TOTAL REPLACEMENT OF FISHMEAL WITH SOYBEAN MEAL IN DIETS FORNILE TILAPIA IN PRE-FERTILIZED PONDS

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Abstract

This study was conducted to investigate the effect of replacing fishmeal with soybean meal in diets with different levels of dietary protein on the production economics of Nile tilapia (*Oreochromis niloticus* L.). Sixteen 0.2 hectare earthen ponds were used for the experiment. Ponds were randomly assigned in groups of four ponds each to one of the four treatments: the first treatment fed commercial fishmeal based diet with 17% crude protein (17-FM), the second treatment fed commercial fishmeal based diet with 25% crude protein (25-FM), the third treatment fed an all vegetable soybean based diet with 25% crude protein (25-SBM), while the fourth treatment fed 32% crud protein soybean based diet (32-SBM). Total growing period was 175 days (70 days of fertilization and 105 days of feeding). The results showed that tilapia growth was better in the treatment with higher protein content regardless the source of protein in the diet. Net return was better in both treatments of 25% CP than those of 17 and 32% CP and the four treatments could be arranged as follows: 25% SBM > 25% FM > 32% SBM > then 17% FM in a descending order. Water quality parameters were however, within the favorable range for freshwater fish in all treatments. The study results demonstrate that soybean meal could replace the fish meal in diets for Nile tilapia without negative effects on growth, or on total production and even leading to high net economic returns in case of using diets with 25% protein from plant source (25%SBM).

Keywords: Tilapia; Fishmeal; Soybean meal; Growth performance; Water quality.

INTRODUCTION

Fish meal was recognized as the best source of protein for most fish species. Recently, the increase cost of fishmeal, however poses real problems for cost effective feed formulation. Fish nutritionists have therefore, begun to evaluate alternative diet ingredients to replace fishmeal with readily available inexpensive plant sources. Fish meal is one of the most expensive ingredients of aquaculture diets. It is estimated that more than 50% of the variable costs of fish production are feed costs (Woods 1999), so profitability of production is significantly influenced by feed. Due to its relatively high cost, cost variability, and growing environmental concerns about harvesting wild fish to produce fish meal, it is desirable to replace fish meal with less expensive protein sources.

A number of animal and plant source proteins have been evaluated for fish meal replacement in diets for a number of different species. In freshwater omnivores, such as tilapia *Oreochromis* sp. and channel catfish *Ictalurus punctatus*, fish meal can be completely replaced by plant protein sources such as soybean meal (Lovell 1998). Because of the limited supplies and the high price of fishmeal, other alternative sources of protein must be considered. Plant proteins are generally cheaper per unit of nutrient than animal protein. Relatively, few plant protein sources have been used in fish feeds, because fish require high levels of dietary protein. Commercial aquaculture feeds for grow out contain 25 to 45% crude protein. Thus, only high protein content plant feedstuffs, such as oilseed residues, are used in fish feed. The most commonly utilized by feed manufacturers are soybean meal, peanut meal, and cottonseed meal. Soy protein is considered the best plant protein source for meeting the essential amino acid requirements of tilapia and other fish species commercially grown. It is highly digestible by fish and the digestion coefficients are comparable or higher than fishmeal protein (Alceste and Jory, 2000).

Over the past few years, the American Soybean Association (ASA) has conducted several tilapia feeding studies with the objective of replacing fishmeal with soybean meal and examining potential benefits of extrusion over pelleting (Cremer *et. al*., 2002). ASA feeding studies have demonstrated that replacement of fishmeal with soybean meal has no impact on fish performance but can improve net income (Swick, 2001).

Tilapia generally has been shown to respond favorably to the dietary replacement of fish meal with soybean meal. Davis and Stickney (1978) conducted a 4 x 4 factorial experiment in aquaria with blue tilapia to evaluate four different combinations of soybean meal and fish meal (each constituting 0, 33, 67 or 100% of dietary protein) at each of four dietary protein levels (15, 22, 29 and 36%). Diets containing all protein combinations, except the 36% protein diet with 100% fish meal were supplemented with DL-methionine. Fish fed diets containing 36% protein experienced the greatest weight gain and feed efficiency. These responses were not influenced significantly by any combination of soybean meal to fish meal. However, at the lower dietary protein levels, a general improvement in growth and feed efficiency was seen with increasing amounts of fish meal in the diet.

