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EVALUATION OF SOYBEAN AND COTTONSEED MEAL'S PROTEIN AS A SUBSTITUTE FOR ANIMAL PROTEIN IN TILAPIA DIETS

(with 10 Tables & 1 Figure)

By

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تقييم مسحوق فول الصويا وكسب القطن كبديل للبروتين الحيواني في علائق اسماك البلطي

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سمر توفيق

في هذه الدراسة تم اجراء تجربتين لتقييم مدي اسستخدام كل من مسحوق فول الصويا وكسب القطن كبديل لمسحوق السمك في علائق اسماك البلطي. تم تغذية اسماك البلطي النيلي التي تزن الواحدة منها ١٠جم علي علائق تحتوي علي ٣٢% بروتين وكان مصدره في التجربة الاولي اما مسحوق السمك او فول الصويا او مخلوط من الاثنين معا بينما كان مصدره في التجربة الثانية اما مسحوق السمك او كسب القطن اومخلوط منهما) المخلوط حسب نسبة استبدال البروتين، وقد اظهرت النتائج التالية: *في التجربة الاولي:* عدم وجود اختلاف معنوي في معدل الزيادة في وزن الجسم بين مجموعات الاسماك التي غذيت علي العلائق التي تحتوي علي ٢٥% (٢٦,٦٠جم) و٥٠% مسحوق فول الصويا (٢٣,٦٧جم) والمجموعة الضابطة (٢٦,٩٥جم). محتوي جسم الاسماك من الدهون قل مع زيادة مستوي بروتين الصويا في العليقة بينما لم يوجد أي اختلاف معنوي بين المجموعات المختبرة في محتوي الجسم من البروتين فيما عدا المجموعة التي غذيت علي ١٠٠% بروتين صويا اعطت مستوي منخفض من هذا المحتوي. زيادة كفاءة البروتين التحويلية في المجموعة الضابطة (١,٧٨) والمجموعة التي غذيت علي العليقة التي تحتوي علي٢٥% بروتين صويا(١,٧٥). بالاضافة الي عدم وجود أي اختلاف معنوي في معامل هضم البروتين بين المجموعات التي غذيت سواء علي بروتين السمك فقط اومخلوط من بروتين السمك والصويا. *في التجربة الثانية:* وجد ان المجموعة الضابطة التي غذيت علي بروتين السمك فقط اعطت اعلي قيم في كل من معدل الزيادة في وزن الجسم (٢٤,٨جم) والتحويل الغذائي (١,٧٢) مقارنة بالمجموعات

المختبرة الاخري التي غذيت علي خليط من مسحوق السمك وكسب القطن او كسب القطن فقط. كذلك محتوي جسم الاسماك من البروتين كان اعلي في المجموعة الضابطة بينما محتوي الدهون قل تدريجيا مع زيادة محتوي كسب القطن في العليقة. بالاضافة الي نقص في كفاءة البروتين التحويلية ومعامل هضم البروتين مع زيادة مستوي بروتين كسب القطن في العلائق. نستخلص من هذه الدراسه الى أنه يمكن أستبدال ٥٠% من بروتين مسحوق السمك ببروتين فول الصويا بدون أى تأثير واضح علـى معدلات النمو والتحويل الغذائى بينما مسحوق كسب القطن أثر عكسيا على هذه المعدلات.

SUMMARY

Along 60 days two growth experiments were conducted to determine the amount of soybean (SBM) and cottonseed (CSM) proteins that could be substituted for fish protein in formulated diets for tilapia *(O.niloticus)* without reducing growth. In the study, juvenile tilapia (average weight, 10g) were fed on 32% crude protein diets in which dietary protein was supplied in exp.I by either FM, SBM or mixtures of FM & SBM, while in exp.II FM, CSM or mixtures of FM & CSM were the sources of protein in the diets. Dietary protein in the exp.I was provided as: 100% fish meal protein; 75% fish meal protein: 25% SBM protein; 50% fish meal protein: 50% SBM protein; 25% fish meal protein: 75% SBM protein; 100% SBM protein and 100% SBM protein with methionine and lysine supplementation to match the level in the control diet, while in the exp.II, the share of the fish or cottonseed meals as source of protein was planned the same as in the exp.I. *In the first experiment*, there was no significant difference in the weight gain between the diets containing 25% SBM (26.60g), 50% SBM protein (23.67g) and control diet (26.95g) and the fish performance was better than on diets containing 75% and 100% SBM proteins. Fat content of the body was significantly ($P<0.05$) decreased with increasing level of SBM protein, while protein content affected only with the level of 100% SBM protein (with or without amino acids suppl.). Protein efficiency ratio of control group (1.78) and fish fed on 25% SBM protein (1.75) was significantly ($P<0.05$) higher than other treated groups. Apparent protein digestibility was not different among groups fed on FM only or a mixture of FM & SBM proteins. *In the second experiment*, the best weight gain and feed conversion were obtained with the control group (24.8g, 1.72) fed on FM protein in comparison with the other treated groups fed either on a mixture of FM and CSM or CSM alone. Protein content of the control group was significantly ($P<0.05$) higher than the other treated groups. Protein efficiency ratio was negatively associated with the increased levels of CSM protein in the diets. Apparent protein digestibility was significantly ($P<0.05$) decreased as the level of CSM protein increased. It could be concluded that, soybean meal protein could replace up to 50% of the fish meal protein without adverse effect on the growth performance and feed utilization, while cottonseed meal appears to be inefficiently utilized.

