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REPLACEMENT OF FISH MEAL BY SILKWORM, *BOMBYX MORI* PUPAE MEAL, IN NILE TILAPIA, *OREOCHROMIS NILOTICUS* DIETS.

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SUMMARY

This study was designed to determine the effect of practically replacing fish meal with Silkworm, *Bombyx mori* pupae meal (SWPM), as a non-conventional protein source, at different levels (0, 33.33, 66.66 or 100% from fish meal) on growth performance, feed utilization, body composition and economical efficiency per fish of Nile tilapia fingerlings. A total number of 120 Nile tilapia fingerlings with average initial weight of 10g/fish were randomly distributed into four experimental groups in triplicate and were fed daily at a rate of 3% of fish live body weight through 14 weeks experimental period, to study the effect of four diets contained 30 % crude protein in average. Results indicated insignificant (P>0.05) differences in the final body weight, weight gain, daily gain, specific growth rate, feed conversion ratio, protein efficiency ratio and protein productive value between fish fed diets containing 33.33 or 66.66% of SWPM and the control diet. However, Fish fed diets contained 100% level SWPM showed the lowest growth performance, feed conversion ratio and protein efficiency as compared to those fed the other levels. Fish muscles area decreased when 100% of fish meal was replaced by silkworm pupae compared with the other diets. The proximately composition of whole fish body was not affected significantly among the all fish groups fed the experimental and control diets. It was concluded that diet containing 66.66% SWPM (from fish meal) was economically superior to the other tested diets. It reduced about 18.79% of feeding cost per unit of fish compared with control diets.

***Keywords**: Nile tilapia, silkworm pupae, growth and growth parameters.*

INTRODUCTION

There has been considerable research efforts towards utilization of less expensive renewable ingredients in fish diet formulations to alleviate problems related to shortage of quality fish meal (Yang *et al.*, 2004 and Mukhopadhyay and Mitra, 2007).

Fish meal and oil are the major components of feed for farmed fish, particularly carnivorous species. Fish meal, however, is a finite resource which cannot be produced in sufficient quantities to sustain the current growth in aquaculture; its rising cost is another cause for concern among fish farmers. Research into alternatives to fish meal has now an international research priority and is the focus of current fish nutrition research. Promising results have been obtained by using plant protein sources (soyabean, rapeseed, corn gluten, wheat gluten, pea and lupine meals) and animal (meat meal, meat and bone meal, feather meal and blood meal) by-product meals. The latest approach, though not new, is the use of insects as a source of protein in fish diets (Tacon,1993 and Adeparusi and Ajayi 2000). The nutritive value of insects as feeds for fish, poultry and pigs has been recognized for some time in China, where studies have demonstrated that insect-based diets are cheaper alternatives to those based on fish meal. The insects used are the pupae of silkworms (*Bombyx mori*), the larvae and pupae of house flies (*Musca domestica*) and the larvae of the mealworm beetle, *Tenebrio molitor*. Silkworm pupae are an important component of cultured carp diets in Japan and China. Dried ground soldier fly larvae have been fed to chickens and pigs with no detrimental effects (Hale,1973 and Newton *et al.*, 1977).

In many parts of the world, silkworm pupae are an important source of dietary protein. Several different species are served up, but *Bombyx mori* is the most common. Silkworm pupae, a waste product of silk industry , could be used as a top class unconventional protein and energy feed for poultry after proper processing at a reasonable cost. Compared to fishmeal, silkworm pupae are a low cost ingredient and both rich in protein and lipid (Bhuiyan *et al.*, 1989). It is also an important source of crude protein, ether extract, crud fiber, nitrogen free extract, ash, calcium, phosphorus, lysine and methionine (Habib and Hasan, 1995). From the above information, it is evident that, successful use of cheaper silkworm pupae as a substitute of costly fishmeal might reduce the production cost of balanced fish diets with a consequent increase in profitability of fish production.

With those considerations, the present study was designed to determine the effect of replacing fishmeal (FM) by silkworm pupae (SWP) in lieu of fishmeal for optimum fish performance and to assess the economic feasibility of replacing FM by SWP in the Nile tilapia diets.

