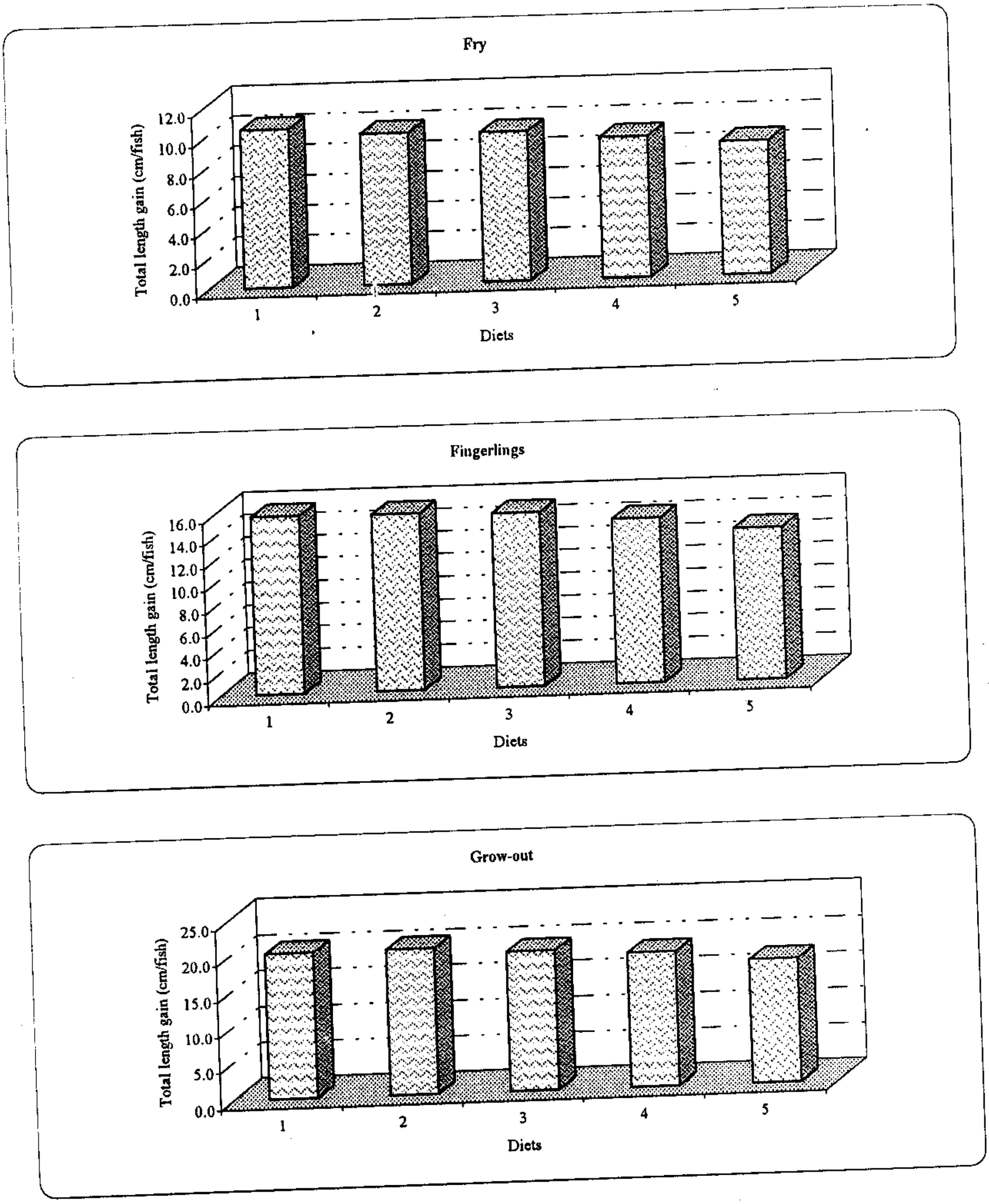



**Fig. (43) : Total length gain (TLG cm/fish) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

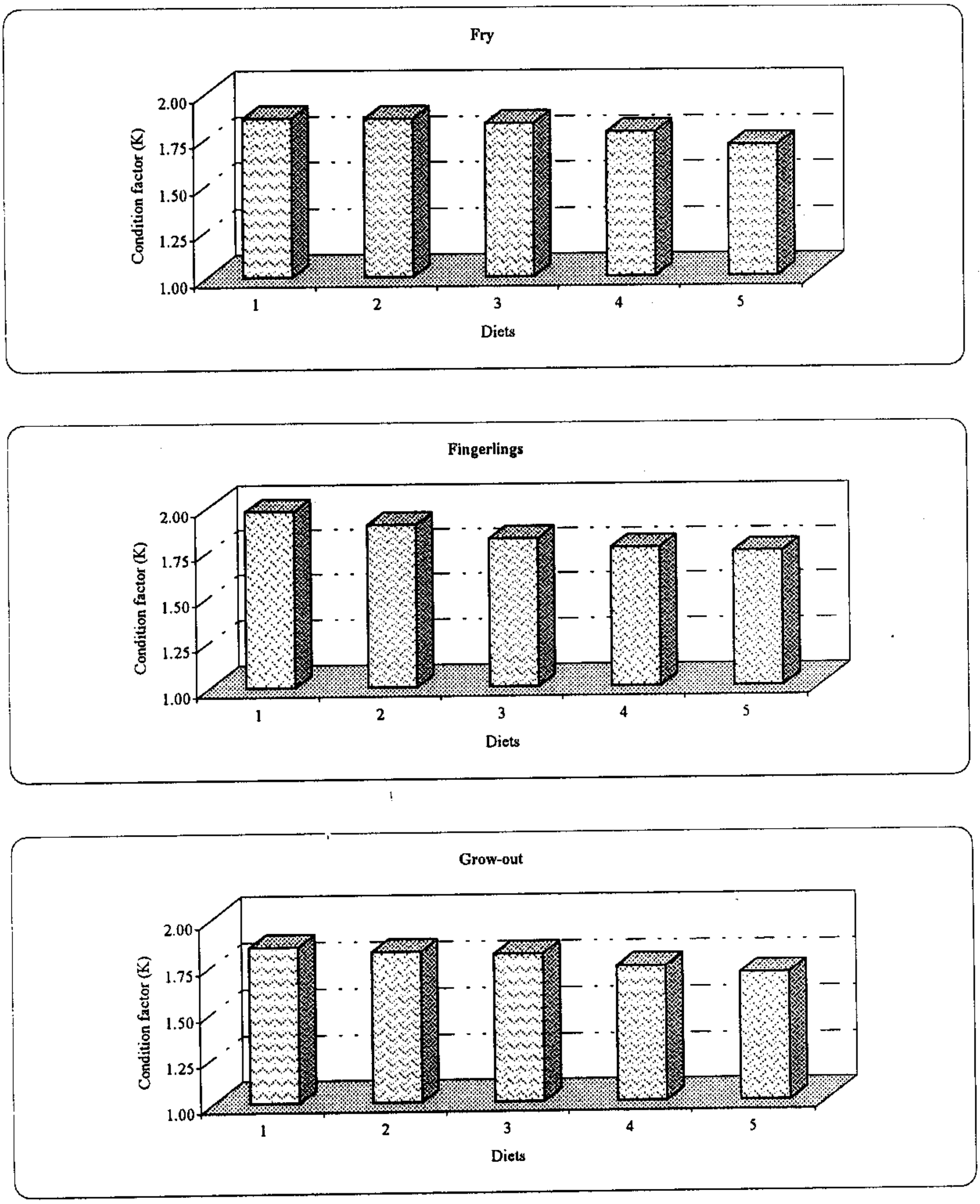



**Fig. (44): Condition factor for of *O. niloticus fed different levels* of mixture of both FFS & BSM (1:1, W/W) for 18 weeks.**

The best "K" values appeared for fish fed diets 2 & 3 (1.82 & 1.80 respectively), while the least (1.69) was for that fed diet 5 which was significantly different as compared with the control fish (Fig. 44).

Statistical analyses of the results of growth performance parameters for all treatments as compared with the corresponding control group are given in table (59).

### 3-2. Effect of using a mixture of both FFS and BSM (MIX) as a FM replacer on feed utilization parameters of *O. niloticus*.

#### 3-2-1. *O. niloticus* fry :

The results of the effect of using different levels of MIX on feed utilization of *O. niloticus* fry are summarized in table (60).

The lowest FCR value was noticed for fry fed diet 2 (1.88), whereas the highest was that fed diet 5 (2.38). The FCR values were insignificantly different as compared with the CTR fish (Fig. 45).

As for PER, the values 3.3 & 3.19 for fry fed diets 2 & 3 respectively were the highest among all treatments, while PER decreased for diets 4 & 5 (2.94 & 2.78 respectively). Variation between values of FCR and the CTR group were proved to be insignificant (Fig. 46).

The results of DFI showed similar trend as those of PER. Thus, fry fed diets 2 & 3 (0.22 & 0.20 respectively) showed the highest DFI, while it decreased along with the increase in MIX inclusion level attaining the lowest DFI values for fry fed diets 4 & 5 (0.15 & 0.14 respectively). The DFI values were tested to be insignificantly different as compared with CTR fish fed diet 1 (Table 60 & Fig. 47).

**Table (60) : Nutritional parameters of *O. niloticus* fry fed different levels of MIX-based diets for 18 weeks.**

| Items | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|
| Food conversion ratio (FCR) | 1.45 | 1.88 | 200 | 1.81 | 2.38 |
| Protein efficiency ratio (PER) | 3.36 | 3.30 | 3.19 | 2.94 | 2.78 |
| Daily feed intake (g/fish/day) | 0.23 | 0.22 | 0.20 | 0.15 | 0.14 |
| Protein productive value | 9.28 | 8.60 | 8.22 | 8.80 | 7.59 |
| Fat retention | 18.97 | 18.56 | 18.38 | 23.26 | 21.56 |
| Energy retention | 11.05 | 10.42 | 10.07 | 11.44 | 10.11 |

MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).

The highest PPV values were recorded for fry fed diets 2 & 4 (8.60 & 8.80 respectively), but was lower for that fed diets 3 & 5 (8.22 & 7.59 respectively). No significant differences were detected between PPV values for fish fed the test diets when compared with that fed diet 1 (Table 60 & Fig. 48).

Fat retention values were insignificantly different for fry fish fed the test diets in comparison with the corresponding for the control fish. The FR values were closely similar for test diets 2 & 3 (Table 60 & Fig. 49). Diet 4 & 5 showed higher FR values than for diet 1 (CTR fish).

As for ER, no significant effects were detected within the test diets for *O. niloticus* fry compared with the CTR fish (Table 60 & Fig. 50).

### 3-2-2. *O. niloticus* fingerlings :

The effect of using different levels of MIX diet on feed utilization of *O. niloticus* fingerlings are summarized in table (61). The lowest FCR (2.28) was attained for fish fed diet 2. Further increase in MIX inclusion level has led to increased FCR, the highest of which was recorded for fish fed diet 5 (3.52), showing a significant difference as compared with the corresponding for fish fed control diet 1 (Fig. 45).

In the mean time, results of PER proved insignificant effect of various inclusion levels as compared with the CTR fish (Fig. 46). The values of PER exhibited a decreasing trend along with the increasing of MIX inclusion level recording the highest value for fish fed diet 2 (1.80) while the lowest was for that fed diet 5 (1.37).

**Table (61) : Nutritional parameters of *O. niloticus* fingerlings fed different levels of MIX-diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Food conversion ratio | (FCR) | 2.10 | 2.28 | 2.56 | 2.43 | 3.52* |
| Protein efficiency ratio | (PER) | 1.81 | 1.80 | 1.78 | 1.64 | 1.37 |
| Daily feed intake | (g/fish/day) | 0.86 | 0.83 | 0.80 | 0.74 | 0.66 |
| Protein productive value | | 1.92 | 1.91 | 1.85 | 1.71 | 1.27 |
| Fat retention | | 3.78 | 3.84 | 4.04 | 3.74 | 3.38 |
| Energy retention | | 2.26 | 2.26 | 2.25 | 2.08 | 1.66 |

MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

As shown in table (61) and demonstrated in fig. (47), the DFI showed the same trend as described for PER. Therefore, the highest value was for fish fed diet 2 (0.83g/ fish/ day). Variations between DFI values for fish fed all test diets and CTR fish were proved to be insignificant.

The PPV was insignificantly affected, despite the apparent decreased trend noted with the increase of MIX inclusion level within the diets, as compared with the value recorded for the control fish (Fig. 48). The maximum value (1.91) was obtained for fish fed diet 2, while fish fed diet 5 recorded the lowest value (1.27).

No significant effects were detected for FR and ER for fingerlings fed the test diets when compared with the corresponding for the control fish (Table 60 and Figs. 49 & 50).

### 3.2.3- *O. niloticus* grow-out :

The effect of using different levels of MIX on feed utilization of *O. niloticus* grow-out stage are summarized in table (62). The lowest FCR value (2.11) was attained for fish fed diet 2. A steady increase in FCR values was observed accompanied by increase in MIX inclusion level, showing the highest value for fish fed diets 4 & 5 (2.70 & 3.23 respectively). These highest values were tested to be significantly different as compared with the control fish (Fig. 45).

A decreasing trend was noticed for the PER values, attaining thus the highest (1.81) for fish fed diet 2. While PER decreased consequently along with the increasing of MIX inclusion level recording the lowest value (1.30) for fish fed diet 5 which was significantly different as compared with the control fish fed diet 1 (Fig. 46).

**Table (62) : Nutritional parameters of *O. niloticus* grow-out fed different levels of MIX-based diets for 18 weeks.**

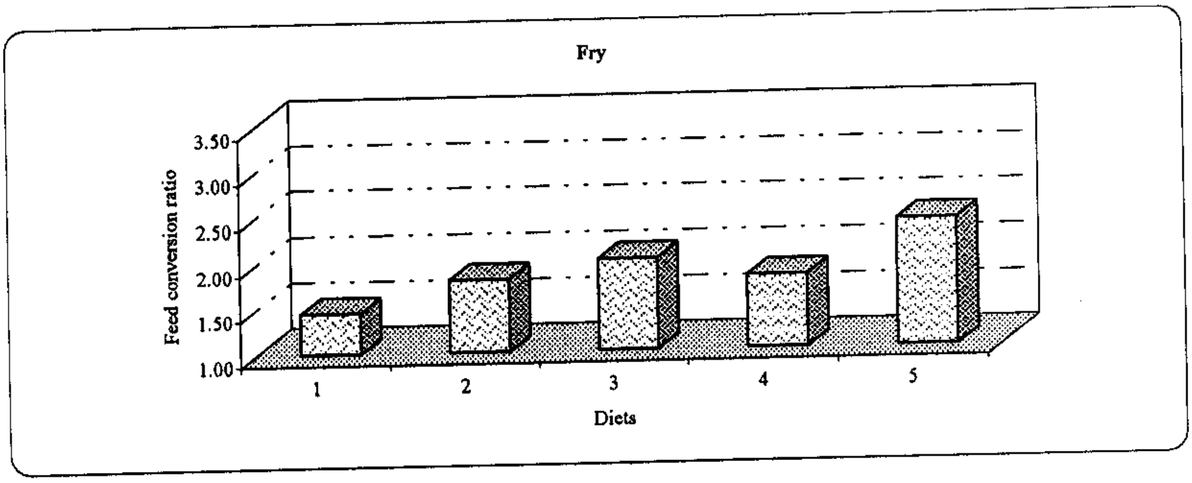
| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Food conversion ratio | (FCR) | 2.09 | 2.11 | 2.39 | 2.70* | 3.23* |
| Protein efficiency ratio | (PER) | 1.79 | 1.81 | 1.74 | 1.51 | 1.30* |
| Daily feed intake | (g/fish/day) | 1.97 | 1.94 | 1.81 | 1.58 | 1.43 |
| Protein productive value | | 2.83 | 2.96 | 2.75 | 2.43 | 1.90 |
| Fat retention | | 5.33 | 5.74 | 5.95 | 5.62 | 5.08 |
| Energy retention | | 3.29 | 3.47 | 3.33 | 3.01 | 2.48 |

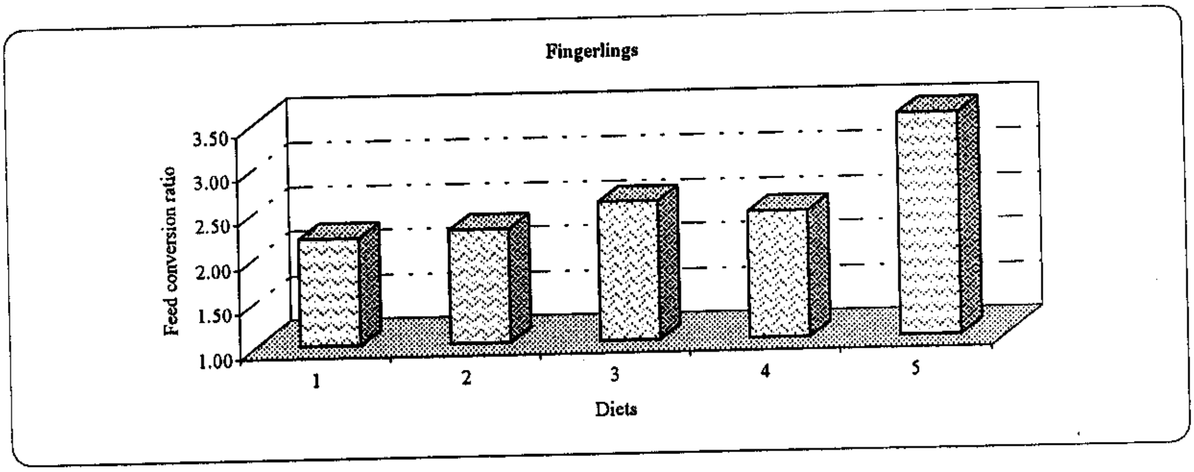
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (63) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of nutritional parameters for fish fed different levels of mixture of both FFS and BSM.**

| Different stages | Test diets | Food Conversion Ratio (FCR) | Protein Efficiency Ratio (PER) | Daily Feed Intake (DFI) |
|---|---|---|---|---|
| | | t-c | t-c | t-c |
| Fry | D2 | -0.572 | 0.064 | 0.135 |
| | D3 | -0.809 | 0.165 | 0.344 |
| | D4 | -0.694 | 0.458 | 1.097 |
| | D5 | -1.354 | 0.585 | 1.292 |
| Fingerlings | D2 | -0.177 | 0.024 | 0.140 |
| | D3 | -0.575 | 0.077 | 0.308 |
| | D4 | -0.597 | 0.625 | 0.673 |
| | D5 | -1.688* | 1.469 | 1.193 |
| Grow-out | D2 | -0.079 | -0.063 | 0.063 |
| | D3 | -0.819 | 0.198 | 0.322 |
| | D4 | -1.659* | 1.214 | 0.912 |
| | D5 | -2.656* | 2.281* | 1.331 |

* Significant at levels $P<0.05$.