Key words:- *Tilapia - Soybean meal - Cottonseed meal - Animal protein.*

INTRODUCTION

Fish meal is well recognized as the best source of protein for most fish species. The increasing cost of high quality fish meal, however, poses real problems for cost-effective feed formulation. The common practice in animal husbandry is to partially or entirely replace animal proteins with less expensive plant protein sources to obtain least-cost without lowering the quality of the feed. These include supplementing the diet with one or more limiting essential amino acids, combining different feedstuffs to provide the required dietary amino acid profile, and processing plant proteins to remove the anti-nutritional factors.

One approach for reducing feed cost is to substitute the cheap feed ingredients as plant products for the more expensive ones as fish meal (Gropp et al., 1979; Jackson et al., 1982; Winfree & Stickney, 1984; Robinson et al., 1985; Wee & Wang, 1987). The use of plant protein concentrates for fish is a subject of current research (Tacon & Ferns, 1976 ; Reinitz, 1980; Jauncey & Ross, 1982).

Typical plant protein alternative that have been used in tilapia diets include soybean meal (Brandt, 1979; Jackson et al., 1982), groundnut meal (Wu & Jan, 1977; Kamara, 1982), rapeseed meal (Ayeni, 1981), sunflower seed meal (Jackson et al., 1982) and cottonseed meal (Jackson et al.,1982; Ofojekwu & Ejike, 1984). The value of soybean meal as a substitute for fish meal in formulated diets has been investigated for a number of fish species as plaice (Cowey et al., 1971), catfish (Andrew & Page, 1974; Murai et al., 1982; Mohsen & Lovell, 1990), rainbow trout (Cho et al., 1974), abernathy (Fowler & Banks, 1976), carp (Dabrowski & Kozak, 1979; Viola et al., 1982), tilapia (Jackson et al., 1982), milkfish (Shiau et al., 1988) and the results indicated that considerable variation exists in the ability of the different species to utilize soybean meal protein as an alternative to fish meal protein. Work on the use of cottonseed meal in the fish diets has been limited to certain fish species. Coho salmon and chinook salmon can tolerate diets with up to 22% & 34% dietary cottonseed meal respectively. Dixon (1981) and Jackson et al. (1982) indicated that cottonseed meal is a promising source of protein in tilapia diets. In the same year, Jauncey & Ross used CSM at 100% level of inclusion without adverse effect.

The objective of this study was to determine the value of the two protein sources (SBM & CSM) for tilapia and as substitutes for fish meal.

MATERIALS and METHODS

Two experiments were carried out, in this study, to compare the nutritive value of the commercially available soybean meal (Exp.I) and cottonseed meal (Exp.II) as a partial or complete replacer for fish meal in practical diets of tilapia (*O.niloticus*) fish, on protein content basis.

A-Experimental design:

The study was performed in two experiments, the first for the soybean meal testing and the second for that of cottonseed meal.

Experiment I :

Six isonitrogenous and isocaloric diets, were formulated to contain 32% crude protein and about 4000 Kcal gross energy/ Kg diet. Dietary protein was supplied either by fish meal, soybean meal (SBM) or a mixture of fish meal and soybean meal (table 2). The protein sources in the different diets were as follows:- 100% fish meal protein (diet 1, control), 75% fish meal protein: 25% SBM protein (diet 2), 50% fish meal protein: 50% SBM protein (diet 3), 25% fish meal protein : 75% SBM protein (diet 4), 100% SBM protein (diet 5) and 100% SBM protein with methionine and lysine supplementation to match the level in the control diet (diet 6).

