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GROWTH PERFORMANCE OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) AS AFFECTED WITH DIETARY INCORPORATION OF FERMENTED FISH SILAGE OR BOILED FULL FAT SOYBEANS AS PROTEIN REPLACERS

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ABSTRACT

Two experiments were performed in order to evaluate two feed stuffs, namely fermented fish silage (FFS) and boiled full-fat soybeans (BFS) as alternative protein sources for fish meal (FM) or fish meal replacers in Nile tilapia feeds. Both FFS and BFS performed well up to 50% substitution of FM without a significant loss in performance reared fish. These results also indicated that FFS is a promising feed ingredients for substituting fish meal at 25-50% dietary protein in Nile tilapia diets.

When different levels of boiled full-fat soybeans (BFS) were tested in the next experiment, similar results were obtained. Among this tested levels, substitution of fish meal with 25% dietary BFS was possible without any significant reduction in performance parameters. The utilization of FFS or BFS as the only dietary protein source (100%) significantly reduced growth performance of the tested fish.

INTRODUCTION

Fish meal is the main dietary protein source in fish feeds (Tacon & Jackson, 1985 and Kanshik, 1989). The cost of fish meal is continuously increasing, affecting in a direct way feeding costs and total fish farm production costs. For this reason, considerable research efforts have been directed towards the evaluation of other ingredients as potential fish meal substitutes in fish diets. Fishery by – catch, undersize fish farm harvest and fish processing wastes are another potential protein source for fishmeal. These raw materials can be easily used, in the developing countries such as Egypt, to produce fish silage, another form of fish meal (Wassef, 1991),that reduces the dependence of imported fish meal for fish feeds.

Nile tilapia (*O. niloticus*) is the most important fish cultured in Egypt. Intensive culture of this species has expanded in recent years, however the potential of using different feed stuffs in practical diets of tilapia is needed. The protein sources namely, fermented fish silage and boiled full-fat soybeans as substitutes for fish meal in Nile tilapia diets are tested to determine the optimum inclusion level of each. These two feed stuffs are relatively inexpensive, easy to produce on farm and readily available than fish meal.

Previous trials for replacing fish meal, by other dietary protein sources, in Nile tilapia diets are numerous, among them may be mentioned Wee & Shu (1989); El Sayed (1990), Lapie & Bigueras-Benitez (1992), Tacon (1993), Fagberno *et al.* (1994), Belal *et al.* (1995), El Sayed & Tacon (1997) and Gobran (2000).

MATERIAL AND METHODS

Experimental fish and rearing conditions

Two feeding trials were carried out in 20 (8-m^2 each) rectangular concrete ponds (1.2 cm depth) located outdoors at El-Kanater El-Khayria Fish Farm (NIOF), 60 km north of Cairo. The ponds were filled with freshwater originally from a Nile branch passed through a 1-mm screen mesh.

Nile tilapia fingerlings were obtained from the wild, acclimated to pond conditions and fed commercial feed for one week before the feeding trials, fish ranged from 7.6 –8.5 cm in total length and 10.4-12.8 g in total weight, randomly stocked in duplicate treatments into the experimental ponds at a rate of 8 fish/m^2. During the experimental period, photoperiod was left at natural conditions. Fish were hand-fed to visual satiety (about 3% of biomass) twice daily at 0900 and 1600 h for 6 days a week. Fish were carefully fed by same person during the feeding trial. Satiation feeding was determined by the point of voluntary feeding activity by fish. The feeding trial started on April 1st and lasted for 18 weeks.

Preparation of experimental diets:

Fermented fish silage (FFS) was prepared from minced small size tilapia (< 50 g) mixed with 5% sugar beat molasses and 2% *Lactobacillus plantarum* as culture media. This mixture was incubated at 30°C for 30 days (Fagbenro *et al.*, 1994).

Boiled full-fat soybeans (BFS):was prepared by boiling the raw soybeans for one hour and then dried into an oven at 48 c° for 20 minutes then milled and sieved (Wee and Shu, 1989).

First experiment: 1. Substitution of fish meal with fermented fish silage (FFS): experimental diets (28% protein) were formulated (No 2, 3, 4 and 5) to contain four levels of fermented fish silage (25, 50, 75 and 100%) as fish meal substitute and tested versus the control fish meal based diet (diet1).