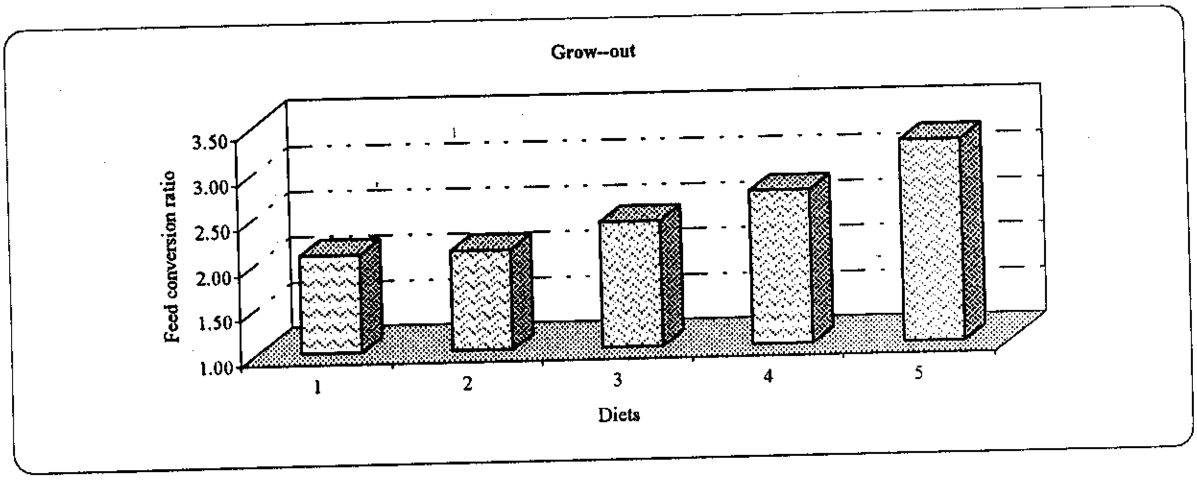




**Fig. (45): Feed conversion ratio (FCR) for *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks.**

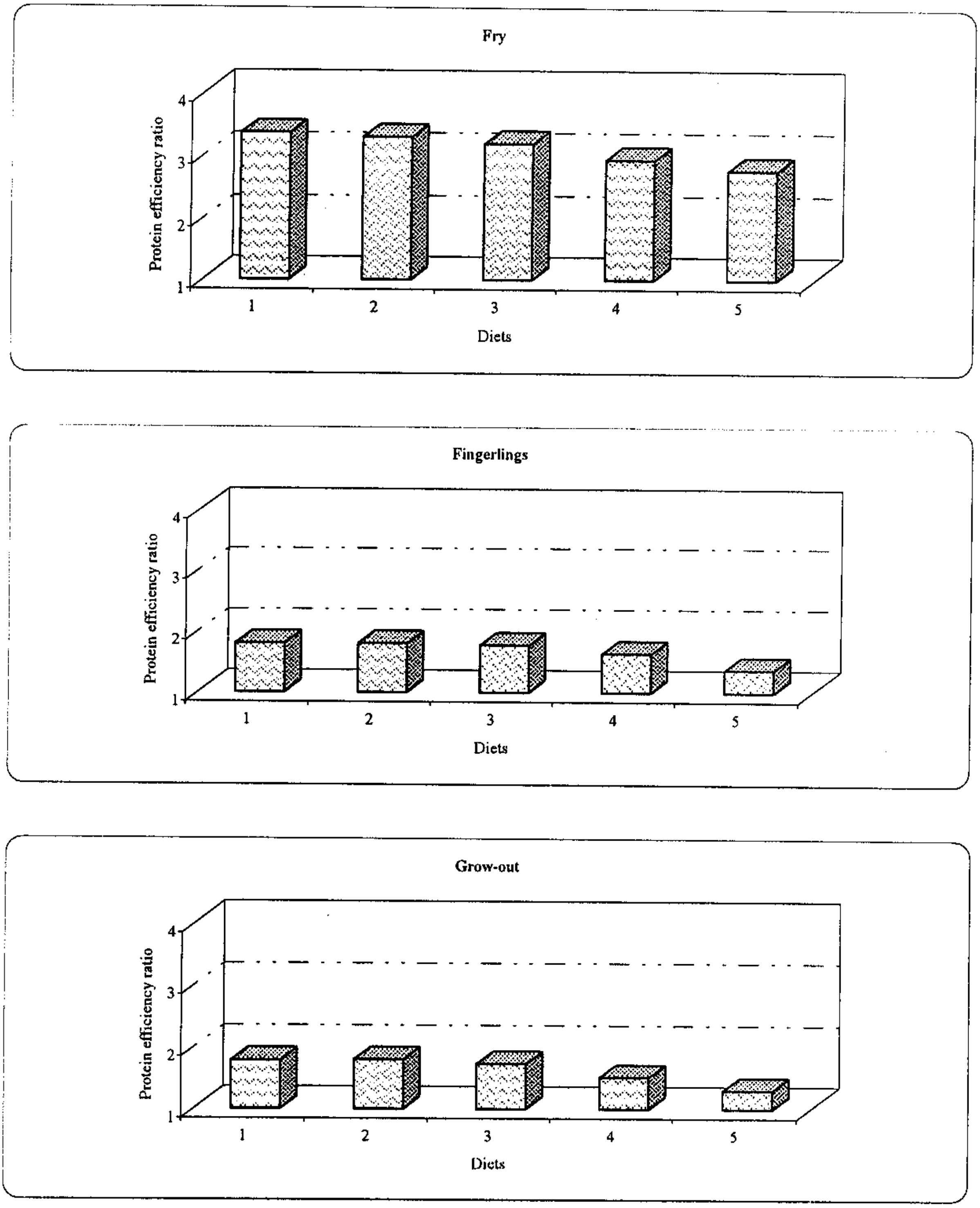
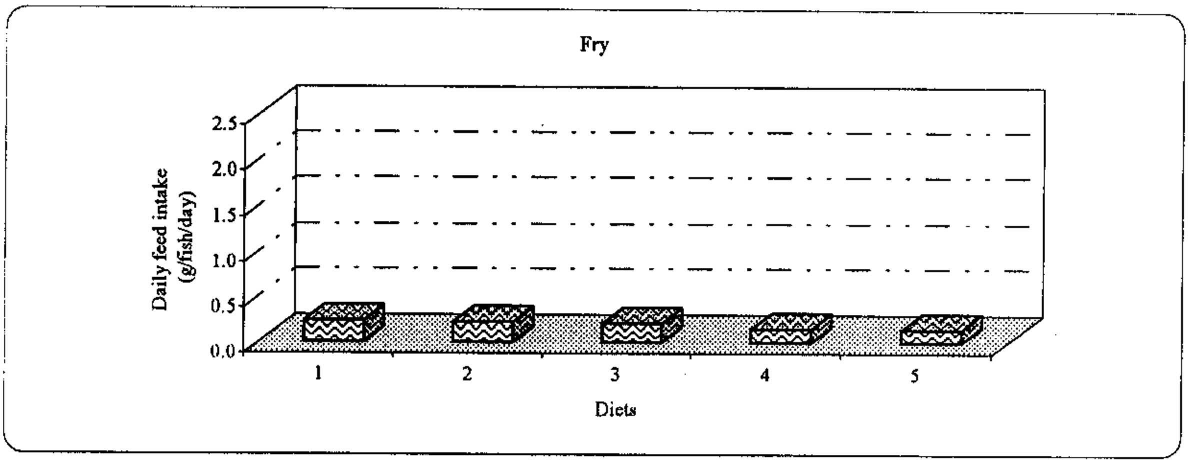
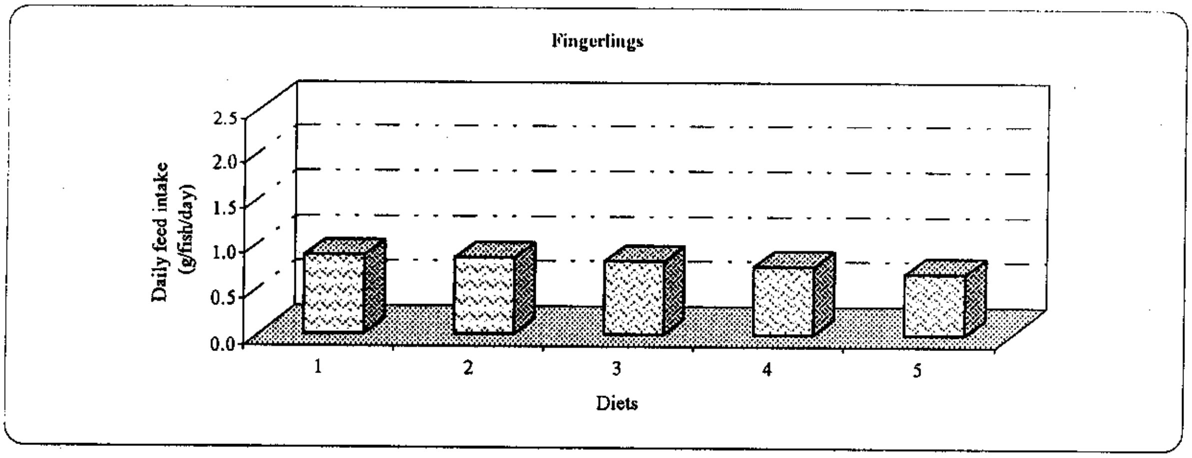



**Fig. (46): Protein efficiency ratio (PER) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1 W/W) for 18 weeks**



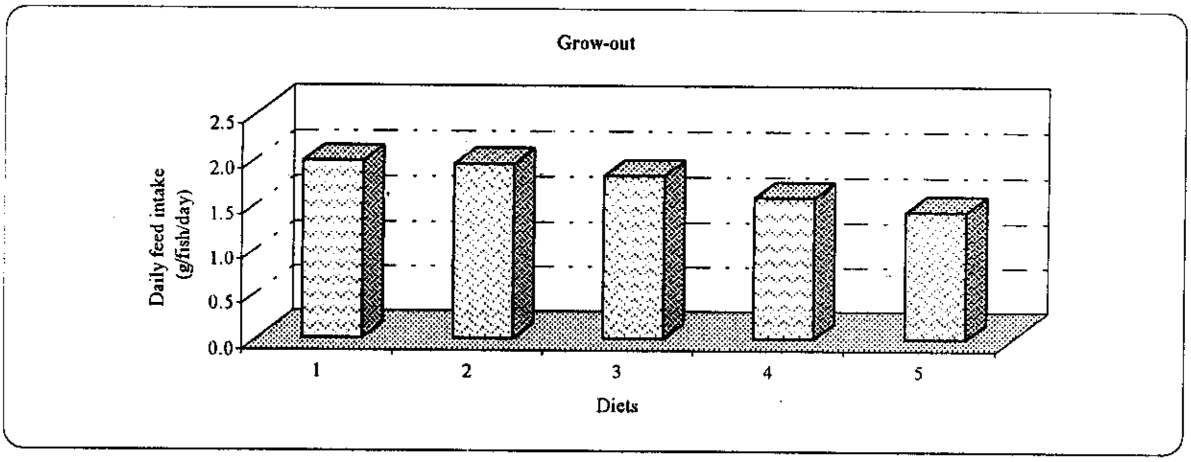




**Fig. (47) : Daily feed intake (DFI g/fish/day) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1 W/W) for 18 weeks**

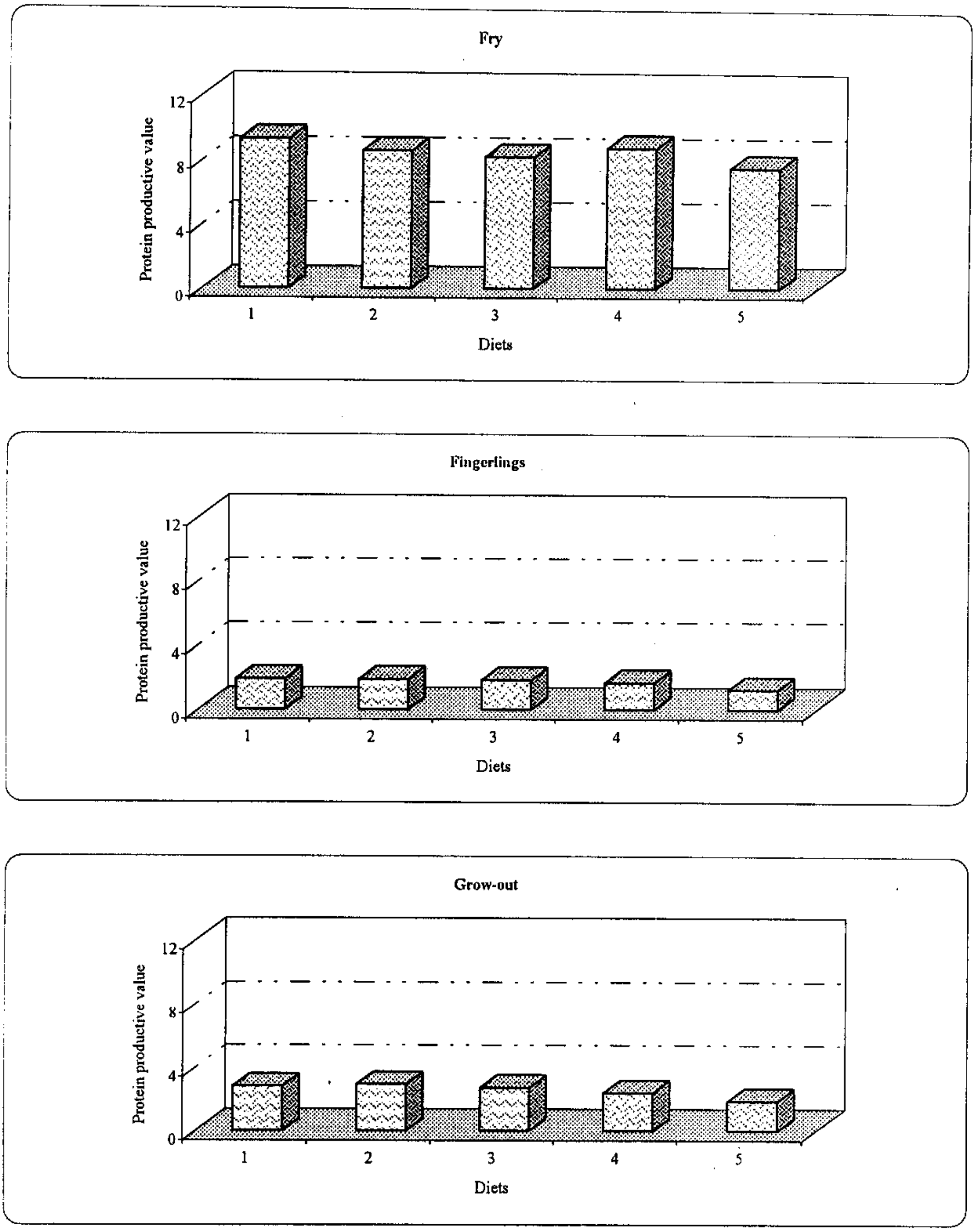



**Fig. (48) : Protein productive value (PPV) of *O. niloticus* fed different levels of both FFS & BSM (1:1, W/W) for 18 weeks**