Experiment II:

Six isonitrogenous and isocaloric diets were formulated as in Exp. I, but the dietary protein was supplied either by fish meal, cottonseed meal (CSM) or a mixtures of them (table 2). The share of the fish meal or the cottonseed meal as a source of protein was planned the same as in the first experiment with the control diet of the 100% fish meal and the methionine-lysine supplemented diet number 6.

B-Fish and management:

In this study tilapia fingerlings of about 10gm body weight were used and distributed to be 30 fish for each group, reared in two aquaria, and with a total of 360 fingerlings. Each aquarium was continually aerated and full of dechlorinated tap water having a temperature of about 26°C, dissolved oxygen of 3.8mg/L, and pH of 7.2. To minimize stress of handling, fish from each aquarium were weighed only at the beginning and end of the study.

All fish were acclimated to the experimental conditions for 2 weeks. A total of 20 fish, at the start, and 5 from each aquarium at the end of the experimental period, were randomly sampled for the analysis of body composition.

C-Experimental diets:

All the experimental and control diets were formulated to satisfy the requirement of tilapia fingerlings (NRC,1993). The 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.

The chemical composition of fish, soybean and cottonseed meals are shown in table (1) and the experimental diets in table (2).

In preparing the diets, the dry ingredients were ground to small particles, thoroughly mixed, combined with water in mixer, pelleted by forcing through 4mm holes and then kept to dry at room temperature. All diets were stored at -20°C until immediately prior to feeding.

Amino acid content of the tested feedstuffs and experimental diets are shown in tables (1 & 3). The amino acid content of the protein sources showed lower levels in both methionine and lysine in the soybean and cottonseed meals when compared with fish meal. Chromic oxide (0.5%) was added to the diets as an inert digestibility indicator.

Fish in the two experiments were fed to satiation on the experimental diets for 60 days (two meals per day at 08.00am and 16.00pm) and each experimental diet was fed to its duplicate aquaria.

D-Parameters evaluated:

Weight gain, feed conversion (FC), apparent digestibility of protein (APD), protein efficiency ratio (PER) were calculated according to the methods of Castell and Tiews (1980).

E-Analytical techniques:

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

F-Statistical analysis:

Statistical comparisons were made using one-way analysis of variance (ANOVA). Mean differences between treatments were tested for significancy (P 0.05) by Duncan' s multiple range test (1955).

RESULTS

All the data of the present study are illustrated in the tables (1-10).

DISCUSSION

Diets:

Eleven tilapia diets were formulated for testing the two plant protein sources and replacing the fish meal was at the rate of 25, 50, 75 & 100%. The diets contained nearly an equal protein content ranging from 31.65 to 32.95% and with a maximum difference of 1.3 units. The fat content differed as it reflects the amount of the high fat fish meal (6.7%) compared with SBM (1.9%) and CSM (1.4%). The fibre content increased as the plant protein sharing increased and ranges from 0.85 in the fish meal diet to a maximum of 4.7 in the SBM diets and 10% in the CSM ones.

The inclusion of FM in diet formulation increases its ash content as it reaches 9.75% in the control one and decreases to 4 & 5.16% in the SBM & CSM diet respectively. The percentage of ash and/ or fat in diets and the nature of the ingredients especially the protein sources determine the gross energy content which varied from 3864 to 4037 and with an average of 3950 Kcal/ Kg diet.

Experiment I:

The performance of fish fed different levels of SBM protein displayed in tables 4, 5, 6 and fig.1. Weight gain of fish fed the diets containing 25% fish protein (20.88 g) and 100% soybean protein (13.33, 14.25 g) were less significantly ($P<0.05$) than that of fish fed diets containing 50% (23.67 g), 75% (26.60 g) and 100 % (26.95 g) fish protein. Weight gains did not differ significantly ($P>0.05$) among fish fed diets containing 50% or more of dietary protein from fish meal (50, 75 & 100% fish protein). Jackson et al. (1982) found that there was no appreciable difference in the growth of tilapia fed a diet which contained all of its protein in the form of fish meal, and one where 25% of fish meal have been replaced by SBM. Result obtained in this study are similar to those reported for previous experiments in soybean meal was substituted for fish meal in diets for freshwater and marine fishes. Soybean meal protein is inferior to fish meal as dietary protein supplement for plaice fish (Cowey et al., 1971, 1974), chinook salmon (Fowler & Banks, 1976), grass carp (Dabrowski & Kozak, 1979), and tilapia (Jackson et al.,1982). Blue tilapia *(O.aureus)* however, are reportedly capable of utilizing SBM protein as effectively as fish protein when dietary protein level is sufficiently high (Davis & Stickney, 1978).