MATERIALS AND METHODS

This work was carried out at the Wet Fish Laboratory, Department of Animal Production, Faculty of Agriculture, Kafrelsheikh University, during 2007 year.

Experimental fish:

The experimental Tilapia fish (*Oreochromis niloticus)* were collected from Moassasa farms, Tolompate 7. Prior to the start of the experiment, the fingerlings were placed in a fiberglass tank and randomly distributed into aquaria to be adapted to the experimental condition until starting the experiment. Fish were fed the control diet for two weeks, during this period healthy fish at the same weight replaced the died ones.

Experimental design of rearing fish:

A total of 120 Nile tilapia, *Oreochromis niloticus* with an average initial body weight of 10 g were randomly stocked into 12 aquaria (70 liter each). Three aquaria were assigned for each treatment. Fresh tap water was stored in fiberglass tanks for 24h under aeration for dechlorination. One third of all aquaria was replaced daily. Four air stones were used for aerating the aquaria water. Water temperature ranged between 25-27 °C. Photoperiod was 14 hr per day using florescent light. Fish feces and feed residue were removed daily by siphoning.

The four groups were fed diets containing dietary energy ranged between 4.86 to 4.72 kcal GE/g with about 30% CP. Fish from each replicate were weighed at the start of each experiment and henceforth counted and weighted every two weeks through out the experimental period (14 weeks). All experimental fish were apparently healthy and free from external parasites.

Experimental Diets:

The chemical analysis of feed ingredient used in the experimental diets and silkworm pupae are presented in Table (1).

Table (1): The chemical analysis of ingredients used in the experimental diets.

Item	DM%	Nutrient % of DM						GE** kcal/g
		OM	CP	EE	CF	Ash	NFE*	
Herring fish meal	94.25	89.02	71.95	14.84	0.91	10.98	1.32	5.523
Yellow corn	92.92	98.65	9.67	7.48	3.03	1.35	78.47	4.254
Soybean meal	89.89	92.12	45.87	1.49	8.70	7.88	36.06	4.564
Wheat bran	94.43	95.13	12.95	7.31	8.48	4.87	66.39	4.224
Silkworm pupae	92.07	92.71	62.14	18.17	3.09	7.29	9.31	5.624

*NFE calculated by differences [NFE = 100- (CP + EE + CF + Ash)].

** Gross energy was calculated according to *NRC (1993)* by using factors of 5.65, 9.45 and 4.22 K cal per gram of protein, lipid and carbohydrate, respectively.

Four diets were formulated (Table 2) where fish meal in the control diet (D1) was replaced by silkworm pupae meal (SWPM) at 33.33, 66.66 and 100% for D2, D3 and D4, respectively. The experimental diets were formulated to contain about 30.45-30.67% crude protein and about 4.70 kcal GE/g in diets (Table 3). The basal and tested diets were formulated from the commercial ingredients. The dry ingredients were grounded through a feed grinder to very small size (0.15 mm). The ingredients were weighed and mixed by a dough mixer for 20 minutes to homogeneity of the ingredients. The estimated amount of oil components (sunflower oil) was gradually added (few drops gradually) and the mixing operation was continued for 20 minutes. The diets were pelleted through fodder machine and the pellets were dried under room temperature. The diets were collected, saved and stored in plastic bags in refrigerator at 4Ċ during the experimental period to avoid the deterioration of nutrients.

Table (2): Ingredients composition (%) of the experimental diets.

Item	Diets[2]			
	D1 Control (0%)	D2 (33.33%)[3]	D3 (66.66%)[3]	D4 (100%)[3]
Herring fish meal	15	10	5	0
Silkworm pupae meal (SWPM)	0	5	10	15
Yellow corn	25	25	20	20
Soybean meal	34	38	42	44
Wheat bran	20	16	17	15
Sunflower oil	3	3	3	3
Vitamins and minerals premix[1]	3	3	3	3
Total	**100**	**100**	**100**	**100**

[1]Vitamins and minerals premix (product of HEPOMIX) each 2.5 kg contain : 12.000.000 IU Vit.A; 2.000.000 IU Vit. D3 ; 10 g Vit. E ; 2g Vit. K3; 1g Vit. B1 5g Vit. B2;1.5 g Vit. B 6 ; 10g Vit.B12; 30 g Nicotinic acid ; 10 g Pantothenic acid; 1g Folic acid; 50g Biotien; 250g Choline chlorid 50% ; 30g Iron; 10g copper; 50g Zinc; 60g Manganese; 1g Iodine; 0.1g Selenium and Cobalt 0.1g (Local market)

[2]D1 Control (0% SWPM), D2 (33.33% SWPM), D3 (66.66% SWPM) and D4 (100% SWPM).