Second experiment: 2. Substitution of fish meal with boiled full-fat soybeans (BFS): similarly other four test diets (B, C,D and E) were formulated, using boiled full-fat soybeans (BFS) as a fish meal replacer and tested versus the control fish meal diet (diet A). The ingredients and composition of the experimental diets are given in tables (1 & 2). Test diets were supplied as a pellets by using California Pellet Meal (CPM) machine.

Sample collection and chemical analysis

Over the experimental period (18 weeks), the growth rate was measured at two-weekly intervals. Food intake and mortality were recorded daily. The feed utilization and growth parameters were calculated using the following formulae ;

SGR = [Ln final weight – Ln initial weight / Rearing period] x 100.
PWG = [Final weight – Initial weight / Initial weight] x 100
FCR = [Food intake / Gain in weight] x 100.
PER = [Gain in weight / Protein intake] x 100.
PPV= [Protein increase in fish body / Protein intake] x 100.

The proximate composition of fish and diets was determined according to AOAC standard methods (AOAC, 1995).

Statistical analysis and economics:

Results were subjected to one-way ANOVA and Duncan's multiple range test was used to compare means (Steel and Torrie, 1980). The significant level was established at $p < 0.05$. The final cost and profitability of rearing Nile tilapia fingerlings were measured using the method of Mohamed (1998) as follows ;

Incident cost = Cost of food consumed / Fish production (kg).

Profit index = Price of fish produced / Feed cost.

RESULTS

First experiment : 1. Substitution of FM with FFS

The data obtained for growth and diet utilization during the first experiment are shown in table (3). Fish fed diet containing 25% FFS (diet 2) exhibited the highest performance among all tested levels. Mean of final weight, FW (79 g), total weight gain, TWG (66.2 gm), percentage weight gain, PWG (22.5%), daily weight gain, DWG (0.5 gm /fish) and specific growth rate, SGR (1.3%) recorded maximum values for fish fed diet 2, followed by fish fed diet 3 (50% FFS). These values were insignificantly different from the corresponding records of fish fed the control diet (100% FM), indicating a comparable growth performance (Table 3). Further substitution of fish meal with FFS (75%, diet 4) resulted in significantly reduced growth parameters and lowest records were shown for fish fed 100% FFS.

On the meantime, best FCR (2.04), PER (1.78), PPV (1.9) and LR (3.99) were obtained for fish fed diet 2 followed by diet 3. These values were comparable and varied insignificantly from those of the control fish meal based diet (Table 4). Higher FFS inclusion levels (diets 4 &5) resulted in inferior growth performance and poor nutrient utilization.

Maximum yield (3.9 kg / pond) was obtained for fish fed diet and diet 3 (3.7 kg / pond). The incidence cost was significantly increased with the elevation of FFS incorporation level (Table V). Best profit was obtained for fish fed diet 2 (1.73) which differ significantly from that of the control group (1.68), indicating that 25% dietary FFS is the optimum inclusion level in Nile tilapia diets.

Second experiment : 2. Substitution of FM with BFS

Similarly, testing different levels of BFS (boiled full-fat soybeans) inclusion in Nile tilapia diets showed the same trends of variation as apparent in the first experiment (FFS). Fish fed 25% BFS (diet B) recorded a highest values of FW (60.9 g), TWG (49.1 g), PWG (20.3%), DWG (0.36 g /fish) and SGR (1.41 %) among all tested levels. These values are close to the corresponding for the control FM diet (A). Higher dietary BFS inclusion levels resulted in significantly lower growth performance values than those of the control diet, but not statistically different for diet C. When 100% of FM was replaced (diet E), the lowest performance values were recorded (Table 3).

The best FCR (2.56), FER (1.63), PPV (1.78) and LR (3.57) records were obtained by fish fed diet B (25% BFS), which are comparable to the control FM diet. Further BFS inclusion levels produced inferior growth performance as well as poor nutrient utilization efficiency (Table 4).

On the meantime, highest yield (2.85 kg/pond), and profit index (1.5) were obtained for fish fed the diet containing 25% BFS (diet B). Similarly, the incidence cost was significantly increased with the increasing of dietary BFS incorporation level (Table 5), indicating that the optimum inclusion level of this product is 25% of diet .