However, major replacement of fish meal protein with SBM protein in fish diets results in a reduction in growth rate with most fish species including rainbow trout (Reichle, 1980; Dabrowski et al., 1989) and tilapia aurea (Wu & Yan, 1977; Davis & Stickney, 1978; Jackson et al., 1982). Growth depression caused by SBM substitution for fish meal in formulated diets have been attributed to reduced diet digestibility caused by increased levels of poorly digested SBM as that reported by Dabrowski & Kozak, 1979 and Jackson et al., 1982 or poor availability of phosphorus (Tacon et al., 1983).

Supplementation of the diet containing 100% SBM protein with limiting amino acids (methionine and lysine) have no beneficial effect on fish growth and feed conversion efficiency. Andrew and Page (1974) reported that reduced weight gain in channel catfish fed a high SBM diet and observed that methionine supplementation had no beneficial effect. A hypothesis was put forward from studies with carp and catfish that this may be due to the inability of the warmwater fish, in contrast to the coldwater fish, to utilize free amino acids (Aoe et al.,1970; Page, 1974). Dabrowski et al. (1989) stated that amino acid availability especially methionine was reduced if SBM protein used in excess of 50% of the diet. Without methionine supplementation, fish meal can be replaced partly by SBM when dietary protein is suboptimal (24%) for tilapia growth, but at the optimal level (32%), SBM depresses both growth and feed conversion (Shiau et al., 1987). Sintayehu et al. (1996) found that supplementation of SBM and CSM based-diets with methionine and lysine did not enhance fish performance.

Feed consumption and feed conversion were affected by the soybean and fish protein content of the diets (table, 4). Consumption increased significantly ($P<0.05$) as the level of fish protein increased. This is due to that the protein component of fish meal is the major factor contributing to the schooling activity of fish and the attractability of the diet. Feed conversion was reduced when fish protein provided less than 50% of dietary protein.

The gross carcass composition of the whole body of tilapia at the beginning and end of the exp. I are shown in table (5). Whole body moisture content was highest ($P<0.05$) in fish fed the diets containing 25% fish protein and 100% soybean protein, while lowest in fish fed diets containing 75% and 100% fish protein. An increase in the dietary level of SBM resulted in a significant ($P<0.05$) decrease in the body fat content and generally an increase in moisture content. The protein content was however, not affected except for fish fed on the 100% SBM diet which had a substantial reduction in the body protein. These results agreement with that reported by Reigh & Ellis (1992) with red drum fish. Addition of methionine and lysine have a little effect on the protein content of the body.

The protein parameters for fish fed on the experimental diets in exp.I are summarized in table (6). The results indicated that protein retention was higher in the fish fed on diets containing fish meal or mixtures of FM and SBM (7.26, 7.07, 6.37 & 5.21g) when compared to those of fish fed on soybean meal only (2.39, 2.59g). The protein efficiency ratio (PER) of the control group (1.78) and fish group fed on 25% SBM protein (1.75) was significantly ($P<0.05$) higher than other treated groups. Protein retention and protein efficiency ratio were improved as fish protein increased from 50% to 100% of dietary protein and soybean protein decreased proportionally. No differences were observed in comparing apparent protein digestibility (APD) values obtained with the groups fed fish meal only or a mixture of SBM and fish meal protein except the lowest APD with the fish fed on 100% SBM protein diet. Adikwu (1997) reported that in fish groups fed on SBM, growth performance and nutrient utilization declined ($P<0.05$) with increasing dietary SBM content.

Experiment II:

The growth responses of fish fed different experimental diets in exp.II are shown in table (7) and fig.(1). The weight gain of fish fed on the fish meal diet (24.80 g) was significantly ($P<0.05$) higher than noted for fish fed on mixture of fish meal & CSM (18.75, 15.30 & 13.10 g) or CSM alone (10.15 & 10.70 g). The poorest growth was found with fish fed on 100% CSM protein (with or without AAs. supplementation). Feed conversion ranged from 1.72 to 2.15 and the best rate was obtained when fish fed on the control diet (fish meal protein). This poor growth of fish fed on CSM diets might have resulted from a high fibre contents of the diets or poor amino acid availability. These results disagreed with that reported by Dixon et al. (1981), Jackson et al. (1982) and Jauncey & Ross (1982) when fed CSM for tilapia. Low lysine & methionine availability in CSM and their possible limitation to growth in fish fed CSM based diets have been highlighted by Jauncey & Ross (1982). The extremely high crude fibre content of CSM will almost certainly limit its use as a major protein source within commercially pelleted fish feeds. The gossypol in cottonseeds is concentrated in pigment glands. If during mechanical processing, the gossypol is released it reacts with the amino groups of the lysine rendering it unavailable. However, processing by solvent extraction methods results in high levels of free gossypol remaining in the glands but less binding of the lysine (Smith, 1970). When using cottonseed meal as a dietary ingredients for fish, attention should be paid to levels of free gossypol and available lysine as well as the oil extraction method used.