[3] Substitution in the expense of fish meal.

The experimental fish were fed the diets at a rate of 3% live body weight/day and the daily rations were introduced at 2 equal meals at 8 am and 2 pm through 14 weeks. The fish were weighed biweekly intervals during the experimental period and the feed quantities were readjusted according to the change in live body weight.

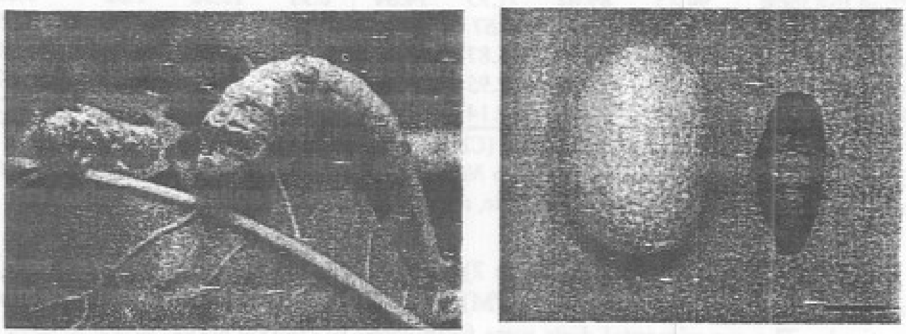


Fig. (1): Silkworm. a) larvae on a mulberry leaf, b) cocoon and pupa. Scale bar; 10 mm.

Biochemical analysis:

The chemical analysis of ingredients, diets and fish samples at the beginning and fish samples (4-5 fishes) from each group were obtained at the end of the experiment for chemical analysis for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash, additionally, the gross energy contents of the ingredients, experimental diets and fish samples were calculated by using the values of 5.65, 9.45 and 4.22 k cal/g of protein, lipid and carbohydrates, respectively (NRC,1993).

Measurements of water parameters:

Water sample from each aquarium was taken weekly to determine dissolved oxygen by using oxygen meter model 9070, pH was determined immediately by using a digital (pH-meter). Analysis of NO_2, NO_3, PO_4, alkalinity and hardness were carried out using commercial kits (Hach International Co., Cairo, Egypt).

Performance parameters:

Average total gain (ATG), average daily gain (ADG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), protein productive value (PPV) and survival rate (SR) were calculated according to Khalil (1997) as follows:

ATG (g/fish)=Average final weight(g) – Average initial weight(g).

ADG (g/fish/day) = [ATG(g)/experimental period(d)].

SGR (%/day) = [(ln final body weight–ln initial body weight) 100]/experimental period (d).

FCR = Feed Intake (g)/Live weight gain (g).

PER= Live weight gain (g)/ Protein intake (g).

PPV (%) =100[Final fish body protein (g)–Initial fish body protein(g)]/crude protein intake (g).

SR =100[Total No. of fish at the end of the experimental/Total No. of fish at the start of the experiment].

Organs indices:

All fish were killed, then abdominal cavity was opened to remove liver, kidneys, gonads, and spleen, each of them was weighed individually. Hepatosomatic index (HSI), kidneysomatic index (KSI), gonadosomatic index (GSI), and spleensomatic (SSI) were calculated as follow:

HSI =100(Liver weight / body weight).

KSI = 100(Kidneys weight / body weight).

GSI = 100(Gonads weight / body weight).

SSI = 100(Spleen weight / body weight).

Muscular and abdominal areas:

The fish were examined also for infiltration / muscular areas using Echo Scan (H5/s) Ultrasonic Diagnostic Instrument, Budapest Remeny Co. according to (Salem, 2003).

