Assiut Vet. Med. J. Vol. 40 No. 79, October 1998.

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EVALUATION OF POULTRY BY-PRODUCT AND EARTHWORM MEALS AS PROTEIN SOURCES FOR TILAPIA FISH

(with 9 tables & 3 figures)

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(Received at 28/9/1998)

تقييم مدى امكانية إستخدام مخلفات مجازر الدواجن ومسحوق دودة الأرض كمصدر بروتيني في علائق أسماك البلطي النيلي

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شملت الدراسه اجراء تجربتين لأختبار مدى أمكانية استبدال بروتين مسحوق السمك جزئياً أو كلياً بمصدر بروتيني آخر في علائق أسماك البلطي النيلي وهذه المصادر عباره عن مسحوق مخلفات مجازر الدواجن ومسحوق دودة الأرض. هذا وقد تم أستبدال بروتين مسحوق السمك ببروتين مخلفات مجازر الدواجن في التجربه الأولى وببروتين مسحوق دودة الأرض في التجربه الثانيه عند مستوى صفر, ٢٥%, ٥٠%, ٧٥%, ١٠٠% في كل تجربه حيث تم تقسيم عدد ١٥٠ سمكه إلى ١٠ مجموعات (كل مجموعه تحتوى على ١٥ سمكه) وتم تغذية الأسماك على العلائق حتى مرحلة الشبع لمدة ٦٠ يوماً (كل عليقه أعطيت لمجموعتين من الأسماك).

التجربه الأولى (مخلفات مجازر الدواجن): عدم وجود أختلاف كبير في معدلات النمو بين مجموعات الأسماك التي غذيت على العلائق التي تحتوى على ٢٥%, ٥٠% بروتين مخلفات مجازر الدواجن وان هذه المعدلات جيده مقارنه بالمجموعه الضابطه والمجموعات التي غذيت على ٧٥% أو ١٠٠% بروتين مخلفات مجازر الدواجن. قلة معدل أستهلاك الأكل في المجموعات التي غذيت على مستويات عاليه من بروتين مخلفات مجازر الدواجن (٧٥%, ١٠٠%). كما أثبتت التجربه أن الكفاءه التحويليه ومخزون البروتين كانت أعلى في المجموعات التي غذيت على العلائق التي تم فيها أستبدال ببروتين مسحوق السمك ببروتين مخلفات مجازر الدواجن عند ٢٥%و ٥٠% بينما كانت أقل قيمه في المجموعه التي غذيت على العليقه التي تحتوى على ١٠٠% بروتين مخلفات الدواجن. معدلات هضم البروتين الظاهريه لم تختلف كثيراً بين العلائق المختبره وقد تراوحت بين ٧٥% إلى ٨٤%.

التجربه االثانيه (مسحوق دودة الأرض): حدثت زياده في معدلات كل من الغذاء ووزن الجسم ومعدلات النمو في مجموعة الأسماك الضابطه التي غذيت على بروتين مسحوق السمك فقط عن المجموعات التي غذيت على العلائق التي تحتوى على بروتين مسحوق دودة

الأرض فقط أو خليط من الأثنين معاً. بالاضافه إلى ذلك كانت الكفاءه التحويليه ومعامل الهضم أعلى فى المجموعه الضابطه التى غذيت على بروتين السمك فقط عن المجموعات التى أستبدل فيها بروتين مسحوق السمك ببروتين دودة الأرض جزئياً أو كلياً. من هذه الدراسه يتضح أنه يمكن أستبدال بروتين مسحوق السمك جزئياً ببروتين مخلفات مجازر الدواجن مع إضافة بعض الأحماض الامينيه الهامه مما يؤدى إلى زيادة أنتاج الأسماك مع قلة تكلفة العليقه. أما بالنسبه لبروتين مسحوق دودة الأرض فانه يعتبر ذو درجه فقيره مقارنه ببروتين مسحوق السمك وان استخدامه له تأثير سئ على أنتاج الأسماك حتى لو استخدم بنسب منخفضه.