As to the whole body composition (table 8), the highest value of protein content was found in the control group (68.15%), while the lowest value in group fed on 100% CSM diet (56.30 %). Fat content of the body was ranged from 10.15% to 15.71% and significantly ($P<0.05$) decreased with the increasing level of the CSM in the diets as that reported by Reinitz et al. (1978).

Protein efficiency ratio (table 9) was negatively associated with the increase in the percentage of CSM in the diets. Estimated PER for the different experimental diets ranged from 1.46 to 1.76 and was the best in the control diet (1.76). Higher values of PER and protein retained were obtained for the diet containing 100% fish protein (1.76, 6.53g), while lowest values for diets containing 100% CSM protein (1.46, 1.65g) . This may be due to the reduced efficiency in protein utilization or alternatively leading to a depression in feed intake. Apparent protein digestibility was significantly ($P<0.05$) decreased with increasing level of CSM in the diets. This may be due to high fibre level which is known to decrease the feed intake and its digestibility. Ofojekwu & Ejike (1984) indicated that the tropical *O.niloticus* cannot be reared successfully by feeding diets formulated from CSM alone.

Fish meal is usually incorporated in large amounts in fish diets because of its high biological value. Attempts to use other proteins have frequently resulted in decreased growth rate (Cowey & Sargent, 1979). The performance of fish fed diets containing oil meals as SBM or CSM have been satisfactory only when they are included at low proportions, while their inclusion as a primary source (more than 25-50% of the total) leads to reduced growth (Cowey et al., 1971; Higgs et al.,1979; Jackson et al., 1982). This may be the result of an improper balance of essential AAs. or poor utilization of them. Machiels (1987) reported that fish weight gain decreased where as increasing part of the fish meal was replaced by alternative protein sources (SBM & CSM).

The slow growth of fish despite supplementation of the diets containing either SBM or CSM with amino acids to approximate the amino acid profile of fish meal diets could also be attributed to the poor utilization of crystalline amino acids compared to whole protein. The difference in absorption rates among amino acid will result in imbalance of amino acids concentration at the cellular level and thus in poor utilization (Cho et al., 1985).

The fact that adding methionine or lysine to the SBM or CSM substituted diets did not enhance growth, raises the following possibilities:(1) the unidentified growth factors which present in fish meal are not protein or AAs but are other non-lipid and non-mineral compounds. (2) free methionine or lysine are not efficiently utilized by tilapia (3) a very delicate amino acid balance is present in fish meal and the substitution of plant protein results in a severe imbalance.

Therefore, it can be concluded that the nutritional value of protein contributed by fish meal was higher than that of the protein from either SBM or CSM despite supplementation methionine and lysine. In need SBM can be used for tilapia at a maximum replacement of 50% while CSM appears to be inefficiently utilized.

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Table(1):Chemical composition and amino acid content of the protein sources expressed in percentage (on as-fed basis)

Composition	Protein sources		
	Fish meal	**Soybean meal**	**Cottonseed meal**
Chemical composition:			
Dry matter	93.0	89.0	94.0
Crude protein	61.1	44.5	40.2
Crude fat	6.70	1.90	1.40
Crude fibre	0.60	6.50	13.50
Ash	20.40	6.00	7.10
Nitrogen free extract	4.20	30.10	31.80
Amino acids contents:			
Arginine	4.21	3.39	3.97
Histidine	1.34	1.19	0.83
Isoleucine	2.67	2.03	1.15
Leucine	4.52	3.49	1.80
Lysine	4.53	2.85	1.89
Methionine+cystine	2.43	1.27	0.95
Phenylalanine+tyrosine	4.28	3.79	2.90
Threonine	2.57	1.78	1.02
Tryptophan	0.60	0.64	0.42
Valine	3.02	2.02	1.68