DISCUSSION

Aquafeeds of fin fish species produced within farming systems have usually based upon the use of fish meal as the main source of dietary protein. The nutritional characteristics of fish meal protein approximating almost exactly to the nutritional requirements cultured fin fish (Tacon, 1993).

Although the dependency of tilapia upon fish meal is not as great as that of carnivorous fin fish species, fish meal is still generally a preferred protein source for use within compound aquafeeds for tilapia because of its high nutritional quality and biological value. A wide variety of feed stuffs have been evaluated and used successfully within tilapia feeds. Studies with acidified fish silage have also been very promising (Wassef, 1991 and Gobran, 2000). Lactic acid fermented fish silage (FFS) could be stored at 30 c° for six months with little or no nitrogen loss or change in nutritional quality (Fagbenro and Jauncey, 1993).

Moreover, experimental aquafeeds containing FFS were reported to have very good water stability and low nitrogen loss irrespectively the binder used (Fagbenro and Jauncey, 1995). Furthermore, excellent apparent digestibilites for dry matter, crude protein and lipid were reported during feeding trials for FFS-based diets when fed to Nile tilapia, *Oreochromis niloticus* (Fagbenro and Jauncey, 1994 & 1995). Similarly, Lapie and Bigueras-Benitez (1992) found that no difference in the growth and feed efficiency between Nile tilapia fed a formic acid preserved fish silage (FS) blended in the FM (1 : 1 ratio) at a FM based ration, although growth performance was reduced when the FS: FM ration was increased to 3:1. The results of present work confirmed the previous bindings and proved that dietary FFS, tested at 25 or 50% inclusion level, provided fish performance comparable to the 100% FM diet. This indicate that FFS offer a good FM alternative feed stuff for Nile tilapia fingerling feeds. Furthermore, Fagbenro *et al*l. (1994) found that up to 75% of the FM protein could be successfully replaced with a dried 1:1 mixture of blended FFS: soybean meal in feeds for all male Nile tilapia.

Although soybean meal (SBM) is generally considered to be one of the best readily available plant protein sources in terms of its protein quality and EAA profile (with the exception of meat), it does contain a wide variety of endogenous antinutrients which require removal or inactivation through processing prior to usage within aquafeeds. Heating, defatting and germination were tried and proved efficient ways to get rid of antinutritional factors (Wassef *et al.*, 1988). Numerous studies have been conducted using processed SBM as a FM replacer within tilapia feeds. Reports have shown that 67% to 100% of the dietary protein could be supplied in the form of SBM, the inclusion level depending upon a variety of different factors. The present work results of the second experiment revealed that BFS could also be used as a fish meal replacer in Nile tilapia diets up to 50%, inclusion level without significant reduction in the fish performance. These results are in agreement with those of Wee and Shu (1989) who reported that the nutritional value of full-fat SBM for *O. niloticus* was improved and the trypsin inhibitor activity level reduced by boiling soybean for one hour prior to usage. It is also of interest to note that the dietary inclusion of SBM in tilapia feeds is affected by the dietary protein level (El Sayed and Tacon, 1997).

In view of cost benefit analysis, the diets containing a ratio of 1 FFS: 3 FM or 1 BFS : 3 FM were the most economic among all ratios tested.

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Table (1) : Composition and analysis of fermented fish silage (FFS) experimental diets fed to *Oreochromis niloticus* fingerlings for 18 weeks

Ingredient	**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**	
	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)
Fish meal (FM)	14.0	8.54	10.5	6.41	7.0	4.27	3.5	2.14	--	--
Fermented fish silage (FFS)	--	--	3.5	1.98	7.0	3.97	10.5	5.95	14.0	7.93
Soybean meal *	25.0	11.00	25.0	11.00	25.0	11.00	25.0	11.00	25.0	11.00
Rice bran	30.7	5.22	30.7	5.22	30.7	5.22	30.7	5.22	30.7	5.22
Wheat bran	29.2	3.50	29.2	3.50	29.2	3.50	29.2	3.50	29.2	3.50
Sunflower oil	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--
Vit & mineral premix	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--
Proximate analysis (%)										
Crude protein (CP)	28.26		28.11		27.96		27.80		27.66	
Ether extract (EE)	3.77		3.90		3.26		4.17		4.30	
Moisture (MC)	8.67		8.50		8.31		8.13		7.95	
Ash (AC)	10.26		10.23		10.21		10.19		10.17	