SUMMARY

In this study two experiments were conducted to test the possibility of replacing fish meal protein partially or completely by other protein sources in the commercial diets of tilapia (*O.niloticus*). These were, the poultry by-product meal (PBPM) and the dried earthworm meal (EWM). In the two experiments, fish meal protein was substituted by poultry by-product meal protein (PBPM) in the first one and earthworm meal protein (EWM) in the second at an levels of 0, 25, 50, 75 & 100% for the two products .In each experiment, 150 *O.niloticus* fish were divided into equal 10 groups (15 fish/group) and the fish were fed to satiation on the experimental diets for 60 days.

In the first experiment, there was nogreat difference between diets containing 25% and 50% PBPM and their performance was better than the control diet, 75% and 100% PBPM. Feed intake was decreased in fish groups fed on the high levels of PBPM replacement (75 & 100%). Protein efficiency ratio (PER) and protein retention of the fish group fed on 25% and 50% PBPM were higher than the control group and the lowest values with 100% PBPM substitution. Apparent protein digestibility (APD) in the diets did not differ greatly and varied from 75% to 84%.

In the second experiment, feed intake was decreased in fish groups fed on the all diets including EWM when compared to the control group fed on the fish meal. Fish fed on the control diet had the highest growth rate and feed utilization, while those fed on 100% EWM protein diet were the poorest. The PER & APD of the control group were higher than for fish fed on EWM protein diets.

It could be concluded that, the protein of PBPM could be improved when it replace partially of fish meal protein, while the use of

EWM has adverse effects on the productivity of fish even at low percentage.

Key word: Tilapia fish-Poultry by-product-Earthworm meal.

INTRODUCTION

The importance of supplementary feeding has been well realized in aquaculture. With intensification of poultry and fish farming in Egypt, the need for animal protein is increasing day by day. Intensification of tilapia culture has made it essential to develop suitable feeds to be used either as a supplementary diet in ponds or as a complete diet in tanks. For economic and practical reasons, locally available protein sources, preferably those unsuitable for direct human consumption must be used. Fish meal has been shown to be highly efficient in promoting fish growth and its high quality has resulted in its wide inclusion as the main protein source in diets for cultured fish. The production of fish meal in the world remained almost constant or slightly decreased in recent years, and it will not be enough to cover the increasing demand . This has led to a lot of research along two main lines, the reduction of the dietary protein level and the testing of some alternative protein sources which can totally or partially replace fish meal. The alternative sources were tested at various inclusion rates, increasing to maximum possible levels compatible with providing a 30% protein diet, which has been shown to be the lowest level still providing reasonable growth in various tilapia species (Cruz and Laudencia, 1978; Davis and Stickney, 1978; Mazid et al., 1979). Fish nutritionists have tried the use of less expensive protein sources to partially or totally replacing fish meal. Therefore, practical and future consideration necessitate the search for alternative sources of protein for aquaculture diets be directed towards the use of commercially available alternative sources of proteins that are being developed to supplement these supplies. The evaluation of various alternative protein sources was carried out by different authors for several species (Capper et al., 1982; Tacon et al., 1984; Hasan et al., 1988, 1990a, 1990b, 1991). Poultry by-product meal is rich in protein and lipid and costs less than fish meal. Gropp et al.(1976) reported that 75% of fish meal protein could be replaced by 30% poultry by-product meal but 100% replacement gave slightly poor results in a diet of rainbow trout. Poultry offal meal, a rich source of dietary protein and lipid is readily available as a by product of growing poultry industry. The efficiency of this protein source has been evaluated as a partial or complete fish meal replacer for coho salmon (Higgs et al., 1979), rainbow trout (Alexis et al.,1986), Asian catfish (Hasan et al. 1989) and Indian major carp (Hasan, 1991). On the other hand, the high protein content and well balanced amino acid profile of earthworm *(Eisenia foetida)*, makes it an interesting protein source to be considered for fish feeding (Stafford and Tacon, 1985) . However, several studies have shown that earthworm meal is unpalatable for fish ,probably due to the composition of its coelomic fluid. Simple treatment oriented to the removal of such fluid has been suggested by Tacon et al.(1983) and Cardenete et al.(1993). Low performance has been reported when feeding eel fish on living or freezed earthworm meal (Aston and Milner, 1982). Protein alternative sources in fish diets should replace fish meal quantitatively and qualitatively so as to provide optimum growth and feed conversion as said by Jauncey and Ross (1982).