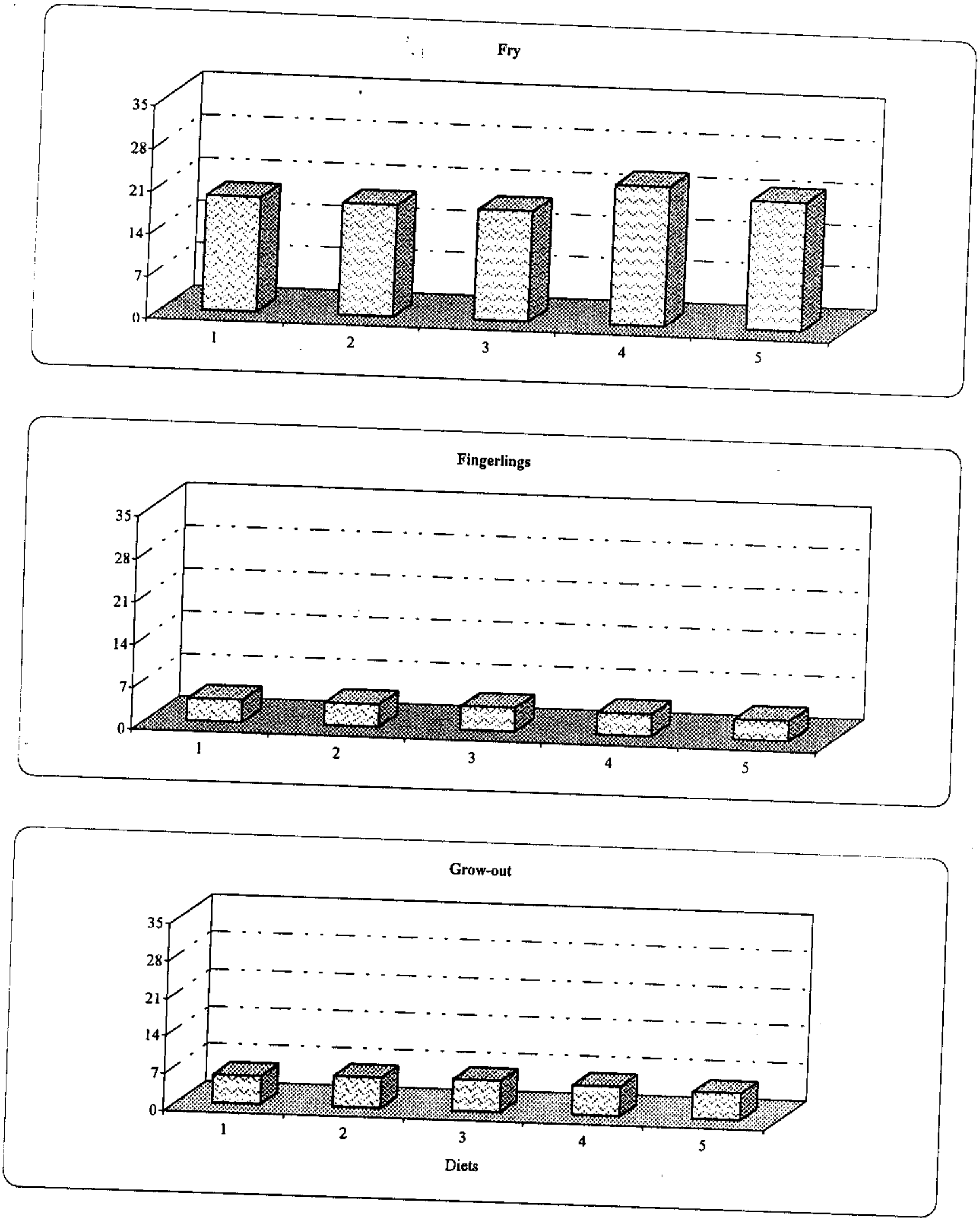



**Fig. (49) : Fat retention (FR) of *O. niloticus* fed different levels mixture of both FFS & BSM (1:1 W/W) fro 18 weeks**

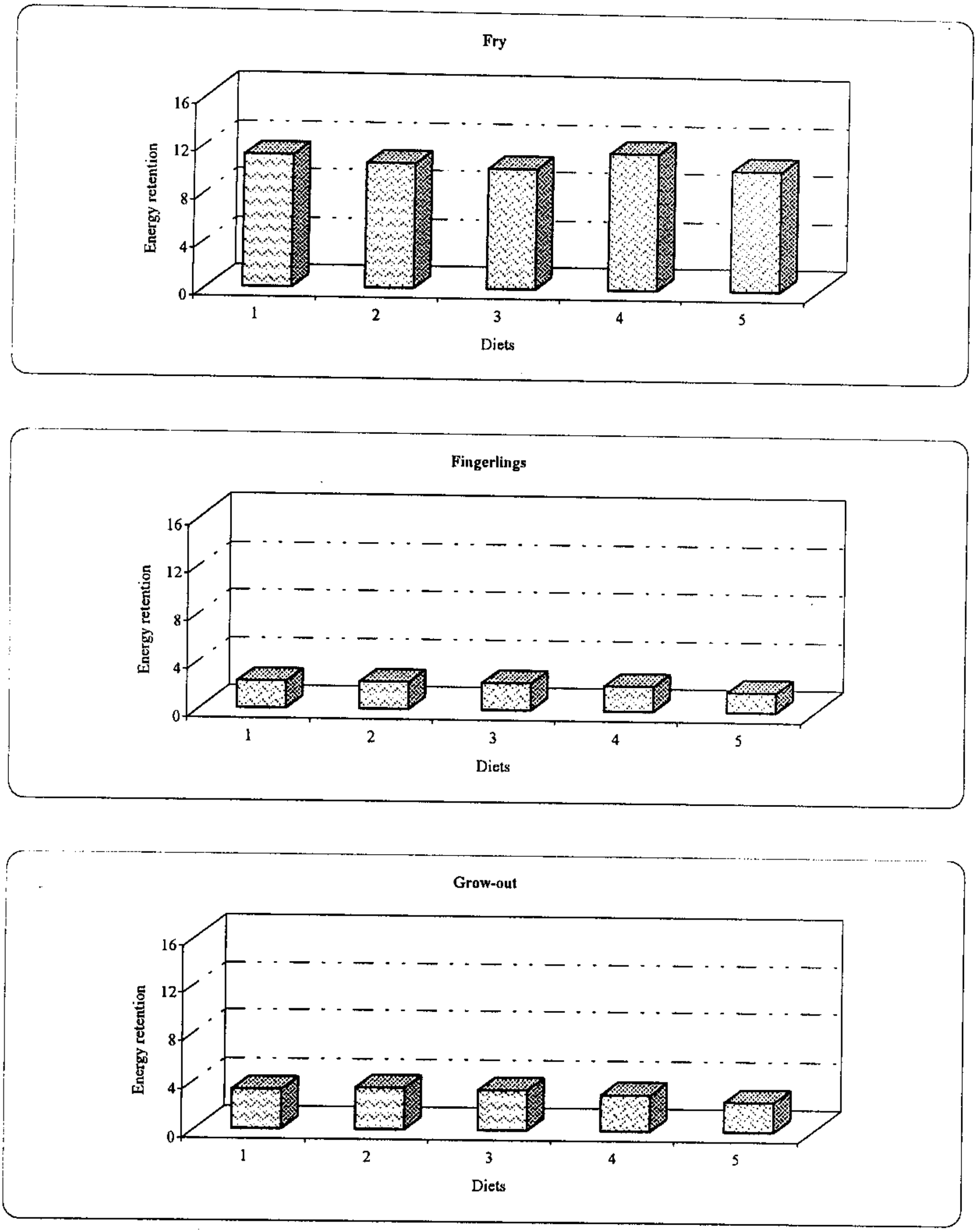



**Fig. (50): Energy retention (ER) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1 W/W) for 18 weeks**

The DFI and PPV revealed similar trend as the PER. They showed a decreasing tendency with the increase of MIX inclusion level of reach insignificantly lowest records (1.43 & 1.90 respectively) for fish fed diet 5 as compared with the respective control fish (Figs. 47 & 48).

Insignificant effects were detected for FR and ER for grow-out stage fed the test diets as compared with the corresponding control fish (Figs. 49 & 50).

Statistical analyses of results for the test diets as compared with the control group are given in tables (63).

## 3-3. Effect of MIX inclusion within diets on the biochemical composition of *O. niloticus* :

### 3-3-1. *O. niloticus* fry

Results of body composition (on dry weight basis) at the end of the feeding trials of fry fed the test diets are summarized in table (64) and demonstrated in figs. (51, 52, 53 & 54).

Liver protein showed the highest value for fry fed diets 2 & 3 (19.33 & 19.20 g/ 100g tissue respectively). Further increase in MIX inclusion within the test diets has led to a decrease in liver protein recording the significantly lowest values (18.27 & 17.60 g/ 100 g tissue) for fry fed diet 4 & 5 respectively, as compared with the control fish.

Hepatic total lipids showed the inverse trend of variation recording the significantly ($P<0.05$) highest value for fry fed diet 5 as compared with the control fish.

**Table (64) : Liver and muscle composition of *O. niloticus* fry fed different levels of MIX-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 16.90 ± 0.43 | 19.52 ± 1.13 | 19.33 ± 1.07 | 19.20 ± 1.01 | 18.27*± 0.92 | 17.60*± 0.51 |
| Total lipids | (g/100 g tissue) | 12.00 ± 0.89 | 10.69 ± 0.63 | 11.06 ± 0.76 | 10.87 ± 0.69 | 11.15 ± 0.83 | 11.71*± 0.84 |
| Glycogen | (g/100 g tissue) | 1.81 ± 0.05 | 2.19 ± 0.08 | 2.12 ± 0.07 | 2.10*± 0.07 | 1.95*± 0.06 | 1.90*± 0.06 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 55.19 ± 4.17 | 61.32 ± 5.11 | 60.69 ± 4.79 | 60.07 ± 4.82 | 57.16*± 3.96 | 55.78*± 4.29 |
| Total lipids | (%) | 20.10 ± 2.22 | 16.95 ± 1.29 | 17.68 ± 1.81 | 18.08*± 1.89 | 20.19*± 2.43 | 20.91*± 2.67 |
| Ash | (%) | 20.97 ± 2.34 | 18.73 ± 1.85 | 19.63 ± 2.66 | 18.74 ± 1.97 | 18.80 ± 2.15 | 17.97 ± 1.64 |
| Moisture | (%) | 74.12 ± 4.11 | 76.14 ± 4.62 | 75.61 ± 4.67 | 77.08 ± 5.11 | 78.30 ± 5.26 | 75.43 ± 4.59 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5017.65 | 5066.27 | 5099.80 | 5102.56 | 5138.00 | 5127.60 |
| Metabolizable energy | (K cal/Kg) | 3760.40 | 3747.50 | 3781.40 | 3789.40 | 3845.20 | 3847.80 |
| P/E ratio | | 68.14 | 61.11 | 62.31 | 63.08 | 67.30* | 68.98* |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

At the mean time, inclusion of MIX within the diets had a significant effect (P<0.05) on liver glycogen for fry fed diets 3, 4 & 5 (2.10, 1.95 & 1.90 g/ 100 g tissue respectively) as compared with the control fish fed diet 1.

Crude protein was significantly affected by the inclusion of 75% and 100% MIX in fry diets recording the lowest values (57.16 & 55.78% respectively), when compared with the CTR fish fed 100% FM.

On the other hand, total lipids showed the inverse trend of vairation recording significantly highest values (18.08, 20.19 & 20.91%) for fry fed diets 3, 4 & 5 respectively, as compared with control fish.

Ash and moisture contents were not significantly affected by MIX inclusion levels in fry fed the test diets as compared with the CTR fish.

Gross energy and metabolizable energy also were not significantly affected by the inclusion of MIX in fish diets of in fry stage.

While P/E ratio was significantly affected by MIX inclusion at levels 75% & 100% in fry diets, when compared with the control fish (100% FM).

**3-3-2. *O. niloticus* fingerlings :**

As shown in table (65) and illustrated in figs. (51, 52 & 53), liver protein was significantly affected (P<0.05) by the inclusion of 75% and 100% MIX in fingerlings diets compared with the control fish. While liver lipids were significantly affected for fish fed diet 5 as compared with the control fish.

**Table (65) : Liver and muscle composition of *O. niloticus* fingerlings fed different levels of MIX-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 18.90 ± 1.00 | 22.07 ± 1.99 | 22.16 ± 2.01 | 21.88 ± 1.82 | 21.43*± 1.71 | 20.58*± 1.51 |
| Total lipids | (g/100 g tissue) | 11.30 ± 0.81 | 9.89 ± 0.66 | 9.69 ± 0.51 | 10.07 ± 0.69 | 10.29 ± 0.82 | 10.24*± 0.79 |
| Glycogen | (g/100 g tissue) | 1.89 ± 0.08 | 2.78 ± 0.21 | 2.90 ± 0.20 | 2.43 ± 0.10 | 2.40*± 0.09 | 2.19*± 0.09 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 55.37 ± 2.26 | 65.16 ± 4.92 | 65.18 ± 5.11 | 63.84 ± 3.89 | 63.52 ± 3.88 | 59.28* ± 3.17 |
| Total lipids | (%) | 24.71 ± 2.91 | 18.71 ± 1.51 | 19.09 ± 1.49 | 19.98* ± 1.69 | 20.08 ± 1.80 | 22.18*± 1.87 |
| Ash | (%) | 17.82 ± 1.21 | 14.14 ± 0.89 | 12.79*± 0.64 | 14.88*± 1.06 | 13.39*± 0.86 | 16.54*± 1.08 |
| Moisture | (%) | 76.00 ± 4.36 | 78.14 ± 5.61 | 75.34 ± 3.77 | 76.86 ± 5.19 | 76.19 ± 4.22 | 78.00 ± 5.11 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5463.10 | 5449.00 | 5486.11 | 5495.11 | 5486.56 | 5445.31 |
| Metabolizable energy | (K cal/Kg) | 4136.23 | 4037.65 | 4069.20 | 4088.40 | 4096.40 | 4086.40 |
| P/E ratio | | 74.70 | 61.97 | 62.43 | 64.04 | 64.49 | 68.93* |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels P<0.05.

On the other hand, fish fed diets 4 & 5 showed glycogen contents significantly different ($P<0.05$) as compared with the control fish.

Replacing FM by MIX had significant effects on crude protein, total lipids and ash contents of *O. niloticus* fingerlings. Thus, fish fed diet 5 showed lowest significantly crude protein content (Fig. 54), while fish fed diets 3 & 5 had total lipids significantly higher than fish fed diet 1 (control). At the mean time, fish fed all test diets (from 2 to 5) had ash contents significantly different as compared with the control fish fed diet 1.

Gross energy and metabolizable energy were not significantly affected by the inclusion levels of MIX in fish diets. On the other hand, P/E ratio was significantly affected showing highest value for fish fed diet 5 as compared with the control fish fed diet 1.

### 3-3-3. *O. niloticus* grow-out :

Results of body composition of *O. niloticus* grow-out stage are given in table (66) and illustrated in figs. (from 51 to 54).

Replacing FM by MIX had a significant effect on liver protein and glycogen at levels 75% and 100%. It had, also a significant effect on liver lipids at levels 50%, 75% & 100% as compared with fish fed diet 1 (control).

Values of gross energy and metablizable energy showed fluctuations but insignificantly different as compared with the corresponding control fish. On the other hand, P/E ratio for fish fed diets 4 & 5 were significantly different as compared with the CTR fish (Table 66).

**Table (66) : Liver and muscle composition of *O. niloticus* grow-out fed different levels of MIX-based diets for 18 weeks.**

| Items | | Initial | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|---|
| **Liver metabolites :-** | | | | | | | |
| Crude protein | (g/100 g tissue) | 17.91 ± 0.65 | 24.49 ± 2.19 | 25.13 ± 2.69 | 23.48 ± 1.80 | 22.75*± 1.96 | 21.30*± 1.81 |
| Total lipids | (g/100 g tissue) | 11.90 ± 1.00 | 7.88 ± 0.38 | 6.37 ± 0.36 | 8.54*± 0.41 | 8.75*± 0.46 | 10.00*± 0.50 |
| Glycogen | (g/100 g tissue) | 2.10 ± 0.07 | 4.21 ± 0.39 | 4.50 ± 0.41 | 4.00 ± 0.37 | 3.61*± 0.29 | 2.78*± 0.20 |
| **Carcass composition :-** | | | | | | | |
| Crude protein | (%) | 52.84 ± 2.98 | 66.05 ± 5.12 | 67.57 ± 6.16 | 65.11 ± 4.81 | 64.36 ± 4.50 | 60.10*± 3.89 |
| Total lipids | (%) | 24.05 ± 2.61 | 18.29 ± 1.90 | 19.14 ± 1.99 | 20.27*± 2.10 | 21.46*± 2.06 | 22.71*± 2.45 |
| Ash | (%) | 20.11 ± 1.64 | 12.85 ± 1.09 | 12.27 ± 1.00 | 13.61*± 1.11 | 13.38 ± 1.23 | 15.09*± 1.41 |
| Moisture | (%) | 74.00 ± 4.17 | 76.75 ± 4.32 | 77.15 ± 5.29 | 77.60 ± 5.98 | 75.06 ± 4.19 | 76.32 ± 5.22 |
| **Energy content :-** | | | | | | | |
| Gross energy | (K cal/Kg) | 5258.23 | 5460.21 | 5626.70 | 5504.52 | 5664.30 | 5542.10 |
| Metabolizable energy | (K cal/Kg) | 3985.00 | 4039.20 | 4166.20 | 4161.60 | 4226.80 | 4160.80 |
| P/E ratio | | 75.42 | 61.15 | 61.66 | 63.92 | 65.75* | 69.23* |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (67) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of liver metabolites for fish fed different levels of boiled soybean meal (BSM).**

| Different stages | Test diets | Hepatic Protein (HP) | Hepatic Lipid (HL) | Hepatic Glycogen (HG) |
|---|---|---|---|---|
| | | t-c | t-c | t-c |
| Fry | D2 | 0.366 | -1.124 | 1.976* |
| | D3 | 0.633 | -0.578 | 2.540* |
| | D4 | 2.574* | -1.324 | 7.200* |
| | D5 | 4.646* | -2.914* | 8.700* |
| Fingerlings | D2 | -0.095 | 0.719 | -1.241 |
| | D3 | 0.211 | -0.566 | 4.514* |
| | D4 | 0.732 | -1.140 | 4.990* |
| | D5 | 1.789* | -1.020 | 7.747* |
| Grow-out | D2 | 0.554 | 8.654* | -1.537* |
| | D3 | 1.069 | -3.542* | 1.172 |
| | D4 | 1.776* | -4.374* | 3.704* |
| | D5 | 3.368* | -10.127* | 9.788* |

* Significant at levels $P<0.05$.