Preliminary economical efficiency:

Costs were calculated according to the commercial feed prices in local markets during 2007, where 1 kg of fish meal, soybean meal, wheat bran, yellow corn, sunflower oil, vitamins and minerals premix and silkworm pupae were 11, 2.5, 1.00, 1.25, 7.00, 10.00 and 2.00 LE, respectively.

Statistical analysis:

The obtained numerical data were statistically analyzed using SPSS (1997) for one-way analysis of variance. When F-test was significant, least significant difference was calculated according to Duncan (1955).

RESULTS AND DISCUSSION

Chemical composition of ingredients and diets.

The chemical composition of silkworm pupae (on DM basis) was 92.07, 92.71, 62.14, 18.17, 3.09, 9.31, 7.29 % and 5.624 kcal/g for DM, OM, CP, EE, CF, NFE, Ash and GE , respectively. Proximate composition suggested that, these unconventional food items (pupae) could be a good source of protein and fat.

Experimental diets (Table 3) contained nearly similar levels of DM, CP, EE, CF, Ash, NFE, GE and CP/GE ratio. The CP and GE content of experimental diets were around 30.56 % and 4.70 kcal/g , respectively. These values were within the range suggested for tilapia by Jauncey and Ross (1982) and NRC (1993) for CP and Hassanen *et al.*, (1995) for GE.

Table (3): The chemical analysis of the experimental diets.

Item	Diets (On DM basis, %)			
	D1	D2	D3	D4
Dry matter	90.48	94.80	93.93	93.58
Crude protein	30.55	30.56	30.67	30.45
Ether extract	12.06	12.58	13.54	14.08
Crude fiber	5.32	5.41	5.62	5.70
Total ash	9.30	9.56	10.21	10.38
Nitrogen free extract	42.77	41.89	39.96	39.39
Calculated energy value				
GE (kcal/g)[1]	4.72	4.68	4.70	4.71
ME (kcal/g)[2]	3.84	3.86	3.87	3.89
CP/GE,mg/kcal[3]	64.72	65.30	65.26	64.65
CP/GE, g/Kj [4]	15.47	15.61	15.61	15.45

[1]GE (Gross energy) was calculated according to NRC (1993) by using factors of 5.65, 9.45 and 4.22 K cal per gram of protein, lipid and carbohydrate, respectively.
[2]ME (Metabolizable energy) was calculated using the value of 4.5, 8.1 and 3.49 K cal per gram of protein, ether extract and nitrogen free extract, respectively according to Pantha (1982).
[3]P/E (protein to energy ratio) = mg crude protein / Kcal GE.
[4] Kcal = 4.184 kj (McDonald, *et al.*, 1979).

Water quality parameters:

Results of water quality parameters of the experimental aquaria were affected by varying feed supplements during the experimental period. Average samples are summarized in Table (4). In general, average water temperature of the different treatments was ranged between 25 and 27 °C. The concentration of dissolved oxygen (mg/L) for different treatments ranged between 5 and 6 ppm which are beneficial to fish growth. Kamal *et al.*, (2004) reported that, levels of dissolved oxygen above 4 ppm is considered a limiting value, below which, fish may live but can not feed or grow well. Average of available phosphorus ranged between 0.1 and 0.4 mg/L which represent the normal range of phosphorus. This range was found to be suitable for growth of fish as reported by Forts *et al.,* (1986) and Boyd and Musing (1981). Nitrite (No_2) and (No_3) concentration ranged from 0.11 to 0.14 mg/L and from 2 to 5 mg/L, respectively. Averages of pH values for the treatments ranged from 6 to 8, the lower pH values may be attributed to the increase in organic matter contents in these aquarium, which lead to lower pH levels (Kamal *et al.,* 2004). The values of the total alkalinity ranged from 125 to 135 ppm. The above results showed that all parameters of water quality were within the normal range.

Table (4): Ranges of some important measured Physico-Chemical parameters of fish rearing water throughout the experimental period.