The present study was undertaken to test the possibility of replacing fish meal protein by poultry by-product meal and utilizing earthworm meal protein as replacement for fish meal protein after improving its acceptance in the diets of tilapia (*O.niloticus*) fish.

MATERIALS and METHODS

In this study, two experiments were conducted to test the possibility of replacing fish meal protein, partially or completely in the diet of tilapia (*O.niloticus*) fish by poultry by-product meal (PBPM) protein (Exp.I) or earthworm meal (EWM) protein (Exp.II).

A-Experimental design:

In the first experiment,five diets were formulated with various levels; 0, 25, 50, 75 &100% of PBPM protein as partial or total replacements for the fish meal protein as shown in table (2). Diet 1 with 47% fish meal served as the control diet.

In the second experiment, five diets were also formulated and contain the same levels of replacements using EWM (table 2). A flavouring compound was added to improve the EWM acceptance and the coelomic fluid was removed.

After two weeks adaptation period, fish in the two experiments were fed to satiation on the tested diets and each experimental diet was fed to duplicate aquaria for an experimental period of 60 days (two meals per day at 08.00 am and 16.00 pm).

B-Fish and management:

Tilapia fish were obtained from Aquatic Animal Research Unit, Fac.of Vet.Med., Assiut Univ. with an average initial weight about 5.1gm. The fish were divided into 10 equal groups, five in each experiment and distributed into 20 glass aquaria (15 fish in each). Each aquarium contained dechlorinated tap water and continually areated. The water temperature ,dissolved oxygen and pH were measured and found to be 26°C, 3.8mg/L and 7.2 respectively. To minimize stress of handling, fish from each aquarium were weighed at the beginning and end of the study.

C-Experimental diets:

All diets were formulated as to be isonitrogenous and isocaloric (about 33% protein and 4.1Kcal gross energy/g) diet to satisfy the requirement of tilapia fingerlings according to (NRC,1993). The composition of ingredients and experimental diets are shown in tables 1& 2, while the calculated amino acid content is shown in table 3 .

The earthworm (*Eisenia foetida*) was cleaned by rinsing in fresh water, and by a 2 minutes, bathing in a 10% (v/v) alcohol/water solution to remove the coelomic fluid. Worms were freeze-dried, finely ground and a flavouring agent (inosine mono-phosphate) was added as a feeding attractant (Cardenete et al., 1993).

For preparing the diets, the dry ingredients were first finely ground, thoroughly mixed, with little water in a mixer, pelleted by forcing through 4mm holes and then dried at room temperature. All diets were stored at -20°C until feeding. Each experimental diet was fed to duplicate aquaria.

D-Parameters evaluated:

Acceptability of the diets was evaluated by recording the daily feed intake. Fish weight were recorded at the beginning and the end of the experimental period, while feed conversion was calculated.

The apparent digestibility of dietary protein was determined by collecting faecal samples from the individual fish by hand stripping along the last 10 days of the experiments. The faeces from each group were pooled,dried at 105°C for 24h and stored in an airtight container at -20°C till used for nitrogen analysis. Digestibility coefficients were calculated by making use of the added 0.5% chromic oxide (Cho and Slinger, 1978)

Dietary protein utilization was evaluated by determining protein efficiency ratio (PER weight gain/protein intake). For this purpose, 15 fish at the start of the experiment (blank group) and five fish from each group at the end of the experimental period were sacrified, homogenized in a blender, stored in polyethylene bags and frozen at -20°C for subsequent proximate analysis.

E-Analytical techniques:

Dry matter, crude protein, ether extract contents of the tested materials and fish tissues were performed according to AOAC (1984).

RESULTS

From the proximate composition analysis done prior to the formulation of diets, it was noted that there is no great difference between the three protein sources FM, PBPM, and EWM in relation to dry matter, crude protein and nitrogen-free extract as they contain 93, 95 & 90; 61.1, 57.5 & 63; and 4.20, 3.74 & 5.10 respectively. Poultry by-product meal contains high fat content reached 14.5% in comparison to FM (6.7%) and EWM (8.3%). Both the alternative protein sources were tested at four inclusion levels (25%, 50%, 75% & 100%) and all the diets and the FM control diet were formulated to be isonitrogenous and isocaloric. The fibre, ash, calcium and phosphorus content of the several diets could not be maintained at a similar level, but it was stressed that calcium and phosphorus levels cover the NRC requirements. All the data of the present study are illustrated in the tables 4-9.