**Table (68) : t-test (at significant level 0.05) among experimental diets compared with control (diet 1) of body composition energy content for fish fed different levels of MIX of both FFS and BSM (1:1, W/W).**

| Different stages | Test diets | Crude Protein (CP%) | Total Lipids (TL) | Ash Content (AC) | Moisture | Gross Energy (GE) | Metabolizable Energy (ME) | P/E ration |
|---|---|---|---|---|---|---|---|---|
| | | t-c | t-c | t-c | t-c | t-c | t-c | t-c |
| Fry | D2 | 0.284 | -1.039 | -0.878 | 0.255 | -0.121 | -0.074 | -0.281 |
| | D3 | 0.563 | -1.562* | -0.012 | 0.431 | -0.125 | -0.109 | -0.492 |
| | D4 | 2.035* | -3.724* | -0.078 | -0.976 | -0.243 | -0.242 | -1.537* |
| | D5 | 2.626* | -4.223* | 0.972 | 0.345 | -0.223 | -0.285 | -1.902* |
| Fingerlings | D2 | -0.013 | -0.566 | 3.894* | 1.310 | -0.130 | -0.202 | -0.155 |
| | D3 | 0.660 | -1.772* | -1.691* | 0.530 | -0.143 | -0.258 | -0.814 |
| | D4 | 0.823 | -1.844* | 1.916* | 0.878 | -0.127 | -0.334 | -0.955 |
| | D5 | 3.172* | -4.565* | -5.423* | 0.058 | 0.012 | -0.245 | -2.871* |
| Grow-out | D2 | -0.600 | -0.977 | 1.240 | -0.185 | -0.578 | -0.603 | -0.159 |
| | D3 | 0.423 | -2.211* | -1.545* | -0.364 | -0.142 | -0.553 | -0.907 |
| | D4 | 0.784 | -3.577* | -1.020 | 0.888 | -0.804 | -0.802 | -1.712* |
| | D5 | 2.926* | -4.508* | -3.975* | 0.201 | -0.287 | -0.479 | -2.990* |

* Significant at levels $P<0.05$.

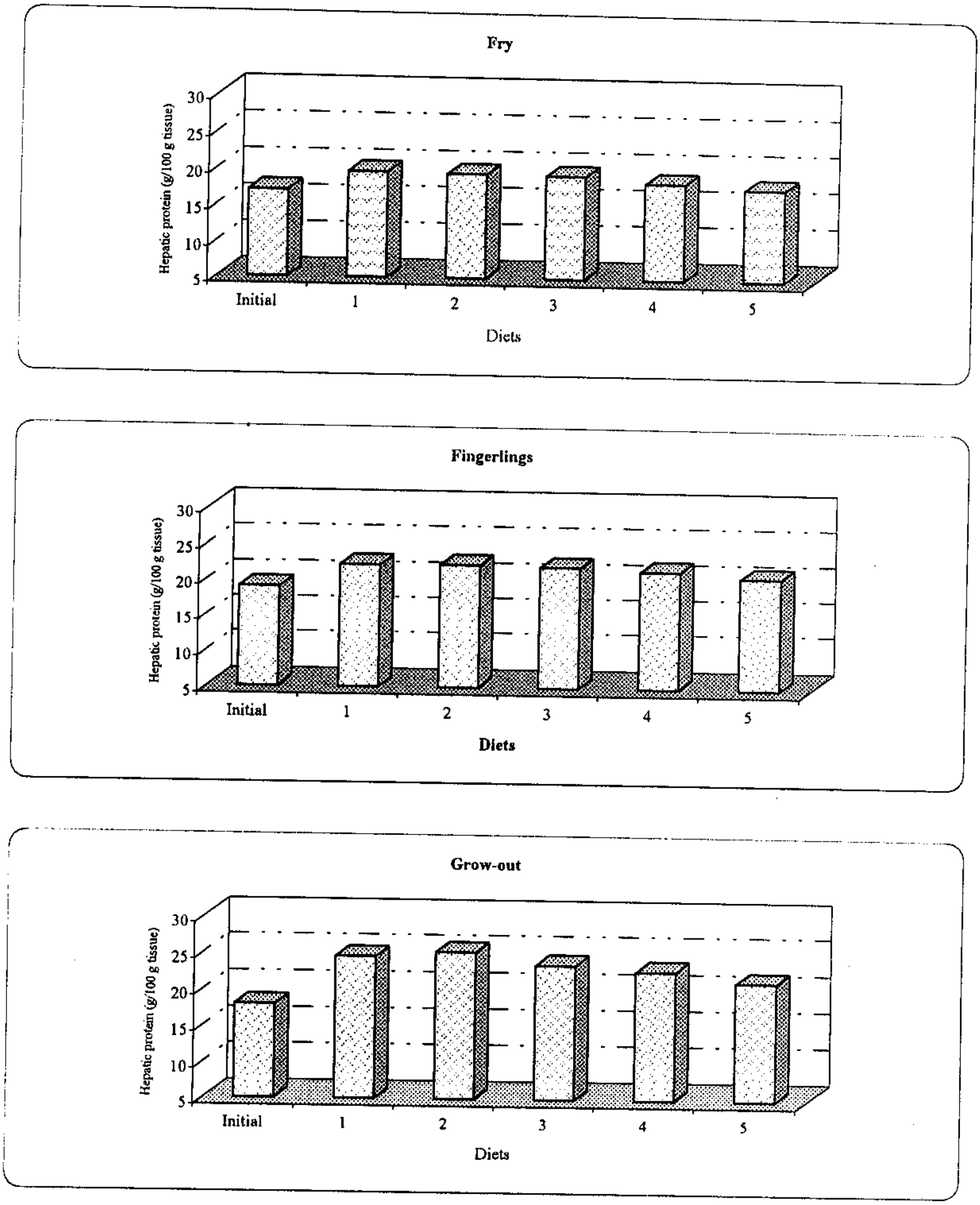



**Fig. (51) : Hepatic protein (g/100 g tissue) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

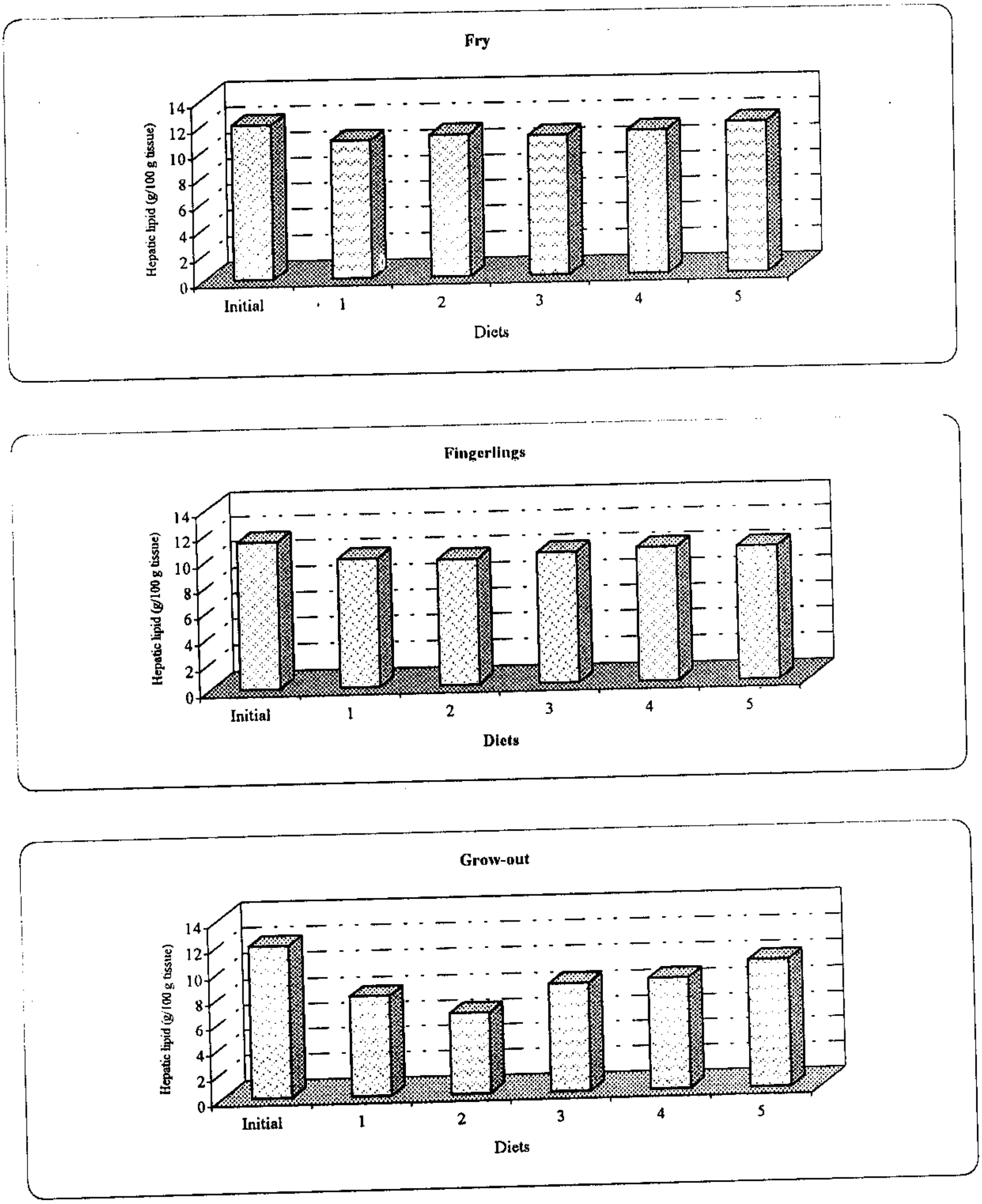



**Fig. (52): Hepatic lipids (g/100 g tissue) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

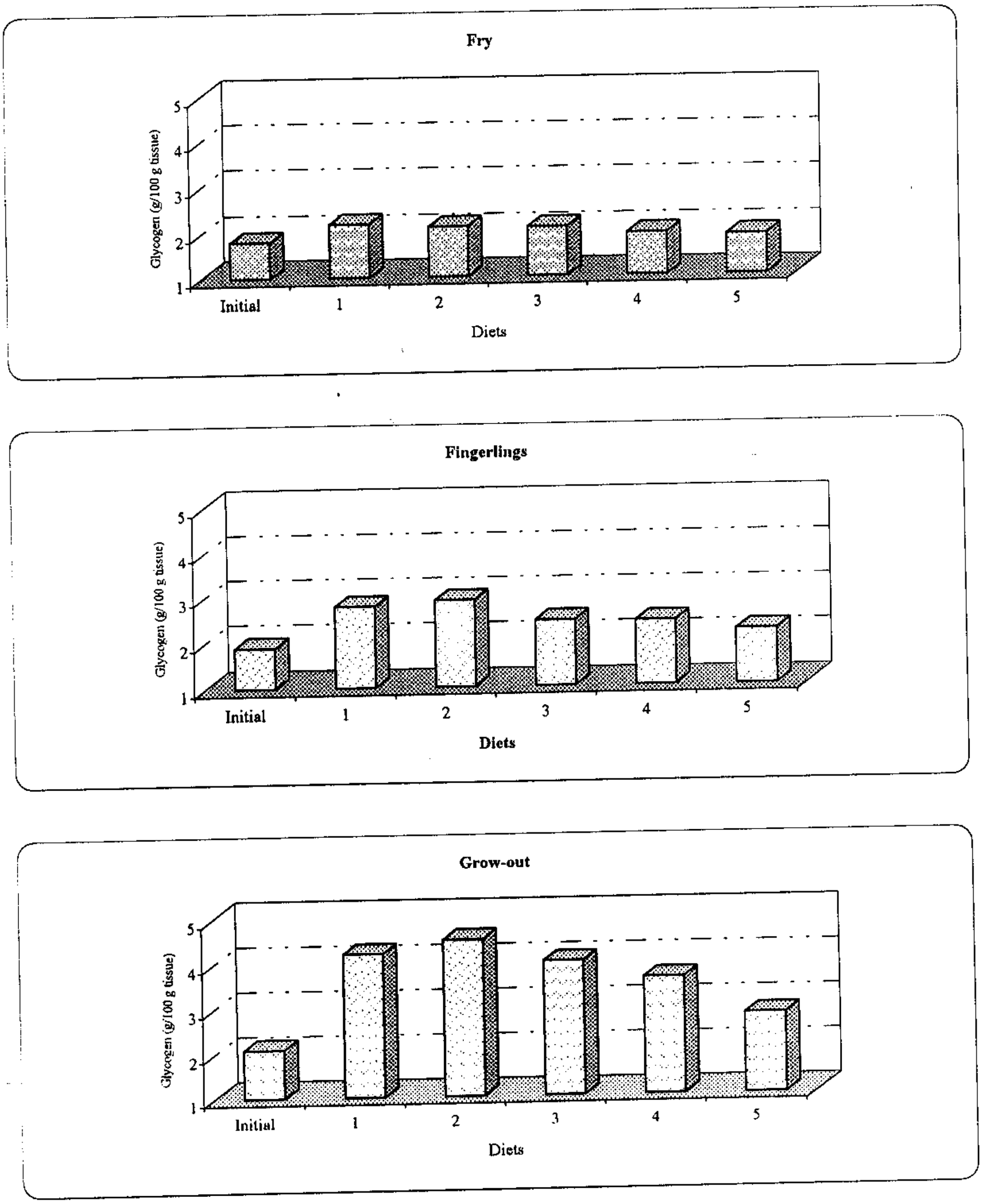



**Fig. (53): Hepatic Glycogen (g/100 g tissue) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

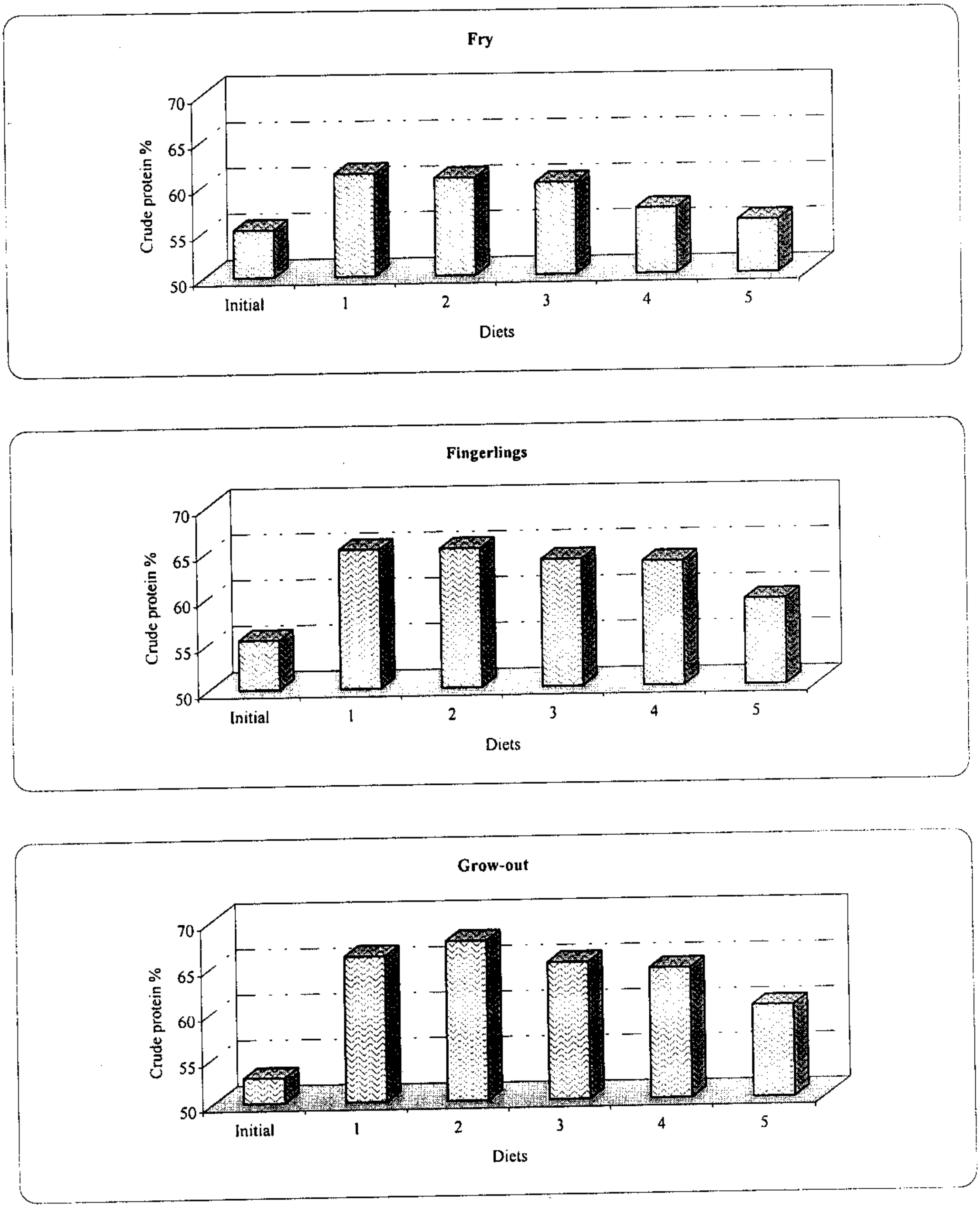



**Fig. (54): Crude protein content for *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) diets for 18 weeks.**

The statistical analysis of the body composition parameters for all treatments as compared with the corresponding for the control group are given in tables (67 & 68).