Temperature C°	PH value	DO ppm	Alkalinity ppm	Hardness mg/L	PO_4 mg/L	NO_2 mg/L	NO_3 mg/L
25-27	6-8	5-6	125-135	295-325	0.1-0.4	0.11-0.14	2-5

Growth performance and survival rate:

Data concerning average total gain (ATG), average daily gain (ADG), specific growth rate (SGR), and survival rate (SR) for the four experimental diets fed to Nile tilapia fingerlings are presented in Table (5).

Data indicated that, no significant differences (P>0.05) in the initial fish weight among different experimental groups were found which indicate that, there are homogeneity at the experimental start for all tested groups. Results also showed that, fish fed diets containing 0 (D1, control), 33.33 (D2) and 66.66 % (D3) SWPM were significantly higher (P<0.05) in final body weight (FW), average total gain (ATG), average daily gain (ADG), specific growth rate (SGR) than those fed the 100% (D4) SWPM , while the lowest weight gain value of daily gain, specific growth rate and survival rate were obtained by group fed diet (4).

Results in Table (5) concerning growth parameters are also in according with results of Sogbesan, *et al.*, (2006) who showed that, increasing replacing level of silkworm pupae meal in diets of *Claries gariepinus* fingerlings at level 25% caused increasing growth of fish, but levels 50, 75, and 100% silkworm pupae meal in fish diets caused decreasing fish growth. The same trend was found by Khatun, *et al., (2005)* who reported that replacement 6 to 8% of fish meal by silkworm pupae meal increased fish growth. Also, Udayasekhara (1994) found that the pupae are being used as fertilizer, and a small proportion is used as a constituent of fish feed. Nandeesha *et al., (2000)* reported that, the pupae could be used to replace fish meal completely and could be included up to 50% in common carp diets without any adverse effect.

Table (5): Growth performance parameters of Nile tilapia fed the experimental diets.

Diets	Initial wt. (g/fish)	Final wt. (g/fish)	ATG (g/fish)	ADG (g/fish/day)	SGR (%/Day)	SR (%)
1 (control)*	10.10± 0.12	40.24± 0.22^a	30.14± 0.15^a	0.31± 0.01^a	1.41± 0.02^a	100± 0.24^a
2	10.14± 0.08	39.64± 0.23^a	29.50± 0.17^a	0.30± 0.01^a	1.39± 0.05^a	100± 0.29^a
3	10.17± 0.10	37.52± 0.19^a	27.35± 0.15^a	0.28± 0.04^a	1.33± 0.08^b	100± 0.34^a
4	10.08± 0.11	32.10± 0.15^b	22.02± 0.21^b	0.22± 0.06^b	1.18± 0.07^c	90± 0.35^b

a, b and *c* Means in the same column bearing different letters differ significantly at 0.05 level.
* D1 Control (0% SWPM) , D2 (33.33% SWPM) , D3 (66.66% SWPM) and D4 (100% SWPM).

Survival rate of the experimental fish groups was within the normal range. It recorded 100% for all fish groups except those fed diet containing 100% SWPM which gave 90% survival rate (Table 5).

Feed intake and nutrient utilization:

Results of nutrient utilization in terms of feed intake (FI), feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV %) are illustrated in Table (6). Average of feed intake (FI) of the control group (D1), 33.33 (D2), 66.66 (D3), and 100% (D4) SWPM were found to be 45.46, 44.35, 44.76 and 46.00 (g/fish). Average of FCR of the different diets were 1.51, 1.50, 1.62, and 2.09 kg feed for each kg gain for D1, D2, D3 and D4, respectively. These results indicated that, the best ($P<0.05$) FCR records were obtained by the groups fed D2 and D1(control) followed by groups fed D3 and D4. The same trend was observed in PER, where the D1, D2 and D3 groups showed significant increase ($P<0.05$) than group fed D4 (Table, 6).