DISCUSSION

1-Poultry by-product meal (PBPM) replacement :

The performance of fish fed different levels of PBPM displayed in tables 4, 5, 6 & fig.1 shows that there was no great difference between the diets containing 25% and 50% and their performance was better than the control diet, 75% and 100% PBPM. The weight gain was 1.11 and 1.16 times the control in the 25% and 50% PBPM, while, it reached only 0.79 and 0.53 in the 75% and 100% PBPM. In relation to the feed intake only replacing all the fish meal resulted in loss of fish appetite to the degree that feed intake ranged from 12.51g to 13.3g for the control and the three inclusion levels, while it reached only 9.5g in the 100% one. This could be attributed to a progressively more difficult adaptation of fish to the organoleptic properties of such diets.

Substitution of PBPM protein for all fish meal protein on an isonitrogenous basis resulted in decrease in growth rate. The inferior conversion of feed or protein to flesh noted in the tested groups fed diets with higher levels of PBPM can mostly be attributed to the marked inferior amino acid balance in the PBPM protein and this disagreed with that found by Higgs et al. (1979).

The suitability of PBPM as an alternative protein source confirmed in this study is in agreement with the observations reported by Tiews et al. (1976), Alexis et al. (1986) and Gropp et al (1976, 1979) for rainbow trout; Higgs et al. (1979) for coho salmon; Hasan et al. (1989) for Asian catfish; Hasan (1991) for carp and Eleraky & Saleh (1989) for tilapia. In contrast, a clear trend of reduced performances was observed with increased inclusion of poultry offal meal in the diet of Indian major carp fry (Hasan et al., 1990b).

Table (5) summarizes the effect of the inclusion of PBPM in tilapia diets on their body composition. Average protein of the fish body ranged from 65.31 % to 69.20 %, with the highest value in fish fed diet containing 25% & 50 % PBPM diet and the lowest value with 100 % PBPM diet. This is in agreement with that reported by the authors Schwarzbach, 1981; Saleh, 1985; Eleraky, 1985 and Eleraky and Saleh, 1989.

The highest values for protein retention and protein efficiency ratio (table, 6) were recorded for the 25% and 50% diets and the lowest for the 75% and 100% PBPM ones, although the apparent protein digestibility in the five diets did not differ greatly and varied from 75% in diet 5 to 84% in diet 3. It seems that, it is the balance in the essential amino acids which made the difference and a mixture of FM and PBPM at a replacement level not more than 50% is more feasible. The lower PER and protein retained percentages obtained by the diet containing 100 % PBPM protein indicated the progressive reduction in nutritional value observed compared to the control diet. This effect may be due to the reduced efficiency in protein utilization or alternatively leading to a depression in feed intake as reported by Hilton (1983) and Dabrowski (1986).

2-Earthworm meal (EWM) protein replacement:

In this experiment, feed intake was decreased in fish groups fed on the diets including EWM (table, 7) when compared to those fed on a fish meal diet (control). However, this decrease in feed intake was not the same for all diets, but was greater for diets containing 75 % and 100 % EWM protein. The tendency toward a lower feed intake as dietary EWM protein content increased could be due to a progressively more difficult adaptation of the fish to the organoleptic properties of such diets.

Fish growth (table, 7; fig., 2) followed a similar pattern to that of feed intake; showing that fish fed the control diet had the highest growth and those fed on 100 % EWM protein diet the poorest. At higher inclusion levels, feed wastage contributed to the poorer conversion ratios and growth rates; this could have been due to unpalatable nature of the diets and reduced appetite. The lower growth promoted by diets containing EWM protein was not only due to a poorer diet acceptance, but also to a lower utilization of EWM protein, which agreed with that found by Cardenete et al. (1993) with rainbow trout fish. Guerrero (1981) when fed meal produced from the EWM to *O.niloticus* found that a diet in which fish meal was partly replaced with EWM was more efficient and economical than a diet with fish meal as the only protein source.