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

Ingredients	Control diet	Soybean meal diets (Exp. I)					Cottonseed meal diets (Exp. II)				
	1	2	3	4	5	6	2	3	4	5	6
a-Physical composition:											
Soybean meal	-----	16.13	32.27	48.40	64.53	64.53	-----	-----	-----	-----	-----
Cottonseed meal	-----	-----	-----	-----	-----	-----	17.86	35.72	53.58	71.44	71.44
Fish meal	47.0	35.24	23.50	11.75	0.00	0.00	35.25	23.50	11.75	0.00	0.00
Wheat flour	30.0	30.0	30.00	30.00	28.97	28.35	30.00	30.00	28.17	22.06	20.27
Corn starch	16.5	12.13	7.73	3.35	0.00	0.00	10.39	4.28	0.00	0.00	0.00
L-Methionine	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.51
L-Lysine	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.80
Vitamin mix.*	- 2.0	2.0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mineral mix.**	4.0	4.0	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Chromic oxide	0.5	0.5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
b-Chemical composition:											
Dry matter	84.77	84.38	84.01	83.62	83.21		85.31	85.86	86.37	86.78	
Crude protein	32.95	32.94	32.94	32.95	32.80		32.95	32.95	32.69	31.83	
Crude fat	3.56	3.08	2.59	2.12	1.63		3.02	2.48	1.93	1.30	
Crude fibre	0.85	1.82	2.80	3.77	4.72		3.18	5.52	7.82	10.04	
Crude ash	9.75	8.32	6.88	5.44	4.01		8.61	7.48	6.33	5.17	
Nitrogen free extract	37.66	38.22	38.80	39.34	40.05		37.55	37.43	37.60	38.44	
Gross energy(Kcal/Kg)	3870	3868	3866	3864	4008		3902	3935	3848	4037	
Calcium	2.67	2.05	1.44	0.82	3.66		2.03	1.40	0.77	0.14	
Phosphorus	1.55	1.27	1.60	1.03	0.48		1.39	1.23	1.08	0.90	

#Replacements at the rate of 25% of FM protein in diets numbered 2, 50% in diets 3, 75% in diets 4, 100% in diets 5 and 100%+AAs in diets 6.

*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; Biotin, 0.15g; Choline, 130g.

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

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

Amino acids	Control diet	Soybean meal diets (Exp.I)					Cottonseed meal diets (Exp.II)				
	1	2	3	4	5	6	2	3	4	5	6
Arginine	**2.13**	2.18	2.23	2.28	2.33	2.33	2.34	2.56	2.76	2.95	2.95
Histidine	**0.71**	0.74	0.77	0.82	0.85	0.85	0.70	0.69	0.68	0.65	0.65
Isoleucine	**1.41**	1.43	1.45	1.45	1.46	1.46	1.31	1.20	1.08	0.94	0.94
Leucine	**2.42**	2.45	2.49	2.52	2.54	2.54	2.21	2.00	1.77	1.51	1.51
Lysine	**2.21**	2.14	2.06	1.99	1.92	2.21	2.02	1.82	1.62	1.41	2.21
Methionine+cys.	**1.31**	1.23	1.15	1.07	0.97	1.31	1.20	1.08	0.96	0.80	1.31
Phenylalanine+tyr.	**2.33**	2.44	2.55	2.65	2.76	2.76	2.35	2.37	2.35	2.31	2.31
Threonine	**1.32**	1.31	1.28	1.27	1.26	1.26	1.20	1.07	0.95	0.81	0.81
Tryptophan	**0.32**	0.35	0.39	0.42	0.45	0.45	0.33	0.33	0.34	0.33	0.33
Valine	**1.59**	1.56	1.53	1.50	1.47	1.47	1.53	1.48	1.41	1.33	1.33

*Calculated.

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

Parameters	Groups					
	1	2	3	4	5	6
Initial body weight(g)	10.50±0.10	10.35±0.15	10.54±0.10	10.20±0.13	10.65±0.15	10.30±0.10
Final body weight(g)	**37.45±1.22[a]**	**36.98±1.20[a]**	**34.21±1.12[a]**	**31.08±1.19[b]**	**23.98±1.16[c]**	**24.55±1.15[c]**
Weight gain (g)	26.95±0.36	26.60±0.35	23.67±0.26	20.88±0.28	13.33±0.21	14.25±0.25
Feed intake (g)	**45.82±1.10[a]**	**46.02±1.21[a]**	**42.61±1.20[a]**	**39.46±1.15[b]**	**29.33±1.16[c]**	**29.93±1.14[c]**
Feed conversion	1.70±0.02	1.73±0.02	1.80±0.03	1.89±0.06	2.20±0.04	2.10±0.05

Figures in the same row having the same superscripts are not significantly different ($P<0.05$).