The insignificant ($P>0.05$) differences in growth, feed conversion ratio and protein efficiency ratio were observed in the present study for D2, D3 and D4 as compared to control diet, which clearly indicates that, fishmeal can be replaced by the silkworm pupae. Begun *et al.*, (1994) and Nandeesha *et al.* (2000) recorded significantly better specific growth rate, feed conversion ratio and protein efficiency ratio for rohu and common carp fed with a diet, 50% of its protein being contributed by silkworm pupae compared to a fishmeal based diets

As presented in Table (6) average of PPV% for the experimental groups was decreased in a gradual significant ($P<0.05$) order with each increase in replacement level of fish meal by silkworm pupae meal (SWPM) to level 100%, where fish fed D1 and D2 recorded the highest PPV% values (32.33 and 26.13%, respectively) and the fish fed D4 recorded the lowest value (14.56%).

Table (6): Average of feed intake, feed conversion, protein efficiency ratio and protein productive value% of Nile tilapia fed the experimental diets.

Diets	Feed utilization		Protein utilization	
	FI (g/fish)**	FCR	PER	PPV%
1 (control)*	45.46± 0.22	1.51± 0.03 b	2.17± 0.01 a	32.33± 0.14 a
2	44.35± 0.24	1.50± 0.05 b	2.18± 0.05 a	26.13± 0.13 ab
3	44.76± 0.13	1.62± 0.07 b	1.99± 0.06 a	21.27± 0.18 b
4	46.00± 0.16	2.09± 0.03 a	1.57± 0.01 c	14.56± 0.21 c

a, b and *c* Means in the same column bearing different letters differ significantly at 0.05 level.
* D1 Control (0% SWPM) , D2 (33.33% SWPM) , D3 (66.66% SWPM) and D4 (100% SWPM).
** On dry matter basis

The pervious results were agreement with the findings of Nandeesh *et al.*, (2000) or Sogbesan *et al.*, (2006) who, reported that, replacement of fish meal with SWPM at 30, 40 and 50% or 25, 50, 75 and 100% levels reduced steadily the apparent crude protein digestibility of Nile tilapia.. The progressive increase in nitrogen retention with increasing levels of pupae indicates the efficient utilization of pupae fat as an energy source in the present study.

Body composition:

Body chemical composition of Nile tilapia is shown in Table (7). Results showed no significant differences (P>0.05) for DM, CP, EE and Ash of Nile tilapia fed diets without or with SWPM. These results are in agreed with the findings of Nanadeesha, *et al.* (2000) and Sogbesan *et al.* (2006).

Table (7): Means ± standard error of proximate analysis (%, on DM basis) of experimental fish fed on graded levels of silkworm pupae.

Diets	DM	CP	EE	Ash
Initial fish	22.23	57.13	16.78	15.53
1 (control)*	25.18± 0.03	61.62± 0.14	17.26± 0.04	17.12±0.02
2	24.71± 0.10	60.67± 0.03	19.05± 0.05	17.43±0.23
3	24.34± 0.06	60.05± 0.01	20.00± 0.02	16.89±0.01
4	23.16± 0.08	59.17± 0.03	21.03± 0.02	16.52±0.26

* D1 Control (0% SWPM), D2 (33.33% SWPM), D3 (66.66% SWPM) and D4 (100% SWPM).

Internal organs indices:

The effect of dietary SWPM inclusion on fish organs is presented in Table(8). Results reflected no significant differences between D1 (control) and D2 and D3 for HSI, GSI for female showed significant differences between D4 and D3 compared with the other treatments, but GSI for male had significant differences between D1 and D2 compared with D3 and D4. Results in KSI and SSI (D1 to D4) non significant. From these results the different levels of SWPM had significant effects on HIS and GSI not for KSI and SSI. These results agree with the findings of Nanadeesha, *et al.*, (2000), and Sogbesan,*et al.*, (2006).

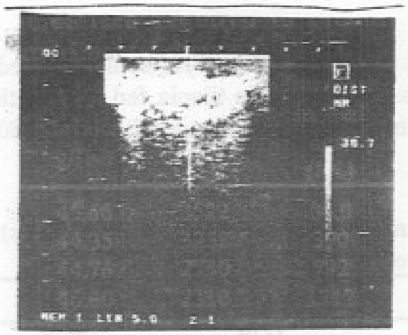
Table (8): Effect of dietary silkworm pupae meal levels on organs indices of the experimental fish.