Fish fed on the control diet showed higher feed conversion when compared to the fish fed EWM protein diet. In this way, low performance has been reported when feeding eel (Aston and Milner, 1982) or rainbow trout (Tacon et al., 1983) on the EWM diets.

The whole body composition of fish of the control group and that fed on the EWM protein diets are displayed in table (8). The highest value of protein content of the fish body was found in control group (68.36 %), while the lowest value in group fed on 100 % EWM protein diet (61.51 %). This suggests lower digestibility and utilzation for the protein of EWM.

The protein efficiency ratio (PER) of the control group was higher than fish groups fed on EWM protein diets as shown in table (9). This may be due to the lower metabolic uses and utilization efficiency of EWM protein as reported by Cardenete et al. (1993). The EWM containing diets had the lowest apparent protein digestibility (APD) values compared to the control group. Since growth is considerably influenced by digestibility of the nutrients, the present study suggests that tilapia fish is not able to adequately digest protein of EWM.

In conclusion, the low cost of poultry by-product meal (PBPM) as an alternative protein source suggests a potential for a commercial production of a pelletized feed containing certain percentages of it and so enhancing fish production enterprises. It is better, for the feasability to be stressed, that the essential amino acids in short be supplemented to match the recommended allowances. It is confirmed that earthworm meal is a low grade replacement protein and it use has adverse effects on productivity of fish even at low percentage.

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Table (1):Chemical composition of the ingredients used in the experiments (on as - fed basis)

Ingredients	DM*	Protein	Fat	Fibre	NFE**	Ash	GE (Kcal/Kg)
Fish meal	93.0	61.1	6.7	0.60	4.20	20.4	4416
Poultry by-product meal	95.0	57.5	14.5	2.96	3.74	16.3	4960
Earthworm meal	90.0	63.0	8.3	2.60	5.10	11.0	4627
Wheat flour	89.0	14.10	1.37	1.83	71.23	0.47	4000
Corn starch	87.0	—	----	0.10	86.37	0.12	3600

*DM : Dry matter ,NFE :Nitrogen free-extract.

Table (2): Composition (in percentage) of the experimental diets in the two experiments#

Ingredients	Control diet	Poultry by-product meal diets (Exp.I)				Earthworm meal diets (Exp.II)			
	1	2	3	4	5	2	3	4	5
Physical composition:									
Poultry by-product meal	----	12.49	24.97	37.46	49.95	----	----	----	----
Earthworm meal	----	----	----	----	----	11.40	22.79	34.19	45.59
Fish meal	47.0	35.25	23.50	11.75	----	35.25	23.50	11.75	----
Wheat flour	30.0	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Corn starch	13.5	13.51	13.53	13.54	13.55	13.45	13.86	14.41	14.96
Fish oil	3.0	2.25	1.50	0.75	----	3.00	2.95	2.75	2.55
Vitamin mix.*	2.0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mineral mix.**	4.0	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Chromic oxide	0.5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Flavouring agent@	----	----	----	----	----	0.40	0.40	0.40	0.40
Chemical composition:									
Dry matter	85.10	84.68	85.52	85.74	85.94	84.43	84.11	83.80	83.49
Crude protein	33.01	33.00	33.00	33.01	33.01	33.01	33.00	33.00	33.00
Crude fat	6.50	6.79	7.07	7.37	7.65	7.15	7.55	8.21	8.85
Crude fibre	0.84	1.15	1.45	1.74	2.04	1.08	1.30	1.53	1.75
Crude ash	9.75	9.39	9.02	8.67	8.30	8.60	7.45	6.31	5.16
Nitrogen free extract	35.00	34.35	34.98	34.95	34.94	34.59	34.81	34.75	34.73
Gross energy(Kcal/Kg)	4157	4159	4161	4163	4166	4163	4179	4181	4183
Calcium	4.00	3.47	2.94	2.42	1.89	3.06	2.12	1.19	0.26
Phosphorus	2.19	1.90	1.62	1.32	1.04	1.76	1.34	0.90	0.47

#Replacements were at the rate of 25% of FM protein in diets numbered 2, 50% in diets 3, 75% in diets 4 and 100% in diets 5 .