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

Composition	Groups						Beginning (blank group)
	1	2	3	4	5	6	
Dry matter (%)	33.2 ± 1.22^{a}	33.0 ± 1.20^{a}	32.8 ± 1.18^{a}	30.85 ± 1.15^{b}	27.30 ± 1.18^{c}	27.85 ± 1.20^{c}	22.40 ± 1.10
Crude protein (%)	69.70 ± 1.30^{a}	69.52 ± 1.30^{a}	69.35 ± 1.25^{a}	69.00 ± 1.25^{a}	58.10 ± 1.15^{b}	58.53 ± 1.20^{b}	62.80 ± 1.20
Crude fat (%)	16.30 ± 0.57^{a}	15.42 ± 0.45^{a}	14.10 ± 0.42^{b}	13.15 ± 0.52^{b}	11.15 ± 0.35^{c}	11.35 ± 0.30^{c}	9.30 ± 0.20

Figures in the same row having the same superscripts are not significantly different ($P<0.05$).

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

Parameters	Groups					
	1	2	3	4	5	6
Protein intake (g/fish)	15.10 ± 0.15^{a}	15.16 ± 0.20^{a}	14.04 ± 0.13^{a}	13.00 ± 0.15^{b}	9.62 ± 0.10^{c}	9.79 ± 0.12^{c}
Protein retention (g/fish)	7.26 ± 0.10^{a}	7.07 ± 0.15^{a}	6.37 ± 0.25^{b}	5.21 ± 0.12^{c}	2.39 ± 0.10^{d}	2.59 ± 0.12^{d}
Protein efficiency ratio	1.78 ± 0.01^{a}	1.75 ± 0.05^{a}	1.69 ± 0.03^{b}	1.61 ± 0.01^{c}	1.39 ± 0.01^{c}	1.46 ± 0.02^{c}
Apparent protein digest.	87.30 ± 1.15^{a}	86.45 ± 1.22^{a}	85.30 ± 1.65^{a}	85.00 ± 1.35^{a}	82.50 ± 1.25^{b}	82.80 ± 1.20^{b}

Figures in the same row having the same superscripts are not significantly different ($P<0.05$).

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

Parameters	Groups					
	1	2	3	4	5	6
Initial body weight(g)	10.20±0.15	10.10±0.20	10.32±0.13	10.50±0.12	10.00±0.10	10.40±0.10
Final body weight(g)	**35.00±1.20^{a}**	**28.85±1.15^{b}**	**25.62±1.10^{c}**	**23.60±1.10^{c}**	**20.15±1.05^{d}**	**21.10±1.20^{d}**
Weight gain (g)	24.80±0.35	18.75±0.28	15.30±0.25	13.10±0.20	10.15±0.17	10.70±0.20
Feed intake (g)	**42.66±1.45^{a}**	**33.75±1.37^{b}**	**28.31±1.25^{c}**	**26.33±1.20^{c}**	**21.82±1.15^{d}**	**22.47±1.18^{d}**
Feed conversion	1.72±0.01	1.80±0.02	1.85±0.05	2.01±0.07	2.15±0.08	2.10±0.07

Figures in the same row having the same superscripts are not significantly different (P<0.05).

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

Composition	Groups					
	1	2	3	4	5	6
Dry matter (%)	33.30±1.12^{a}	32.48±1.05^{a}	31.60±1.10^{b}	31.00±1.17^{b}	27.00±1.12^{c}	27.15±1.10^{c}
Crude protein (%)	68.15±1.35^{a}	64.54±1.25^{b}	64.10±1.20^{b}	63.70±1.20^{b}	56.30±1.15^{c}	57.70±1.18^{c}
Crude fat (%)	15.71±0.25^{a}	14.85±0.27^{a}	13.80±0.20^{b}	12.98±0.25^{c}	10.15±0.12^{d}	10.30±0.15^{d}

Figures in the same row having the same superscripts are not significantly different (P<0.05).

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

Parameters	Groups					
	1	2	3	4	5	6
Protein intake (g/fish)	14.06±0.30^{a}	11.12±0.25^{b}	9.33±0.20^{b}	8.61±0.17^{b}	6.95±0.15^{c}	7.11±0.15^{c}
Protein retention (g/fish)	6.53±0.15^{a}	4.64±0.15^{b}	3.78±0.12^{b}	3.25±0.13^{b}	1.65±0.12^{c}	1.90±0.15^{c}
Protein efficiency ratio	1.76±0.02^{a}	1.69±0.01^{b}	1.64±0.04^{b}	1.52±0.01^{c}	1.46±0.05^{c}	1.50±0.03^{c}
Apparent protein digest.	85.10±1.70^{a}	80.25±1.50^{b}	78.70±1.55^{b}	75.32±1.55^{b}	72.20±1.50^{c}	73.80±1.53^{c}

Figures in the same row having the same superscripts are not significantly different (P<0.05).

Table (10):-Performance of fish in soybean and cottonseed meal diets.