### 3-4. Effect of mixture (MIX) of fermented fish silage (FFS) and soybean meal (BSM) as fish meal (FM) replacer on *O. niloticus* biological characteristics :

#### 3-4-1. *O. niloticus* fry

At the end of the feeding trials, the hepatosomatic indices (H.S.I.) showed significant differences for fry fed diets 4 & 5 compared with the control fish (Table 69 & Fig. 55). On the other hand, the gastrosomatic indices (Ga.S.I.), filling indices (F.I.) and condition of fish flesh (C.F.F.) values showed significant differences for fry fed diet 5 compared with the corresponding CTR group as shown in table (69) and demonstrated in fig. (56). While gonadosomatic index (G.S.I.) values showed insignificant differences for fish fed all the experimented diets as compared with the control diet (Fig. 57).

#### 3-4-2. *O. niloticus* fingerlings

Likewise, the bilogical parameters of fingerlings fed the test diets are summarized in table (70) and illustrated in figs (55, 56 & 57). The H.S.I. for fish fed diets 4 & 5 were significantly ($P< 0.05$) lower than for that fed the control diet. Whereas the Ga.S.I for fish fed diet 5 was significantly different as compared with the CTR fish. On the other hand, G.S.I., F.I. and C.F.F. were not significantly affected by MIX levels as compared with the control fish.

### 3-4-3. *O. niloticus* grow-out :

Table (71) and fig. (55) showed that, H.S.I. of *O. niloticus* grow-out stage was significantly affected (P<0.05) by the inclusion of MIX at levels 75% & 100%, compared with the control fish (100% FM). Whereas G.S.I. for fish fed diets 3, 4 & 5 were significantly affected compared with the control fish.

On the other hand, Ga.S.I., F.I. and C.F.F. were not significantly affected by inclusion of MIX at all treatment levels, when compared with the CTR fish fed the control diet (Fig. 56 & 57).

Results of statistical analyses of the biological parameters for all treatments as compared with the corresponding control group are given in table (72).

**Table (69) : Biological parameters of *O. niloticus* fry fed different levels of MIX-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 10.47 ± 1.72 | 10.02 ± 1.63 | 9.89 ± 1.62 | 9.37 ± 1.56 | 8.88 ± 1.22 |
| Total weight (T. wt.) | (g) | 21.00 ± 4.89 | 18.49 ± 4.09 | 16.38 ± 3.36 | 13.65 ± 2.29 | 11.13 ± 2.81 |
| Gutted weight (G. wt.) | (g) | 16.38 ± 2.25 | 14.74 ± 2.01 | 13.18 ± 1.67 | 11.54 ± 1.14 | 8.87 ± 1.03 |
| Hepatosomatic index (H.S.I.) | (g) | 1.94 ± 0.30 | 1.93 ± 0.29 | 1.80 ± 0.22 | 1.54*± 0.16 | 1.29*± 0.09 |
| Gastrosomatic index (Ga.S.I.) | | 8.22 ± 2.11 | 8.16 ± 2.05 | 7.61 ± 1.71 | 7.12 ± 1.39 | 6.98*± 1.09 |
| Gonadosomatic index (G.S.I.) | | 1.61 ± 0.93 | 1.51 ± 0.98 | 1.52 ± 0.86 | 1.09 ± 0.87 | 1.18 ± 0.92 |
| Filling index (F.I.) | | 2.04 ± 0.99 | 1.96 ± 0.94 | 1.78 ± 0.90 | 1.76 ± 0.77 | 1.29*± 0.38 |
| Condition of fish flesh (C.F.F.) | | 1.43 ± 0.14 | 1.47 ± 0.16 | 1.36 ± 0.13 | 1.40 ± 0.14 | 1.27*± 0.09 |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (70) : Biological parameters of *O. niloticus* fingerlings fed different levels of MIX-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 15.65 ± 2.64 | 15.58 ± 3.66 | 15.35 ± 3.09 | 14.53 ± 2.95 | 13.37 ± 2.83 |
| Total weight (T. wt.) | (g) | 66.75 ± 15.12 | 63.86 ± 14.16 | 60.78 ± 13.17 | 52.77 ± 11.63 | 40.38 ± 10.11 |
| Gutted weight (G. wt.) | (g) | 54.69 ± 10.14 | 51.22 ± 9.66 | 48.93 ± 8.47 | 43.60 ± 8.42 | 33.18 ± 5.63 |
| Hepatosomatic index (H.S.I.) | (g) | 1.87 ± 0.19 | 1.84 ± 0.19 | 1.76 ± 0.12 | 1.59*± 0.10 | 1.42*± 0.06 |
| Gastrosomatic index (Ga.S.I.) | | 8.91 ± 2.40 | 9.14 ± 2.76 | 8.66 ± 2.19 | 8.07 ± 1.86 | 7.11± 1.74 |
| Gonadosomatic index (G.S.I.) | | 1.56 ± 0.66 | 1.55 ± 0.67 | 1.52 ± 0.46 | 1.29 ± 0.51 | 1.34 ± 0.39 |
| Filling index (F.I.) | | 2.10 ± 0.89 | 2.08 ± 0.69 | 1.89 ± 0.71 | 1.59 ± 0.62 | 1.61 ± 0.69 |
| Condition of fish flesh (C.F.F.) | | 1.43 ± 0.20 | 1.35 ± 0.19 | 1.35 ± 0.18 | 1.42 ± 0.20 | 1.39 ± 0.18 |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (71) : Biological parameters of *O. niloticus* grow-out fed the test MIX-based diets for 18 weeks.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| | | X ± SD | X ± SD | X ± SD | X ± SD | X ± SD |
| Total length (T. L.) | (cm) | 20.25 ± 6.50 | 20.37 ± 6.83 | 19.48 ± 6.49 | 18.78 ± 5.54 | 17.29 ± 5.19 |
| Total weight (T. wt.) | (g) | 147.74 ± 21.17 | 146.26 ± 20.58 | 133.01 ± 19.92 | 106.56 ± 17.51 | 85.84 ± 15.68 |
| Gutted weight (G. wt.) | (g) | 119.71 ± 16.92 | 118.10 ± 16.16 | 112.65 ± 14.36 | 87.85 ± 12.11 | 69.70 ± 11.65 |
| Hepatosomatic index (H.S.I.) | (g) | 2.11 ± 0.31 | 2.12 ± 0.36 | 1.94 ± 0.25 | 1.80*± 0.20 | 1.48*± 0.14 |
| Gastrosomatic index (Ga.S.I.) | | 8.60 ± 1.75 | 8.67 ± 1.76 | 7.84 ± 1.59 | 7.83 ± 1.55 | 8.12 ± 1.71 |
| Gonadosomatic index (G.S.I.) | | 1.46 ± 0.20 | 1.40 ± 0.21 | 1.19*± 0.19 | 1.06*± 0.13 | 1.21*± 0.14 |
| Filling index (F.I.) | | 2.08 ± 1.02 | 1.98 ± 0.91 | 2.00 ± 0.96 | 1.86 ± 0.88 | 1.60 ± 0.72 |
| Condition of fish flesh (C.F.F.) | | 1.44 ± 0.18 | 1.40 ± 0.17 | 1.52 ± 0.20 | 1.33 ± 0.14 | 1.35 ± 0.13 |

FM = Fish meal.
MIX = Mixture of both fermented fish silage (FFS) and boiled soybean meal (BSM) (1:1, W/W).
* Significant at levels $P<0.05$.

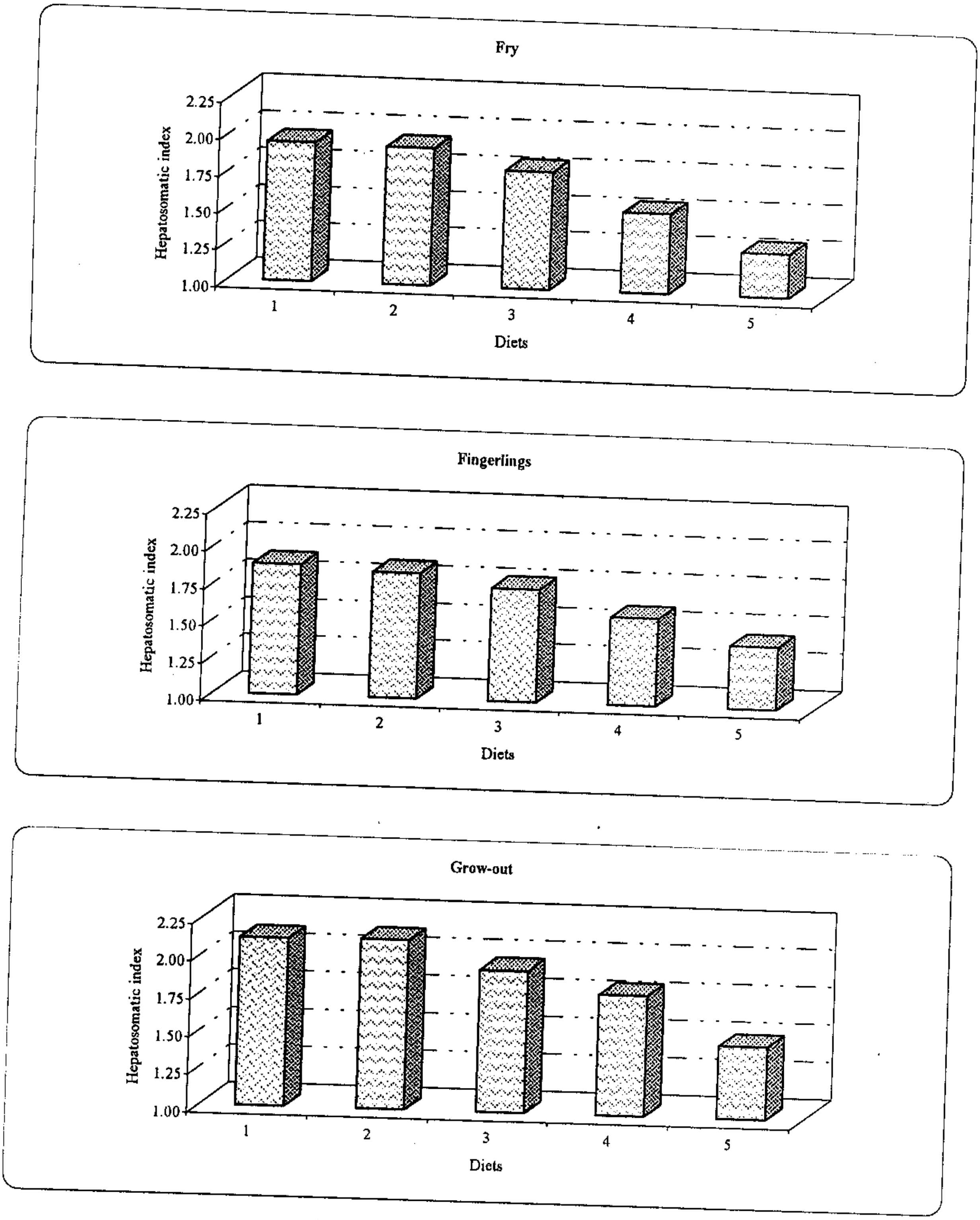



**Fig. (55): Hepatosomatic index (H.I.S) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1 W/W) diets for 18 weeks**

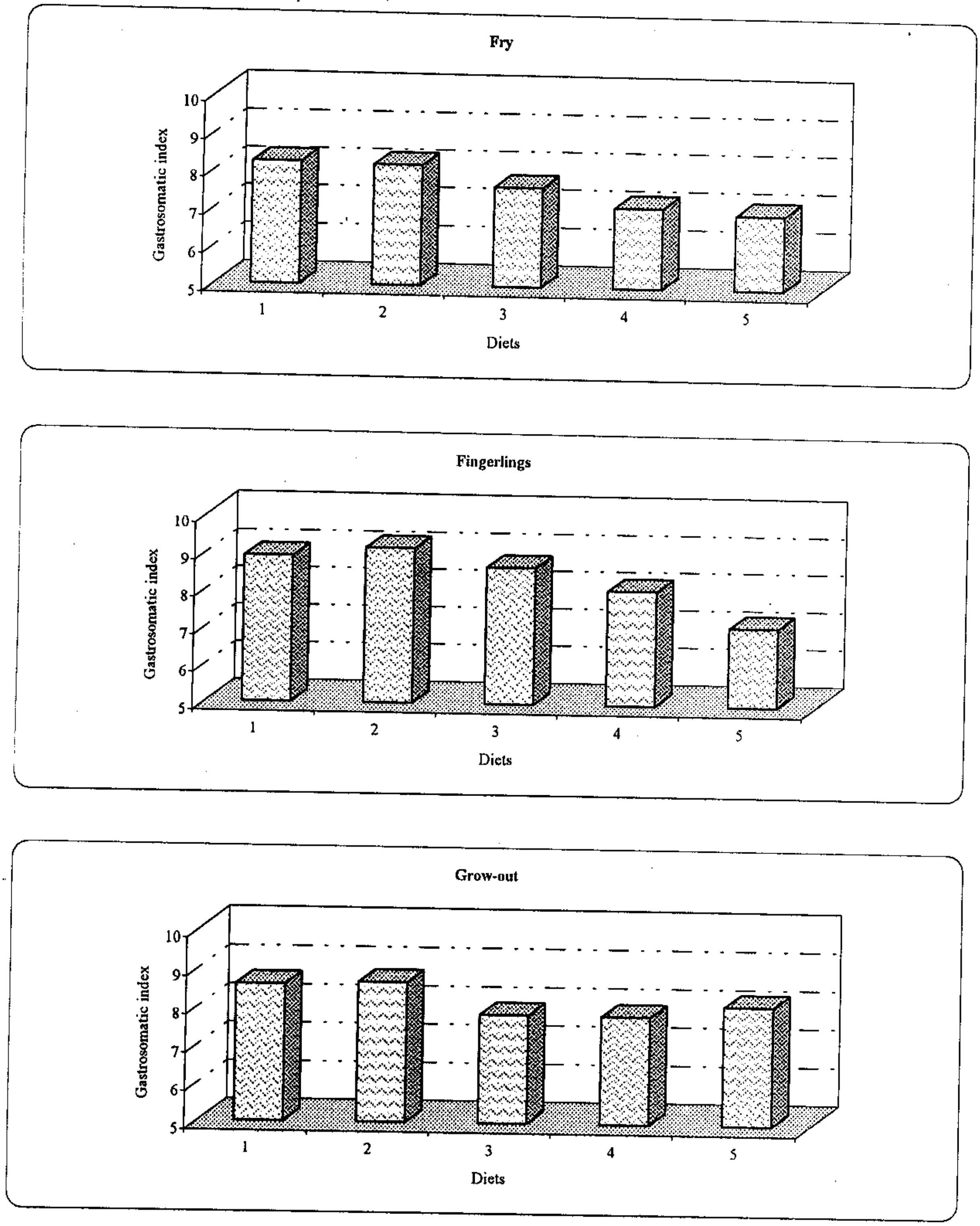



**Fig. (56): Gastrosomatic index (G.S.I) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) diets for 18 weeks**

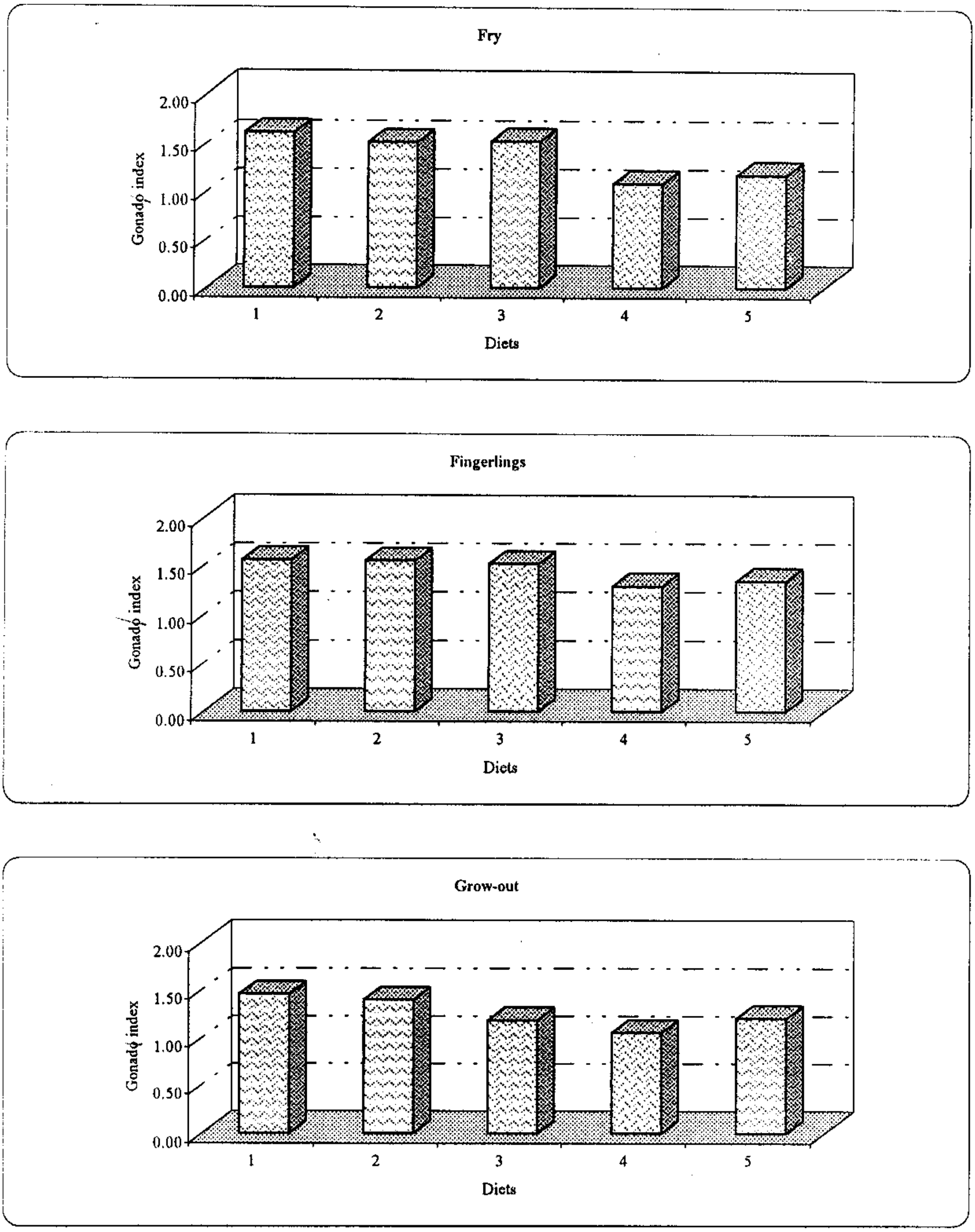



**Fig. (57): Gonadosomatic index (G.I) of *O. niloticus* fed different levels of mixture of both FFS & BSM (1:1, W/W) diets for 18 weeks**

# CHAPTER VI

## Economical evaluation of the tested fish meal (FM) replacers:

### 1. Fermented fish silage (FFS) :

#### 1-1. *O. niloticus* fry :

Incidence cost increased significantly by increasing the level of FFS in the diets (Table 73). The best profit indices were obtained for fish fed diet 2 (7.06) followed by diet 3 (6.83), whereas the least was that fish fed diet 5 (4.42).