*Vitamin mix.,each Kg contains:Vit.A, 2000,000IU; Vit.D, 200,000IU; Vit.E, 10,000IU; Vit.K, 0.5g; Vit.B1, 1.89g; Vit.B2, 3.6g; Vit.B6, 3g; Vit.B12, 0.02g; Pantothenic acid, 10g; Nicotinic acid, 27g; Folic acid, 0.55g; Biotine, 0.15g; Choline, 130g.

**Mineral mix., each Kg contains: Mn, 60g; Fe, 80g; Cu, 5g; Zn, 40g; Se, 0.15g; I, 0.35g.

@Flavouring agent: Inosine monophosphate.

Table (3):Essential amino acid content (per 100g diet) of the experimental diets*

Amino acid@	Control diet	Poultry by-product meal diets (Exp.I)				Earthworm meal diets (Exp.II)			
	1	2	3	4	5	2	3	4	5
Arginine	2.13	2.10	2.09	2.07	2.05	2.46	2.80	3.13	3.48
Histidine	0.71	0.65	0.59	0.54	0.48	0.98	1.26	1.54	1.81
Isoleucine	1.42	1.39	1.36	1.33	1.31	1.70	2.00	2.28	2.58
Leucine	2.42	2.41	2.41	2.40	2.40	2.60	2.77	2.95	3.13
Lysine	2.21	2.00	2.19	1.58	1.38	2.51	2.80	3.11	3.41
Methionine+Cystine	1.31	1.29	1.26	1.25	1.27	1.46	1.61	1.76	1.90
Phenylalanine+Tyrosine	2.33	2.12	1.90	1.68	1.47	2.94	3.54	4.14	4.74
Threonine	1.32	1.27	1.27	1.16	1.11	1.70	2.08	2.46	2.85
Tryptophan	0.32	0.31	0.30	0.30	0.29	0.49	0.66	0.83	1.00
Valine	1.59	1.59	1.60	1.61	1.62	1.37	1.88	2.02	2.18

@Amino acid requirements of tilapia (as % of diet) as follows: Arginine 1.18; histidine 0.48; isoleucine 0.87; leucine 0.95; lysine 1.43; methionine+cystine 0.90; phenylalanine+tyrosine 1.55; threonine 1.05; tryptophan 0.28 and valine 0.78 (NRC, 1993).

* Calculated.

Table(4): Growth performance and feed utilization efficiency of tilapia fish in groups of experiment I

Parameters	Groups				
	1	2	3	4	5
Initial body weight(g)	5.50	5.41	5.35	5.65	5.52
Final body weight(g)	13.71	14.53	14.84	12.10	9.84
Weight gain (g)	8.21	9.12	9.49	6.45	4.32
Weight gain (%)	150	169	179	114	78
Feed intake (g)	12.93	13.3	12.51	12.77	9.5
Feed conversion	1.58	1.46	1.32	1.98	2.20

Table (5): Body composition of fish (on dry matter - basis) in groups of experiment I

Items	Groups					Beginning (blank group)
	1	2	3	4	5	
Dry matter (%)	25.8	25.6	25.3	24.1	23.91	21.15
Crude protein (%)	66.28	68.95	69.20	67.22	65.31	62.88
Crude fat (%)	15.51	15.38	15.35	14.98	14.40	10.24

Table(6): Protein parameters in fish of the experiment I

Items	Groups				
	1	2	3	4	5
Protein intake (g/fish)	4.27	4.39	4.13	4.22	3.14
Protein retention (g/fish)	1.67	1.89	1.93	1.29	0.87
Protein efficiency ratio	1.92	2.08	2.30	1.53	1.38
Apparent protein digestibility.	80.10	82.01	84.35	79.15	75.23

Table(7): Growth performance and feed utilization efficiency of tilapia fish in groups of experiment II