* Hexane extracted

Table (2). Composition and analysis of boiled full-fat soybeans (BFS) experimental diets fed to *Oreochromis niloticus* fingerlings for 18 weeks

Ingredient	Diet 1 (control) 100% FM		Diet 2 75% FM 25% BFS		Diet 3 50% FM 50% BFS		Diet 4 25% FM 75% BFS		Diet 5 100% BFS	
	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)	Weight (g)	Protein (%)
Fish meal (FM)	14.0	8.54	10.5	6.41	7.0	4.27	3.50	2.14	0.00	0.00
Boiled full-fat soybeans (BFS)	--	--	3.50	1.54	7.0	3.08	10.5	4.62	14.0	6.16
Soybean meal *	25.0	11.0	25.0	11.0	25.0	11.0	25.0	11.00	25.0	11.00
Rice bran	30.7	5.22	30.7	5.22	30.7	5.22	30.7	5.22	30.7	5.22
Wheat bran	29.2	3.50	29.2	3.50	29.2	3.50	29.2	3.50	29.2	3.50
Sunflower oil	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--
Vit & mineral premix	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--
Proximate analysis (%)										
Crude protein (CP)	28.26		27.67		27.07		26.46		25.88	
Ether extract (EE)	3.77		3.52		3.27		3.02		2.78	
Moisture (MC)	8.67		8.78		8.88		8.97		9.07	
Ash (AC)	10.26		9.81		8.37		8.92		8.48	

* Hexane extracted

Table (3): Growth performance of parameters *O. niloticus* fingerlings fed different levels of FFS or BFS-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)	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	53.03
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 *
	Diet A (control) 100% FM	Diet B 75 % FM 25 % BFS	Diet C 50% FM 50% BFS	Diet D 25% FM 75% BFS	Diet E 100% BFS
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	16.34	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 *

* Significant at levels $P < 0.05$

Table (4): Nutritional parameters of *O. niloticus* fingerlings fed FFS or BFS-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
First experiment	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 (PPV)	0.96	1.90	1.80	1.69	1.78
	Lipid retention (LR)	4.31	3.99	4.75	3.52	3.02
Second experiment		Diet A (control) 100% FM	Diet B 75 % FM 25 % BFS	Diet C 50% FM 50% BFS	Diet D 25% FM 75% BFS	Diet E 100% BFS
	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 (PPV)	1.95	1.78	1.77	1.62	1.55
	Lipid retention (LR)	3.53	3.57	3.73	5.97	5.27

* Significant at levels $P < 0.05$

Table (5): Economic analysis and production of *O. niloticus* fingerlings fed fermented fish silage or boiled full-fat soybeans based diets for 18 weeks.

Items		First experiment					Second experiment				
		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	Diet A control 100% FM	Diet B 75 % FM 25 % BFS	Diet C 50% FM 50% BFS	Diet D 25% FM 75% BFS	Diet E 100% BFS
Total weight gain	(g/fish)	64.25	66.20	62.25	53.34	35.03	52.16	49.11	46.34	37.40	24.26
Number	(fish/pond)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Mortality	(fish/pond)	1.00	1.00	1.00	3.00	3.00	2.00	2.00	3.00	2.00	3.00
Survival rate	(%)	98.33	98.33	98.33	95.00	95.00	96.60	96.60	95.00	96.60	95.00
Total food given	(kg)	7.59	8.09	7.98	7.23	5.83	6.88	6.78	6.56	5.68	5.42
Total yield	(kg/pond)	3.79	3.91	3.67	3.04	2.00	3.03	2.85	2.64	2.17	1.95
Production	(kg/m^2)	0.47	0.49	0.46	0.38	0.25	0.38	0.36	0.33	0.27	0.24
Cost / kg feed		1.19	1.12	1.11	1.08	1.04	1.20	1.12	1.11	1.07	1.03
Incidence cost	(Ic)	2.38	2.32	2.41	2.56 *	3.03 *	2.71	2.67	2.75	2.80	2.86 *
Profit index	(Pi)	1.68	1.75 *	1.66	1.56 *	1.32 *	1.47	1.50 *	1.45 *	1.42 *	1.40 *

FM = Fish meal.
BFS = Boiled full-fat soybeans.
FFS = Fermented fish silage.
* Significant at levels $P < 0.05$