#### 1-2. *O. niloticus* fingerlings and grow-out :

Similar results to the fry's were attained for the two other growth stages and were shown in tables (74 & 75). Thus, maximum incident cost (3.03 and 2.95, respectively) were obtained for fish fed diets 5 (100% FFS inclusions), with significant differences as compared with the control groups (P>0.05). *O. niloticus* fingerlings or grow-out stage fed diets 2 resulted into highest profit indices (1.73 and 3.94 respectively). In the mean time, least values (1.32 and 3.05 respectively) were recorded for fish fed diets 5.

Fig. (58) illustrates the production of *O. niloticus* fed the FFS diets.

## 2. Boiled soybean meal (BSM) :

### 2-1. *O. niloticus* fry :

Incident cost increased significantly by increasing BSM inclusion level as shown in table (76). The best profit indices were gained for fish fed diet 3 (7.88) followed by diet 2 (7.77) without significant effect compared with control diet.

### 2-2. *O. niloticus* fingerlings and grow-out stages

Similarly, maximum profit indices (1.5 and 2.65) were noticed for fingerlings and grow-out stages, respectively when both fed diets 2 (25% BSM) tables (77 & 78).

Minimum record (1.4 and 2.47) were indicated for fingerlings fed diet 5 and grow-out stage fed diet 4 respectively, without significant differences compared to fish fed control diets.

Fig. (59) illustrates the production of *O. niloticus* fed the BSM diets.

## 3. MIX of FFS and BSM

### 3-1. *O. niloticus* fry :

Further increase in MIX inclusion level within *O. niloticus* diets did not result in an increase in incidence cost (Table 79). Fry fed diet 3 followed by those fed diet 2 gave the best profit indices with significant differences with control fish. The lowest Pi (4.67) was attained when using diet 5.

### 3-2. *O. niloticus* fingerlings and grow-out stages

Referring to tables (80 & 81) maximum profit indices (1.64 and 2.45) were obtained for fingerling and grow-out, respectively, fed diets 2, followed by diet 3. Minimum Pi records (1.25 and 1.84) were observed for both treatments respectively stages fed diet 5.

Fig. (60) illustrates the production of *O. niloticus* fed the MIX diets.

Cost analysis for economic production of *O. niloticus* fry, fingerlings and grow-out stages are given in tables (82, 83 & 84) and illustrated in figs. (61, 62 & 63).

**Table (73) : Economic analysis and production of *O. niloticus* fry fed different levels of fermented fish silage.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 17.50 | 14.28 | 13.70 | 11.70 | 9.03 |
| Number | Fish/aquarium | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| Mortality | Fish/aquarium | 1.00 | 0.00 | 1.00 | 1.00 | 2.00 |
| Survival rate (%) | Fish/aquarium | 93.34 | 100.00 | 93.34 | 93.34 | 86.67 |
| Total food given | Kg | 0.44 | 0.38 | 0.37 | 0.33 | 0.28 |
| Total yield | Kg / aquarium | 0.25 | 0.21 | 0.19 | 0.16 | 0.12 |
| Production | Kg/l | 0.007 | 0.006 | 0.005 | 0.005 | 0.003 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.08 | 1.04 |
| Incidence cost | (Ic) | 2.12 | 1.99* | 2.14 | 2.166 | 2.45* |
| Profit index | (Pi) | 5.38 | 7.06* | 6.83* | 5.93* | 4.42* |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (74) : Economic analysis and production of *O. niloticus* fingerlings fed different levels fermented fish silage.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% FFS | Diet 3 50% FM 50% FFS | Diet 4 25% FM 75% FFS | Diet 5 100% FFS |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 64.25 | 66.20 | 62.25 | 53.34 | 35.03 |
| Number | Fish/pond | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| Mortality | Fish/pond | 1.00 | 1.00 | 1.00 | 3.00 | 3.00 |
| Survival rate (%) | Fish/pond | 98.33 | 98.33 | 98.33 | 95.00 | 95.00 |
| Total food given | Kg | 7.59 | 8.09 | 7.98 | 7.23 | 5.83 |
| Total yield | Kg | 3.79 | 3.91 | 3.67 | 3.04 | 2.00 |
| Production | $Kg/m^2$ | 0.47 | 0.49 | 0.46 | 0.38 | 0.25 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.08 | 1.04 |
| Incidence cost | (Ic) | 2.38 | 2.32 | 2.41 | 2.56* | 3.03* |
| Profit index | (Pi) | 1.68 | 1.73* | 1.66 | 1.56* | 1.32* |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (75) : Economic analysis and production of *O. niloticus* grow-out fed different levels of fermented fish silage.**

| Items | | Diet 1<br>Control<br>100%FM | Diet 2<br>75% FM<br>25% FFS | Diet 3<br>50% FM<br>50% FFS | Diet 4<br>25% FM<br>75% FFS | Diet 5<br>100% FFS |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 168.70 | 156.20 | 140.02 | 114.60 | 83.70 |
| Number | Fish/pond | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Mortality | Fish/pond | 1.00 | 0.00 | 1.00 | 1.00 | 2.00 |
| Survival rate (%) | Fish/pond | 97.50 | 100.00 | 97.50 | 97.50 | 95.00 |
| Total food given | Kg | 13.30 | 12.76 | 12.21 | 11.56 | 9.04 |
| Total yield | Kg | 6.58 | 6.25 | 5.46 | 4.47 | 3.18 |
| Production | $Kg/m^2$ | 0.82 | 0.78 | 0.68 | 0.56 | 0.40 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.08 | 1.04 |
| Incidence cost | (Ic) | 2.41 | 2.29* | 2.48 | 2.79* | 2.95* |
| Profit index | (Pi) | 3.74 | 3.94* | 3.63 | 3.22* | 3.05* |

FM = Fish meal.
FFS = Fermented fish silage.
* Significant at levels $P<0.05$.

**Table (76) : Economic analysis and production of *O. niloticus* fry fed different levels of boiled soybean meal.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 17.26 | 15.66 | 13.36 | 10.36 | 9.16 |
| Number | Fish/aquarium | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| Mortality | Fish/aquarium | 1.00 | 1.00 | 2.00 | 2.00 | 3.00 |
| Survival rate (%) | Fish/aquarium | 93.30 | 93.30 | 86.66 | 86.66 | 80.00 |
| Total food given | Kg | 0.34 | 0.33 | 0.30 | 0.25 | 0.22 |
| Total yield | Kg / aquarium | 0.24 | 0.22 | 0.17 | 0.14 | 0.11 |
| Production | Kg/l | 0.007 | 0.006 | 0.005 | 0.004 | 0.003 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 1.65 | 1.66 | 1.89 | 1.95* | 2.08* |
| Profit index | (Pi) | 7.00 | 7.77* | 7.88* | 7.50 | 7.50 |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (77) : Economic analysis and production of *O. niloticus* fingerlings fed different levels of boiled soybean meal.**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% BSM | Diet 3 50% FM 50% BSM | Diet 4 25% FM 75% BSM | Diet 5 100% BSM |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 52.16 | 49.11 | 46.34 | 37.40 | 34.26 |
| Number | Fish/pond | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| Mortality | Fish/pond | 2.00 | 2.00 | 3.00 | 2.00 | 3.00 |
| Survival rate (%) | Fish/pond | 96.60 | 96.60 | 95.00 | 96.60 | 95.00 |
| Total food given | Kg | 6.88 | 6.78 | 6.56 | 5.68 | 5.42 |
| Total yield | Kg | 3.03 | 2.85 | 2.64 | 2.17 | 1.95 |
| Production | $Kg/m^2$ | 0.38 | 0.36 | 0.33 | 0.27 | 0.24 |
| Cost | /Kg feed | 1.20 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 2.71 | 2.67 | 2.75 | 2.80 | 2.86* |
| Profit index | (Pi) | 1.47 | 1.50* | 1.45* | 1.42* | 1.40* |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (78) : Economic analysis and production of *O. niloticus* grow-out fed different levels of boiled soybean meal.**

| **Items** | | **Diet 1**<br>**Control**<br>**100%FM** | **Diet 2**<br>**75% FM**<br>**25% BSM** | **Diet 3**<br>**50% FM**<br>**50% BSM** | **Diet 4**<br>**25% FM**<br>**75% BSM** | **Diet 5**<br>**100% BSM** |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 118.80 | 107.30 | 89.88 | 83.05 | 74.87 |
| Number | Fish/pond | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Mortality | Fish/pond | 1.00 | 1.00 | 1.00 | 2.00 | 1.00 |
| Survival rate (%) | Fish/pond | 97.50 | 97.50 | 97.50 | 95.00 | 97.50 |
| Total food given | Kg | 10.61 | 9.85 | 8.78 | 8.37 | 7.80 |
| Total yield | Kg | 4.43 | 4.19 | 3.51 | 3.16 | 2.92 |
| Production | $Kg/m^2$ | 0.55 | 0.52 | 0.44 | 0.40 | 0.37 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 2.85 | 2.64* | 2.78 | 2.84 | 2.75* |
| Profit index | (Pi) | 2.46 | 2.65* | 2.51* | 2.47 | 2.54 |

FM = Fish meal.
BSM = Boiled soybean meal.
* Significant at levels $P<0.05$.

**Table (79) : Economic analysis and production of *O. niloticus* fry fed different levels of mixture of both FFS and BSM (1:1, W/W) .**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 20.04 | 17.53 | 15.42 | 16.29 | 10.17 |
| Number | Fish/aquarium | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| Mortality | Fish/aquarium | 1.00 | 0.00 | 1.00 | 2.00 | 1.00 |
| Survival rate (%) | Fish/aquarium | 93.30 | 100.00 | 93.30 | 86.67 | 93.30 |
| Total food given | Kg | 0.47 | 0.45 | 0.41 | 0.31 | 0.28 |
| Total yield | Kg / aquarium | 0.28 | 0.26 | 0.22 | 0.17 | 0.14 |
| Production | Kg/l | 0.008 | 0.007 | 0.006 | 0.005 | 0.004 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 2.00 | 1.92* | 2.07* | 1.91* | 2.06 |
| Profit index | (Pi) | 5.00 | 6.00* | 6.08* | 5.98* | 4.67 |

FM = Fish meal.
MIX = Mixture of both FFS and BSM (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (80) : Economic analysis and production of *O. niloticus* fingerlings fed different levels of mixture of both FFS and BSM (1:1, W/W).**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 56.05 | 53.51 | 50.43 | 42.42 | 30.03 |
| Number | Fish/pond | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| Mortality | Fish/pond | 3.00 | 2.00 | 3.00 | 5.00 | 3.00 |
| Survival rate (%) | Fish/pond | 95.00 | 96.67 | 95.00 | 91.67 | 95.00 |
| Total food given | Kg | 6.96 | 6.74 | 6.48 | 5.98 | 5.34 |
| Total yield | Kg | 3.20 | 3.10 | 2.88 | 2.33 | 1.71 |
| Production | $Kg/m^2$ | 0.40 | 0.39 | 0.36 | 0.29 | 0.21 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 2.59 | 2.43 | 2.50 | 2.74* | 3.21* |
| Profit index | (Pi) | 1.54 | 1.64* | 1.60* | 1.46* | 1.25* |

FM = Fish meal.
MIX = Mixture of both FFS and BSM (1:1, W/W).
* Significant at levels $P<0.05$.

**Table (81) : Economic analysis and production of *O. niloticus* grow-out fed different levels of mixture of both FFS and BSM (1:1, W/W).**

| Items | | Diet 1 Control 100%FM | Diet 2 75% FM 25% MIX | Diet 3 50% FM 50% MIX | Diet 4 25% FM 75% MIX | Diet 5 100% MIX |
|---|---|---|---|---|---|---|
| Total weight gain | g/fish | 124.29 | 122.81 | 109.56 | 83.11 | 62.39 |
| Number | Fish/pond | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| Mortality | Fish/pond | 1.00 | 1.00 | 2.00 | 2.00 | 1.00 |
| Survival rate (%) | Fish/pond | 97.50 | 97.50 | 95.00 | 95.00 | 97.50 |
| Total food given | Kg | 10.64 | 10.46 | 9.80 | 8.52 | 7.70 |
| Total yield | Kg | 4.85 | 4.80 | 4.16 | 3.16 | 2.43 |
| Production | $Kg/m^2$ | 0.61 | 0.60 | 0.52 | 0.40 | 0.30 |
| Cost | /Kg feed | 1.19 | 1.12 | 1.11 | 1.07 | 1.03 |
| Incidence cost | (Ic) | 2.61 | 2.45* | 2.61 | 2.88* | 3.26* |
| Profit index | (Pi) | 2.29 | 2.45* | 2.29 | 2.08* | 1.84* |

FM = Fish meal.
MIX = Mixture of both FFS and BSM (1:1, W/W).

**Table (82) : t-test (at significant level 0.05) among experimental fermented fish silage test diets as compared with the control (diet 1).**

| Different stages | Test diets | Incidence cost | Profit index |
|---|---|---|---|
| | | t-c | t-c |
| Fry | D2 | -1.54* | 3.36* |
| | D3 | 0.40 | 2.90* |
| | D4 | -2.14* | 1.51* |
| | D5 | 6.60* | 3.70* |
| Fingerlings | D2 | 1.20 | 1.50* |
| | D3 | 0.60 | 0.40 |
| | D4 | 3.60* | 2.40* |
| | D5 | 13.00* | 7.20* |
| Grow-out | D2 | 2.21* | 1.63* |
| | D3 | 1.16 | 0.73 |
| | D4 | 6.33* | 3.46* |
| | D5 | 9.00* | 4.60* |

* Significant at levels $P<0.05$.

**Table (83) : t-test (at significant level 0.05) among experimental boiled soybean meal test diets as compared with the control (diet 1).**

| Different stages | Test diets | Incidence cost | Profit index |
|---|---|---|---|
| | | t-c | t-c |
| Fry | D2 | 0.03 | 1.54* |
| | D3 | 0.03 | 1.77* |
| | D4 | 6.00* | 1.00 |
| | D5 | 8.60* | 1.00 |
| Fingerlings | D2 | 0.40 | 6.00* |
| | D3 | 0.40 | 4.00* |
| | D4 | 0.90 | -1.59* |
| | D5 | 1.50* | 1.83* |
| Grow-out | D2 | 2.27* | 1.90* |
| | D3 | 0.70 | 1.50* |
| | D4 | 1.32 | 0.10 |
| | D5 | 1.70* | 0.80 |

* Significant at levels $P<0.05$.

**Table (84) : t-test (at significant level 0.05) among experimental test mixture of both FFS and BSM (1:1, W/W) diets as compared with the control (diet 1).**

| Different stages | Test diets | Incidence cost | Profit index |
|---|---|---|---|
| | | t-c | t-c |
| Fry | D2 | -2.14* | 2.00* |
| | D3 | 6.60* | 2.16* |
| | D4 | 1.80* | 1.96* |
| | D5 | 1.20 | 0.66 |
| Fingerlings | D2 | -0.51 | 2.00* |
| | D3 | 0.90 | 1.60* |
| | D4 | 3.60* | 2.40* |
| | D5 | 6.20* | 7.20* |
| Grow-out | D2 | -2.90* | 3.20* |
| | D3 | 0.00 | 1.10 |
| | D4 | 5.40* | 3.46* |
| | D5 | 9.80* | 4.60* |

* Significant at levels P<0.05.