Parameters	Groups				
	1	2	3	4	5
Initial body weight(g)	5.35	5.10	5.12	5.20	5.11
Final body weight(g)	13.95	12.61	10.73	7.21	6.83
Weight gain (g)	8.60	7.51	5.61	2.01	1.72
Weight gain (%)	161	148	111	39	34
Feed intake (g)	13.1	12.77	10.83	7.10	6.78
Feed conversion	1.52	1.70	1.94	3.54	4.00

Table(8): Body composition of fish (on dry matter - basis) in groups of experiment II

Items	Groups				
	1	2	3	4	5
Dry matter (%)	25.60	26.71	26.87	26.25	26.01
Crude protein (%)	68.36	66.19	67.29	65.52	61.51
Crude fat (%)	13.60	13.87	14.30	14.62	14.75

Table(9): Protein parameters in fish of experiment II.

Items	Groups				
	1	2	3	4	5
Protein intake (g/fish)	4.32	4.22	3.57	2.34	2.24
Protein retention (g/fish)	1.77	1.56	1.27	0.57	0.42
Protein efficiency ratio	1.99	1.78	1.57	0.86	0.77
Apparent protein digestibility.	80.00	70.18	68.25	60.50	58.32

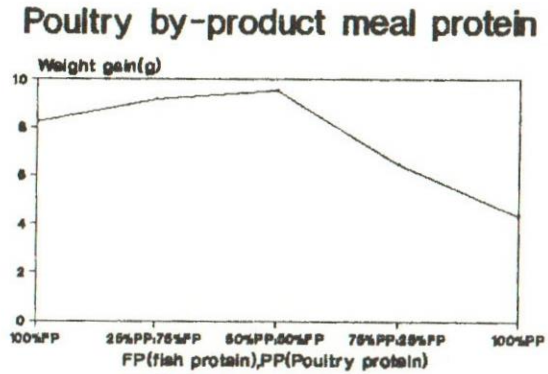

Fig.(1):Weight gain for the different groups in the exp.I

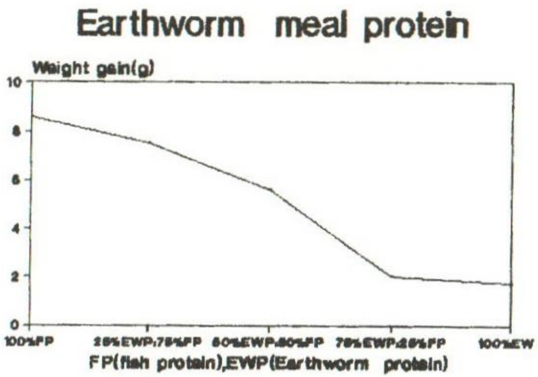

Fig.(2):Weight gain for the different groups in the exp.II

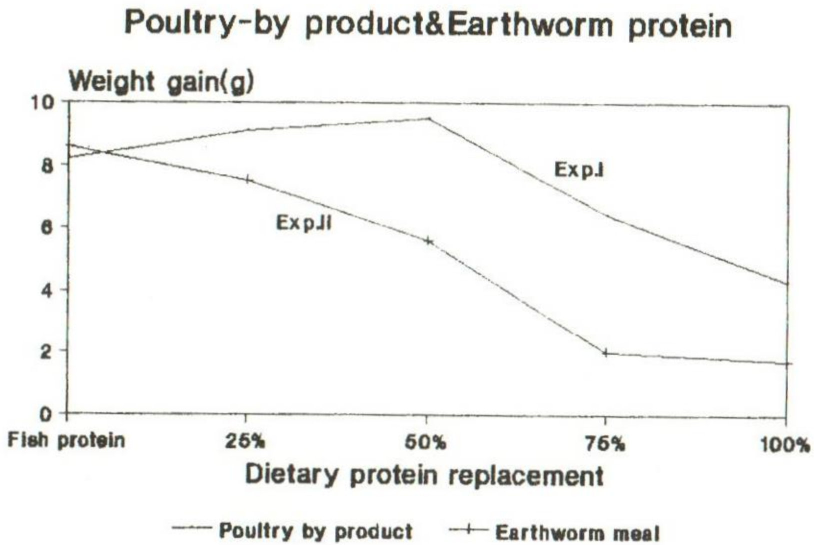

Fig.(3):Weight gain for the different groups in the two experiments