Parameters	Groups				
	2	3	4	5	6
Feed conversion:-					
SBM	1.73	1.80	1.89	2.20	2.10
CSM	1.80	1.85	2.01	2.15	2.10
Body composition (%):-					
Dry matter :- SBM	33.00	32.80	30.85	27.30	27.85
CSM	32.48	31.60	31.00	27.00	27.15
Protein :- SBM	69.52	69.35	69.00	58.10	58.53
CSM	64.54	64.10	63.70	56.30	57.70
Fat :- SBM	15.42	14.10	13.15	11.15	11.35
CSM	14.85	13.80	12.98	10.15	10.30
Protein retention (g):-					
SBM	7.07	6.37	5.21	2.39	2.59
CSM	4.64	3.78	3.25	1.65	1.90
Protein efficiency ratio:-					
SBM	1.75	1.69	1.61	1.39	1.46
CSM	1.69	1.64	1.52	1.46	1.50

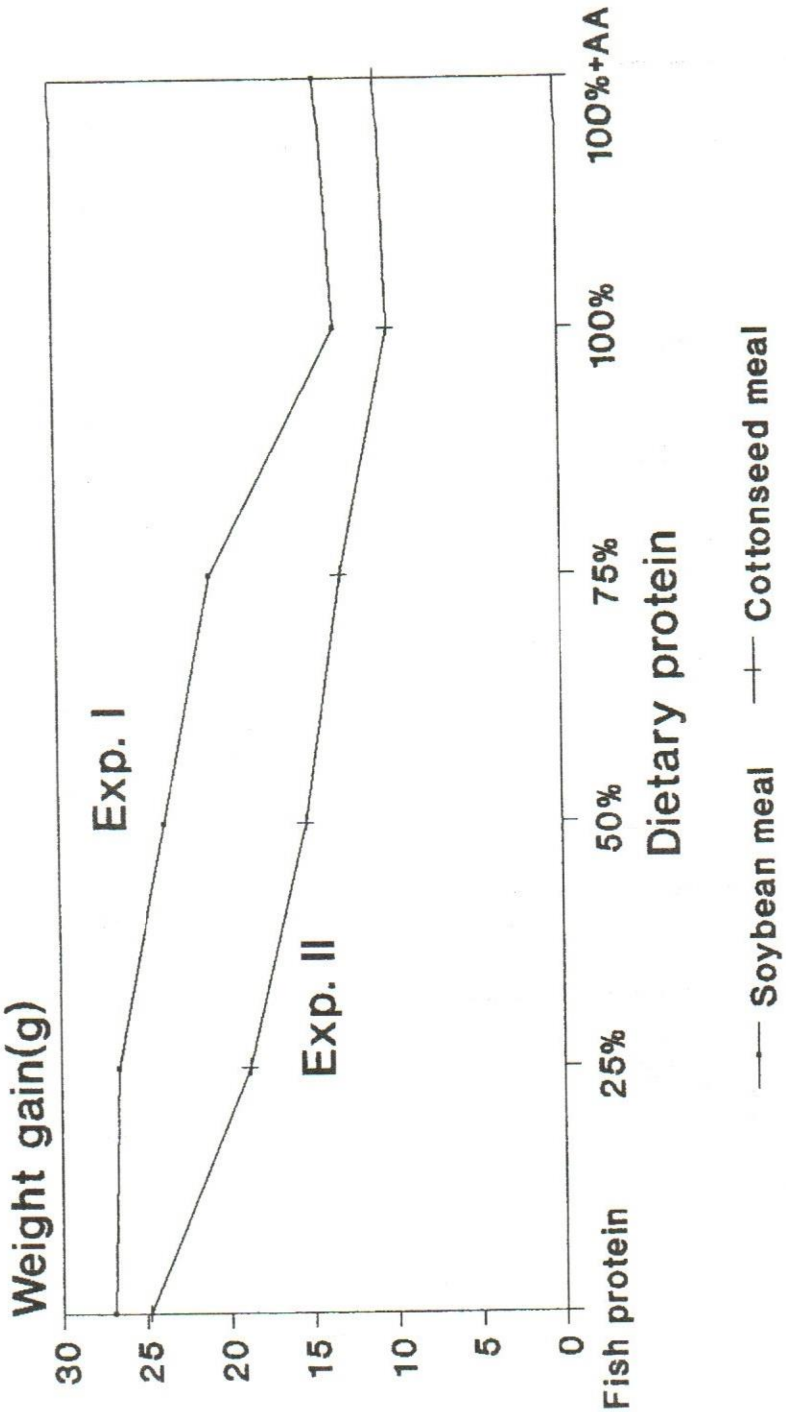

Fig.(1):Weight gain for the different groups in the two experiments