Diets	HSI	GSI (Female)	GSI (Male)	KSI	SSI
1 (control)*	2.19±0.01a	3.12±0.02a	0.86±0.02a	0.13±0.03	0.17±0.01
2	2.20±0.01a	2.93±0.03b	0.85±0.05a	0.12±0.01	0.16±0.02
3	2.16±0.04a	2.45±0.05c	0.64±0.08b	0.13±0.03	0.16±0.01
4	1.65±0.15b	2.38±0.08c	0.63±0.08b	0.11±0.01	0.15±0.01

a, b and *c* Means in the same column bearing different letters differ significantly at 0.05 level.
* D1 Control (0% SWPM) , D2 (33.33% SWPM) , D3 (66.66% SWPM) and D4 (100% SWPM).

Muscular and abdominal areas:

This test presented the variations among the tested fish groups, where Figs. 2, 3, 4 and 5 presented the groups 1, 2 and 3 (control, 33.33 and 66.66% SWPM) with larger muscular (white area) than in group 5 (100% SWPM) Fig. (5). But the increase at abdominal cavity (black area) is proportional to the level of 100% SWPM.



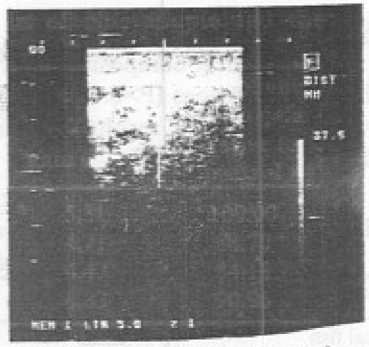
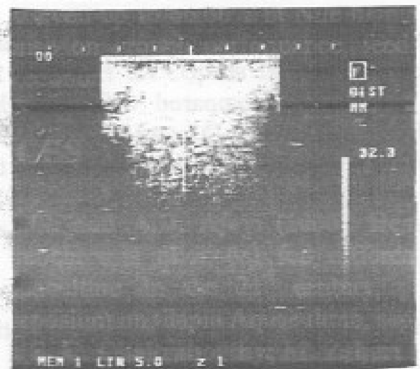


Fig. (2) : D1 (control), 0% SWPM of fish meal **Fig. (3) : D2, (Muscular area about**
33.33% SWPM of fish meal (Muscular area
about 38.7 cm)37.9 cm)



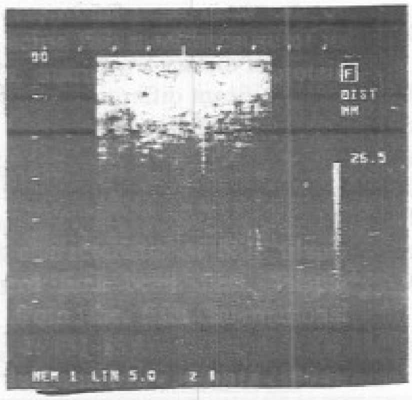


Fig. (4) : D3, 66.66% SWPM of fish meal **Fig. (5) : D4, (Muscular area**
100% SWPM of fish meal Muscular
area about 32.3 cm) about 26.5 cm)

Preliminary economical efficiency:

Data of preliminary economical efficiency, Table (9), cleared that, diets containing different levels of SWPM had lower incidence costs than the control diet. The results indicate that, the diet containing 66.66% SWPM (D3) from fish meal had the lowest cost for producing one kg fish, it recorded about 84.18% of those fed the control diet, followed by 33.33 and 100% SWPM instead of fish meal, which recorded 88.70 and 90.96%, respectively of those fed the control diet. Improvement of preliminary economic efficiency of fish fed different levels of silkworm pupae meal may be due to their ability to increase useful economical protein. These findings coincide with the findings of Habib *et al.*, (1992), Rahman *et al.*, (1996), Choudhury *et al.*, (1998) and Khatun *et al.*, (2003). They reported that, silkworm pupae is a useful economical protein and reduce production costs when it replaced FM.

Table (9): Cost of feed required to produce one Kg gain of Nile tilapia fed the experimental diets.