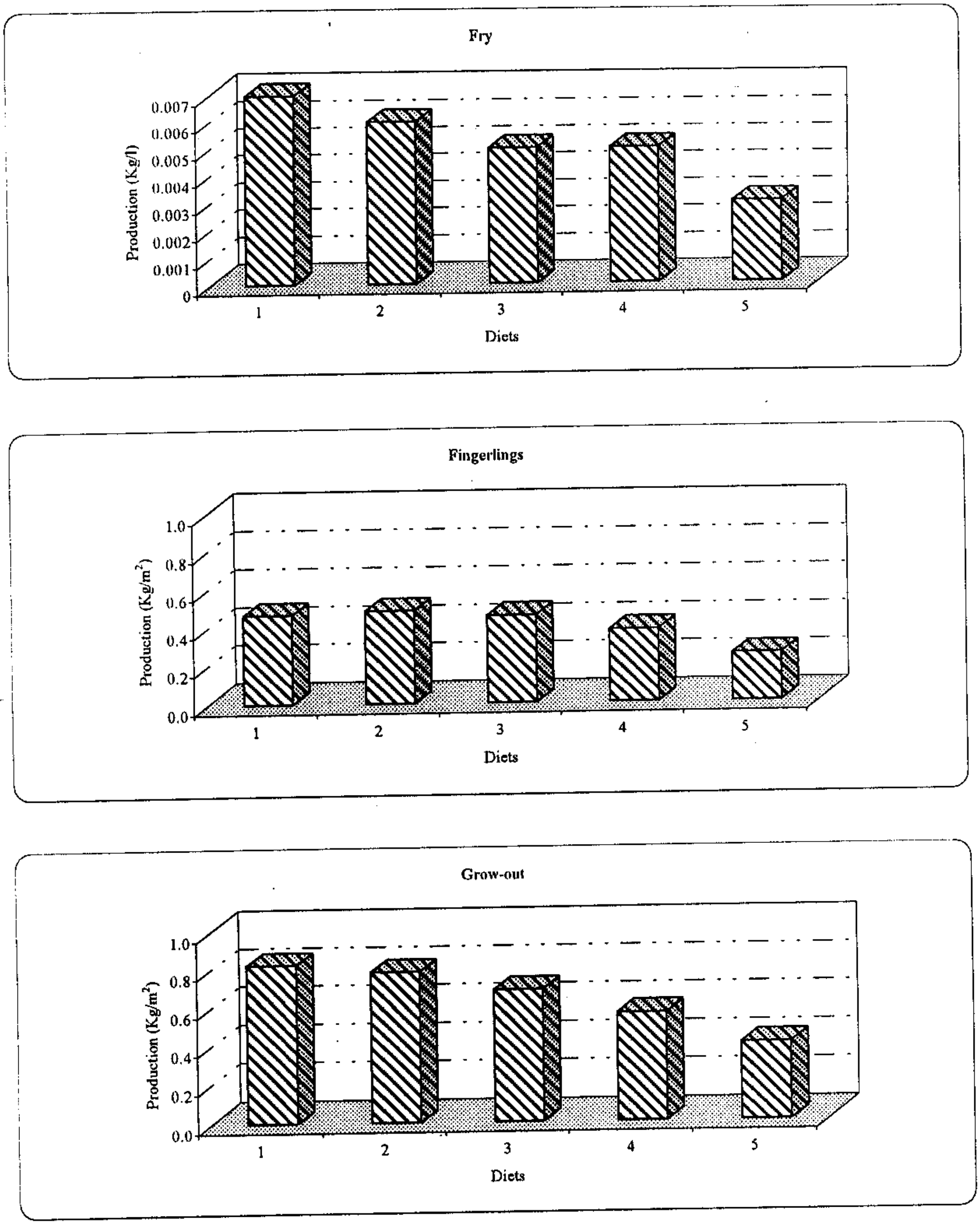



**Fig. (58): Production of *O. niloticus* fed on different levels of dried fermented fish silage (FFS) for 18 weeks.**

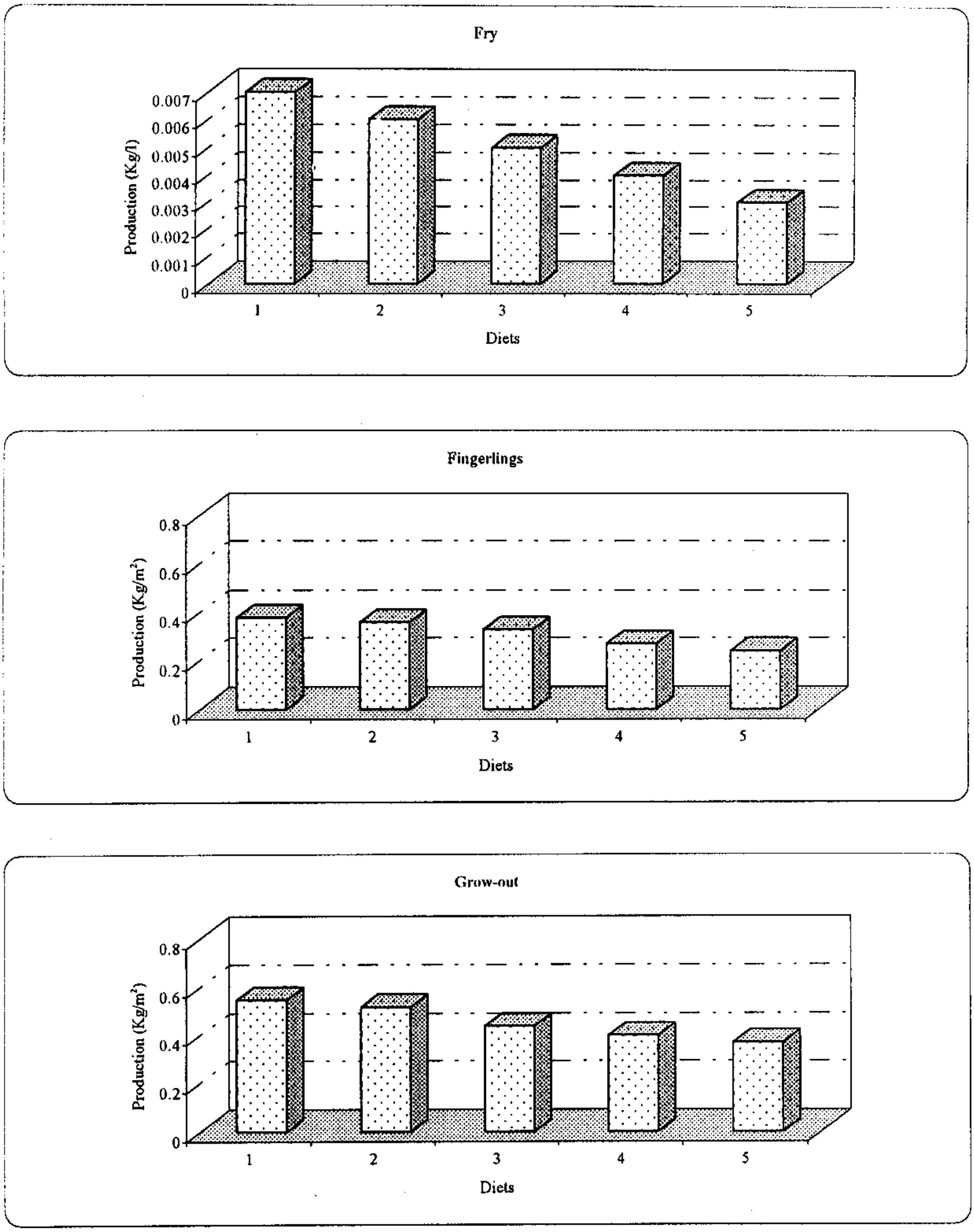



**Fig. (59): Production of *O. niloticus* fed on different levels of dried soybean meal (BSM) for 18 weeks**

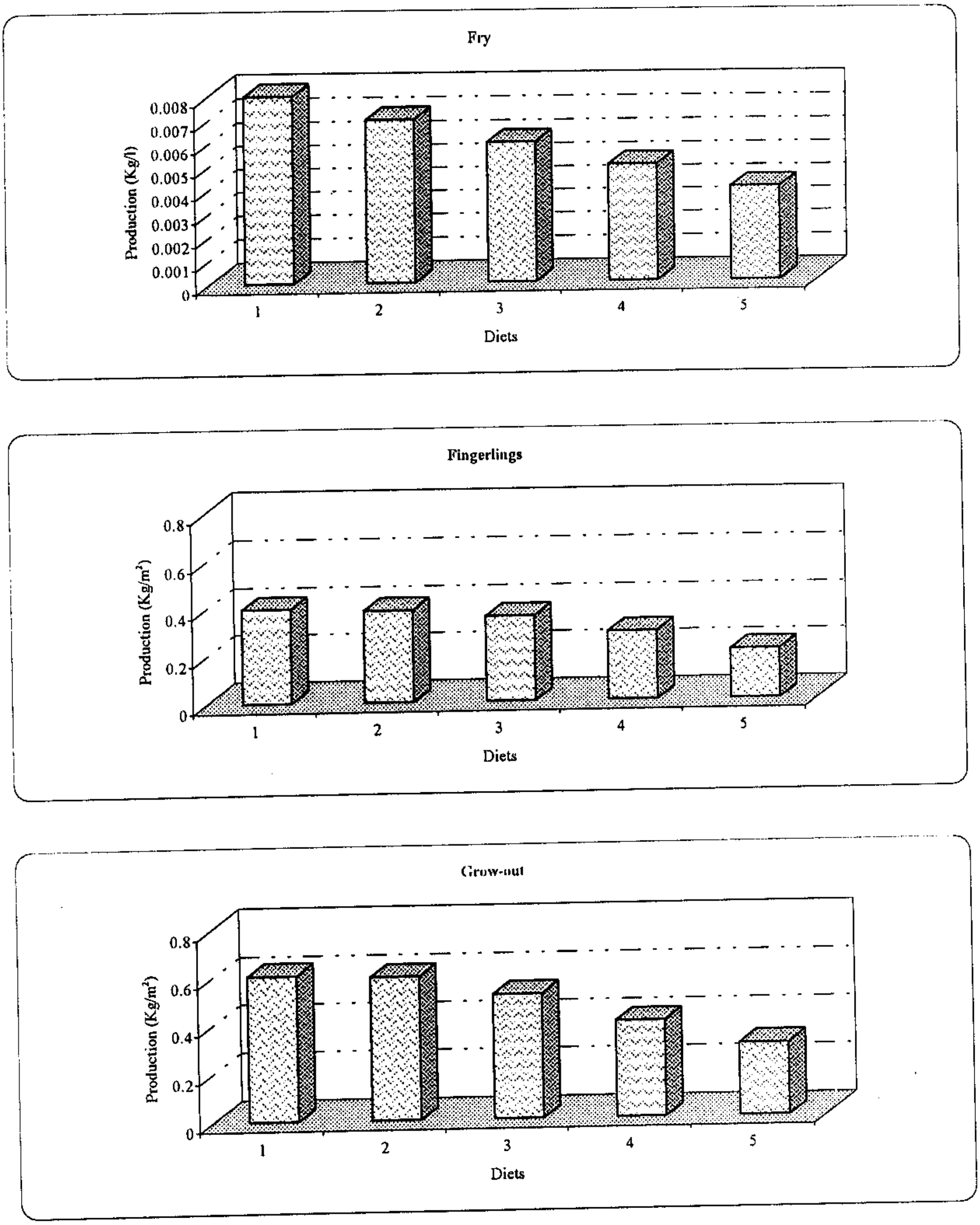



**Fig. (60): Production of *O. niloticus* fed on different levels of dried mixture of both FFS & BSM (1:1, W/W) for 18 weeks**

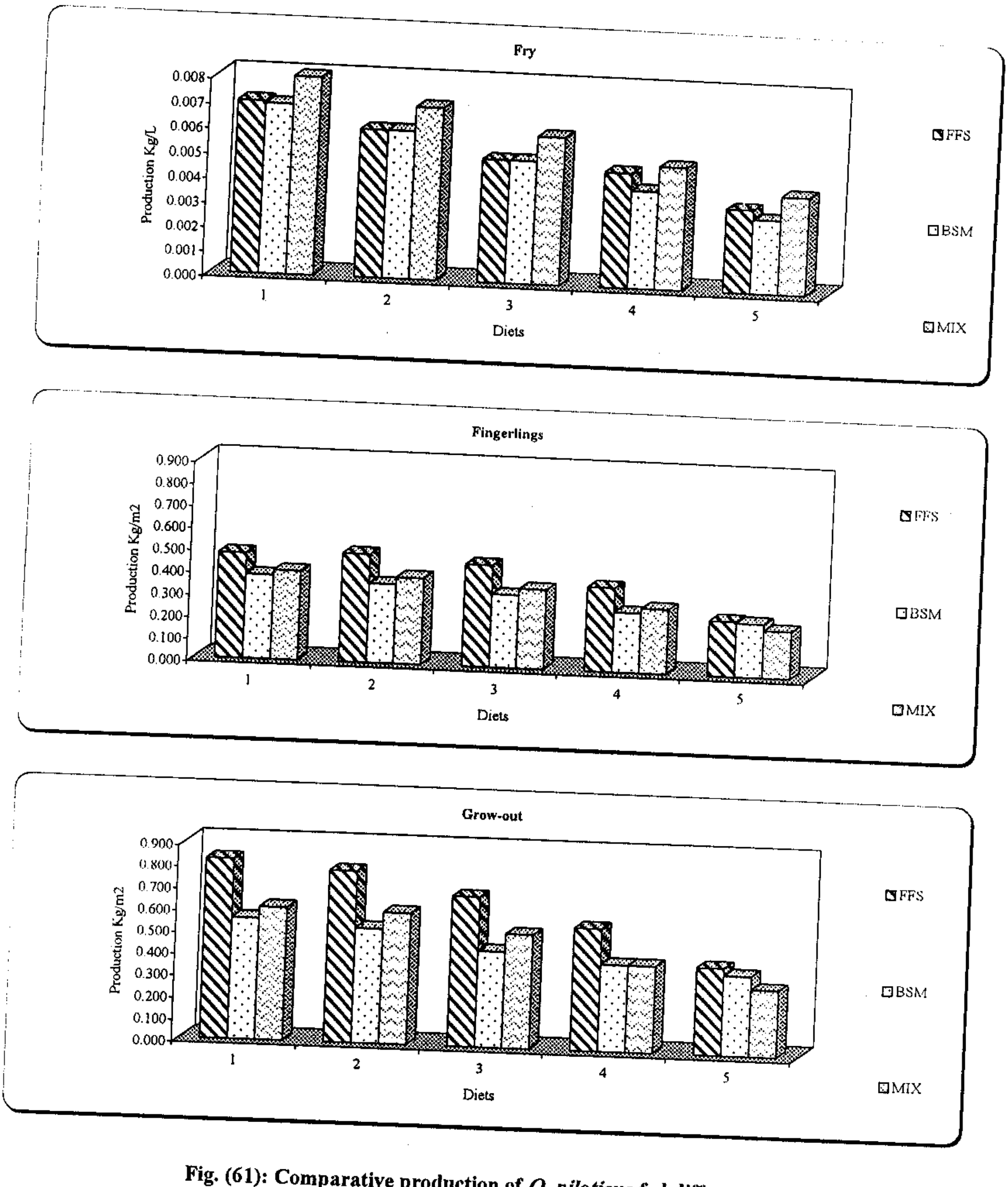



**Fig. (61): Comparative production of *O. niloticus* fed different fish meal replacers for 18 weeks**

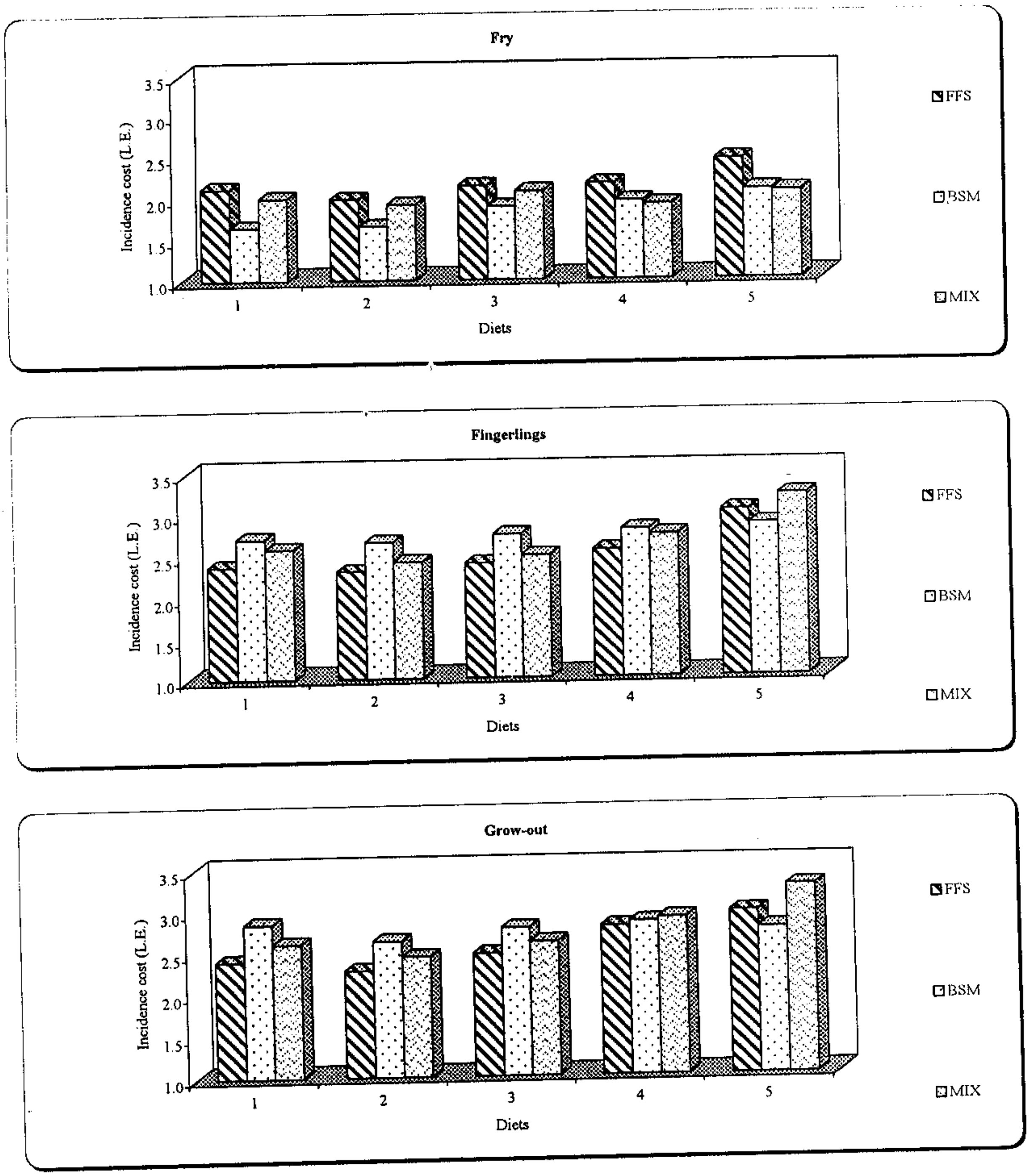



**Fig. (62): Incidence cost (L.E.) of *O. niloticus* fed different fish meal replacers for 18 weeks**

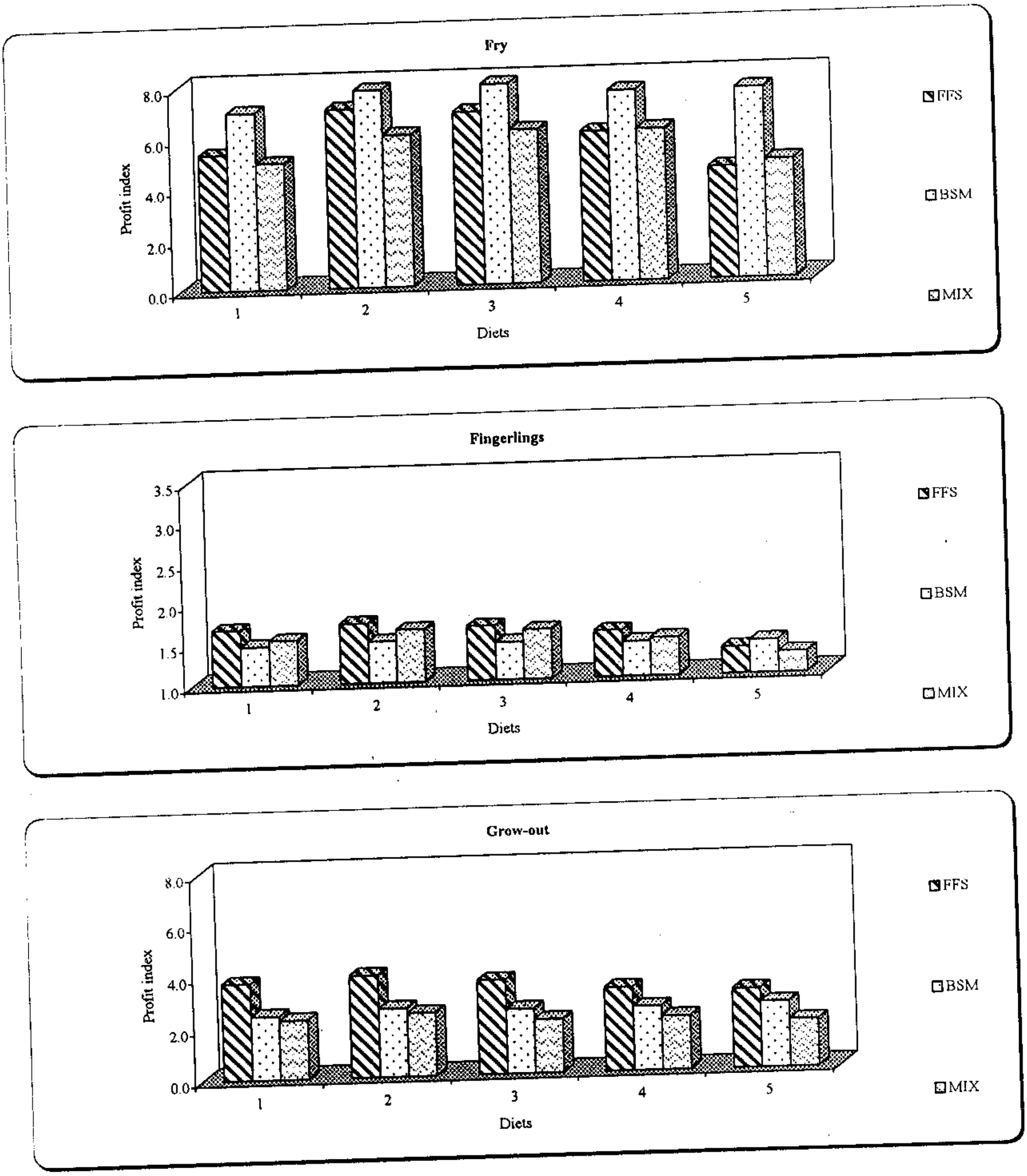



**Fig. (63): Profit index of *O. niloticus* fed different fish meal replacers for 18 weeks**

# DISCUSSION AND CONCLUSION

# DISCUSSION AND CONCLUSION

Fish species being cultured have a high dietary protein requirements, so the economically formulated fish feeds should contain 25-45% crude protein (Murai, 1992). Formulating high quality fish feeds is required, but reducing the cost of feeds is also the ultimate goal of fish nutrition researches, particularly in the developing countries, like Egypt.

Almost all fish contain a proportion of fish meal in their formulation. In Egypt, the current dependence of aquafeeds upon the imported fish meal and in view of the escalating cost of fish meal and the need to make aquaculture independent of capture fisheries, it is important to determine the feasibility of producing acceptable production diets which have little or no fish meal protein in them. Therefore, there is a great need to identify and utilize locally available feed ingredient sources, wherever possible, so as to minimize imports and reduce feed costs, and the present study therefore was conducted.

Several promising formulations for tilapia spp. have been tested locally and shown to have merit. Among the novel protein sources used with variable success it is worth to mention : decorticated cotton seed meal (Elsayed, 1990); poultry by-product meal (Yousif and Al Hadrami, 1993); chicken offal silage (Belal *et al.*, 1995); shrimps meal meat and bone meal (Mansour, 1997); black seed meal (10%) (Atwa, 1997); vegetable leaves wastes (Mohamed, 1998) and acid fish silage & soybean meal (Sobhy, 2000).

The ability of tilapia to utilize carbohydrates and lipids as energy sources were also investigated in Egypt (El-Sayed & Garling, 1988)

Partial or total replacement of fishmeal protein with alternate sources of protein could be of considerable economic advantage, even if this approach was associated with a moderate reduction in feed utilization (Hajen *et al.*, 1993). Therefore the present study was conducted to determine the optimum inclusion level of three protein alternate sources i.e. FFS, BSM and MIX for *O. niloticus* feeds.

In this study fish fed the fish meal-based diets exhibited better significantly growth (weight gain and SGR) than that obtained by fish fed the diets contained the tested sources FFS, BSM or MIX.

**Total or partial replacement of fishmeal protein (FM) by FFS protein :**

Fish silage is another form of fish meal, the introduction of the fish silage techniques for aquafeed production can be considered as one possible solution to FM deficiency problems. Details of the preparatory methods when using trash and other aquatic by-products are already known (Wassef, 1991). The present work add another new approach for preparations fish silage by applying the fermentation technique.

In this experiment when FM protein was totally replaced with the FFS in the diets of Nile tilapia (fry, fingerlings and adults), fish growth was significantly reduced.

The reduction in liver weight combined with the drop of total muscle and liver protein for fish fed the 100% FFS diet, indicated the intolerance of fish to levels of FFS exceeding 50% of the dietary protein. However, partial replacement of FM with FFS by 25-50% showed growth performance and feed utilization efficiency comparable to those recorded for fish fed the FM-based diet. Improvement of liver composition including higher values of hepatosomatic indices, hepatic protein and glycogen confirm these findings and suggest 25% FFS inclusion level as the optimum for the species.

Previous trials for preparation and testing fish silage (acid addition) for *O. niloticus* & *O. aureus* were recently achieved (Sobhy, 2000). Her results revealed that *O. niloticus* and *O. aureus* fry fed 30% dietary silage protein recorded the highest fish growth and feed utilization efficiency. Also, In a previous study, FM was replaced by different levels (0, 10, 15, 20%) of chicken offal silage in diets fed to Nile tilapia fingerlings (Belal *et al.*, 1995). They found that weight gain, FCR, PER and proximate body composition did not vary significantly between treatments. The authors concluded that on an isocaloric/ isonitrogenous basis chicken offal silage can make up as much as 20% of *O. niloticus* fingerlings commercial feeds.

The biochemical composition of fish revealed that a reduction in liver weight for fishes fed diets (5) which includes 100% FFS. Also, the total protein content of the liver and flesh decreased. By contrast, the total lipid in liver and flesh for the tree stages of *O. niloticus* fed FFS reached to maximum for diets (5), while these values were minimum for fish receiving 25% inclusion. These results were supported by Delahunty & Valming (1980) and Jauncey (1982). Fish composition and condition factor showed similar trend of variation among all treatments i.e. in the present investigation, the protein and lipid contents usually increased as compared to initial ones for all treatments.

The body ash content was also unaffected by different dietary FM replacement levels as mentioned by Jauncey (1982). The present observations are on the line with those of Clement and Lovell (1994) for cultured Nile tilapia and Conçeic *et al.* (1998) for *Clarias gariepinus*. Further, The fish composition recorded in the present study agreed with that previously recorded by Siddiqui *et al.* (1988) for the species protein content (between 55.9 & 60.9%) and fat (19.5 & 26.0%) and exceeds the percentage on dry weight basis, composition given by Rodriguez-Serna *et al.* (1996) for fed tilapia.

The two formulae tested in the present study diets 2 and 3 were suggested for best growth performance for *O. niloticus* fingerlings as evidenced from the insignificantly daily weight gain (66.2g x 0.49g/ fish/ day) as compared with that of the CTR group of fish fed the fish meal diet (64.25g x 0.47g/ fish/ day).

The progressive poorer growth performance at higher inclusion levels was due to depression of feed utilization and not feed intake as all fish received the same amount of food. One of the major factors limiting the usage of fish silage in fish feeds is the acidic nature of the products (pH $\simeq$ 2) which influence diet palatability (Wassef, 1991). Another factor that should be considered is the period of FFS storage (Fagbenro and Jauncey, 1993b).

No significant difference in profit index for fish fed the CTR diet and the diet containing 25% FFS, and the lowest profit obtained by fish fed the diet containing 100% (the highest inclusion level of FFS). These results are in agreement with those results reported by Sobhy (2000) who stated that there were economic benefits at 30% protein silage inclusion level, in *O. niloticus* and *O. aureus* diets, but at higher inclusion level the economic efficiency was significantly reduced.

Therefore, from the economical view point 25% FFS inclusion level is recommended in Nile tilapia feeds.

## Total or partial replacement of fishmeal protein with boiled soybean meal (BSM) :

Soybean meal is one of the most abundant of the oilseed meals used widely in animal and fish nutrition. However, a reduction of the fish growth has been reported when fish meal was replaced with increasing levels of soybean meal (Shiau *et al.*, 1990; Webster *et al.*, 1992; Gallagher, 1994 and Robaina *et al.*, 1995).

However raw soybean meal or inadequately heated soybean meal contains higher activity of trypsin protease inhibitors casusing growth reduction (Wilson and Poe, 1985). Therefore, soybean should be either properly heated by boiling or defatted or germinated prior roasting, ... ect before inclusion as meals in aquafeeds (Wassef *et al.*, 1988 and Wee & Shu, 1989).

The present findings confirm the boiling technique of raw soybean as proper treatment before inclusion in Nile tilapia feeds. Results suggested 50% dietary BSM to replace FM without adverse effect on fish growth or feed utilization efficiency. In the meantime, muscle composition and liver glycogen are comparable to those of fish fed FM-based diets.

The values of the liver weight, hepatic protein and glycogen were much higher at using diets 2 and 3 in which fish receiving the lowest level of BSM (25-50%). In contrast, the total lipid in liver for the 3 stages of *O. niloticus* fed BSM reached maximum values for diets 5 and they were minimum for fish receiving 25% level.

Total protein and lipids showed no significant differences for fish fed 25 – 50% BSM compared with CTR diet. Siddiqui *et al.* (1988) showed similar results with *O. niloticus* fry when found that the body protein content increased with increasing protein levels in the diet.

El-Ghobashy (1990) found an irregular trend (correlation) between water and protein content for *O. niloticus*. The present study nearly agreed with El-Ghobashy results besides to the inverse relationship between protein and water content for fish fed different levels of BSM which was detected .

A maximum recommended dietary inclusion level of BSM might be 50% in Nile tilapia feeds.

Biological and biochemical composition of fish revealed that full replacement of FM was achieved using BSM (diet 5) gave lowest filling index with the decrease of dietary protein level. Also, the same trend for gonadosomatic and hepatosomatic indices were observed.

On the contrary, when fish fed diet 1 or 3 where 25- 50% replacement of FM by BSM, the highest FI, GSI and HSI were obtained.

In other words, the aforementioned parameters (indices) decreased gradually with increase in BSM levels with diets. Also, condition of fish flesh followed the same trend of the condition factor. The incidence cost was significantly increased for fish fed the diet incorporating 100% BSM than those for fish fed the test diets containing 25% BSM. The best profit index was recorded for fish fed the diets containing up to 50% BSM with significantly difference if compared with CTR diets.

The growth results obtained in the present experiment are logic and reasonable when compared with those previously reported by other authors (Khalifah, 1995; Zeweil,1996 and Atwa, 1997). Similarly Shiau *et al.* (1990) experimented SBM as a partial replacement for FM in tilapia hybrid (*O. niloticus* and *O. aureus*) diets. They found that all growth performance and nutritional parameter values (PWG, FCR, PER & protein digestibility) for fishes were not significantly different from those fed the CTR diet (100% FM). The last authors showed also that SBM could be used to replace 30% FM in a diet for tilapia fingerlings hybrids.

Robaina *et al.* (1995) reported that the deamination process of dietary protein was increased by increasing the substitution of fish meal by soybean meal. Therefore, the deamination process may be occurred particularly in the most crystalline amino acid resulting in increasing liver weight. This may explain why hepatosomatic indices (HSI) were higher for fish fed the diets containing over 50% BSM.

Also, Alexis *et al.* (1990) reported a positive correlation between the carob seed germ meal (CSGM) of the diet and HSI. The authors suggests that this correlation might result from glycogen accumulation created by a high digestibility of CSGM carbohydrate.

Robaina *et al.* (1995) stated that, the delay in ammonia excretion noticed in fish fed diets containing vegetable proteins may have been related to a larger time required for the digestion, absorption and metabolism of plant proteins. This indicates an increase in length of intestine by increasing plant protein level therefore, increasing the level by BSM may result in higher gut indices.

The bad effect of increasing the inclusion levels of BSM on fish growth was the higher production cost of fish fed these diets since both feed price and feed conversion ration increased.

**Partial or complete replacement of FM protein by MIX(a mixture of both plant and animal proteins) :**

Previous experiments (1 & 2) proved that 25 – 50% inclusion levels of FFS and 25% of BSM in Nile tilapia diets should not exceeding 50% for FFS and 25% for BSM to obtain growth rate comparable to that of fish fed the FM control diet.

The present findings revealed that in Nile tilapia feed up to 50% of FM can be substituted with a mixture of both FFS and BSM without significant adverse effects on fish growth or feed utilization efficiency.

Davies *et al.* (1989) reported that, when appropriate ratios are maintained between the dietary components used, better results can be achieved. They stated that, diets containing meat and bone meal (MBM) or high MBM / blood meal (BM) ratios (3:1) and (2:3) were found to be superior to FM even at a 100% substitution level in diets fed to *O. mossabica* fry. Also, Nieves and Barro (1991) used various combinations of fish, shrimp and snail, with different plants in diets fed to *O. niloticus* fingerlings.

In another study, Bishop *et al.* (1995) reported that hydrolyzed feather meal (HFM) could replace up to 50% and 66% of the FM or FM : MBM within diets for *O. niloticus* fingerlings and fry respectively, with no loss in growth performance.

Rodriguez – Serna *et al.* (1996) studied the use of commercially defatted animal by product meal (ABM: a combination of BM, MBM, HFM and FM) with soybean oil or a soybean oil : fish oil mixture (1 : 1), as a replacement for FM in *O. niloticus* fry feeds. They found that ABM could replace up to 75% of the FM within the CTR diet tested and that ABM supplemented with soybean oil could totally replace FM.

Cost / benefit analyses of the 3 test FM replacers indicated that the cost per Kg feed decreased significantly by increasing the FM replacer in diets. The lowest incidence cost was observed for fish fed the lowest incorporation level (25% Mix). The best profit index was obtained by fish fed the diets containing 25-50% level of MIX.

In conclusion, the present work findings indicated that FFS, BSM and MIX could replace 25 to 50% of FM in *O. niloticus* diets.

The superiority of FM over other proteins alternate are referred to :

It is well documented that the biological value of animal protein is higher than that of plant origin (McDonald *et al.*, 1995). Also, the indispensable amino acid profile (IAA) of fish meal constitutes the most suitable source of IAA for fish, given high conversion between the whole IAA profile and IAA requirement pattern (Mambrini and Kaushik, 1995). Jauncey, (1982) and Hossain *et al.* (1992) reported that fish fed fishmeal diet has significantly the highest amino acid digestibility (90.5%) followed by those fed linseed diet (85.5%) and the lowest was for fish fed the sesame diet (82.4%). The apparent protein digestibility for fish meal (about 92%) was higher than that for soybean meal (75.8%) or full-fat soybean meal (86.4%) (Hajen *et al.*, 1993 and Gomez *et al.*, 1995). Fish meal contain no toxic substances, but raw soybean meal (untreated) contain antinutritional factors which make their protein bodies undigestable to fish (Wassef *et al.*, 1988).