Diets No.	Feed intake g/fish	Cost (LE) of one ton diet	Decrease in feed cost (LE)	Total gain g/fish	Feed cost/kg gain (LE*)	Cost of one kg fish gain relative to control
1 (control)**	45.46	3522	00.0	30.14	5.31	100.00
2	44.35	3232	390	29.50	4.71	88.70
3	44.76	2730	792	27.35	4.47	84.18
4	46.00	2310	1212	22.02	4.83	90.96

* feed cost/kg gain (LE) = feed intake x cost (LE) of one ton feed/1000xtotal gain.
** D1 Control (0% SWPM), D2 (33.33% SWPM), D3 (66.66% SWPM) and D4 (100% SWPM).

CONCLUSION

The results of the present study demonstrated that, silkworm pupa meal can be profitably used even up to 66.66% in Nile tilapia diets replacing fish meal because of its positive response on growth performance, feed conversion, nutrient utilization, protein efficiency and economical efficiency.

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استبدال مسحوق السمك بمسحوق عذارى دودة الحرير في علائق اسماك البلطي النيلى

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أجريت هذة الدراسة بغرض دراسة استبدال مسحوق السمك بمصدر غير تقليدي للبروتين الحيواني والمتمثل في استخدام مسحوق عذارى دودة الحرير وكانت نسبة الاستبدال بمستويات مختلفة (صفر و٣٣,٣٣ و ٦٦,٦٦ و ١٠٠٪) من مسحوق السمك في العليقة المتكونة لأسماك البلطي النيلي لدراسة تأثيرها على أداء النمو وكفاءة تمثيل الغذاء ومكونات الجسم في نهاية التجربة وكذلك التعرف على أحسن نسبة استبدال يمكن بها تحقيق أحسن عائد اقتصادي للتعرف على الكفاءة الاقتصادية. وتم استخدام عدد ١٢٠ سمكة (بمتوسط وزن ١٠ جم) تم توزيعها عشوائيا في أربعة معاملات كل معاملة في ثلاث مكررات وكانت تتم التغذية بمعدل ٣٪ من الوزن الحي يوميا خلال ١٤أسبوع وهى مدة التجربة وذلك لدراسة تأثير الأربع علائق والتي تراوحت نسبة البروتين بها من٣٠,٤٥ إلى ٣٠,٦٧٪.

أظهرت النتائج عدم وجود اختلافات معنوية في معدل الوزن النهائي ومعدلات الزيادة اليومية و الكلية للأسماك وكذلك في معدل النمو النوعي وكفاءة التحويل الغذائي وكفاءة تمثيل البروتين وذلك بين الأسماك التي تغذت على علائق تحتوى على مستوى استبدال ٣٣,٣٣ أو ٦٦,٦٦ ٪ مسحوق عذارى دودة الحرير (عليقه ٢ و ٣ على الترتيب) والأسماك التي تغذت على عليقة الكنترول (عليقة ١) – بينما الأسماك التي تغذت على عليقه ٤ (١٠٠ ٪ مسحوق عذارى دودة الحرير) أظهرت انخفاضا في معدلات النمو وكفاءة التحويل الغذائي و كفاءة تمثيل البروتين وذلك بالمقارنة بمستويات الاستبدال الأخرى وكذلك الأسماك التي تغذت على عليقة الكنترول. كما أظهرت النتائج انخفاض مساحة عضلات الأسماك التي تغذت على العليقه الرابعة (١٠٠ ٪ مسحوق عذارى دودة الحرير) بالمقارنة بالأسماك التي تغذت على العلائق الأخرى – كما لوحظ عدم وجود أي اختلافات معنوية في التركيب الكيماوي لجسم الأسماك التي تغذت على العلائق المختلفة بالمقارنة بأسماك الكنترول.

ومن خلال النتائج السابقة فقد وجد أن العليقة التي تحتوى على نسبة استبدال ٦٦,٦٦ ٪ مسحوق عذارى دودة الحرير (عليقه ٣) كانت أفضل العلائق من الناحية الاقتصادية حيث أنها توفر حوالي ١٥,٨٢ ٪ من تكاليف التغذية لإنتاج كجم من الأسماك وذلك مقارنة عليقة الكنترول.