Shiau *et. al*., (1988) suggested that up to 67% of fish meal in milkfish feed could be replaced by commercial hexane-extracted soybean meal and a methionine supplement without any adverse effect on milkfish growth and feed conversion rate.

Hybrid tilapia (*Oreochromis niloticus* x *O. aureus*) fed a diet in which 30% of the fish meal in the control diet was replaced with SBM had similar weight gain, feed efficiency, protein efficiency ratio and protein digestibility, compared to fish fed the control diet (Shiau *et al.,* 1990).

In recent studies, some attempts were carried out to replace the high cost animal protein source by plant source proteins (e.g., Sanz *et al.,* 1994; Fagbenro and Davies, 2000; Olvera-Novoa *et al.,* 2002; El-Saidy and Gaber, 2002; Borgeson *et.al.* 2006).

Previous studies (El-Saidy and Gaber, 2002) compared a commercial tilapia diet containing 20% fish meal and 30% soybean meal to diets with all of the protein coming from soybean meal with graded levels of L-lysine supplementation formulated for Nile tilapia fingerlings. After feeding for ten weeks, the diet containing 55% soybean meal and 0.5% L-lysine was significantly ($P>0.05$) better than the commercial tilapia diet with respect to final weight, weight gain, feed conversion, protein efficiency ratio and feed intake. This diet had the highest digestibility coefficients for protein, fat and energy. These researchers suggested that a diet with 55% soybean meal supplemented with 0.05% L-lysine can totally replace fish meal in a diet for Nile tilapia fingerings without adverse effect on fish performance.

The objective of this trial was to demonstrate tilapia growth and economic performance from fingerling to market stages with the soymeal-based growout feed and the commercial fishmeal-based feed at different levels of protein content.

MATERIALS AND METHODS

This experiment was conducted in sixteen 0.2-ha earthen ponds located at The WorldFish Center, Abbassa, Sharkia, Egypt. Ponds were stocked with mixed sex Nile tilapia (*Oreochromis niloticus* Linn.) averaging 0.13 g at a rate of 30,000 fish/ha (3 fish/m^2). In addition to tilapia, each pond received 40 silver carp fingerlings with average body weight of 50 grams in order to prevent excessive algal blooms. Ponds were prepared as follows: 1) they were drained to get rid of unwanted wild fish. 2) Ponds then were fertilized by splashing dry cattle manure on pond bottom (250 kg/ha) and, 3) refilled with water one week before stocking the fish.

Mixed sex Nile tilapia fry were obtained from the hatchery of the Arab League Fisheries Company, Abbassa, Abou-Hammad, Sharkia. Fry were graded, counted, placed into fiberglass tanks then transferred to growing ponds. Total experimental period was 175 days (70 days of fertilization and 105 days of feeding).

Ponds were fertilized for 10 weeks with organic manure and chemical fertilizer with the rate of 500 kg/ha/week of cattle manure, 5 kg/ha/week urea (46.5% N), and 50 kg/ha/week super phosphate (15.5% P). After 10 weeks of fertilization, Ponds were randomly assigned the following treatments: the first treatment fed 17% crude protein commercial fishmeal based diet (17-FM), the second treatment fed 25% crude protein commercial fishmeal based diet (25-FM), the third treatment fed 25% crude protein soybean based diet (25-SBM), while the fourth treatment fed 32% crud protein soybean based diet (32-SBM).

Supplementary artificial feeds, with different protein levels and sources, were introduced to all ponds at the rate of 90% of satiation until the harvest. Ponds were fed six days a week twice daily. Monthly fish samples were collected using seining net to check body weight and length. At least twenty five fish were collected and then released again in the pond after weighed and measured. Condition factor, (K) was then calculated according to Fulton (1902) using the following formula:

$K = W \div L^3$. (where, **W**= weight in grams, and **L**= standard length in mm).

Economic analysis was conducted to determine economic returns of the four treatments tested during the experiments (Shang, 1990). The analysis was based on farm prices in Egypt for harvested fish and current local market prices for all other items expressed in US dollar at the time of the experiment (US$1= 5.71 L.E.). Farm price of Nile tilapia varied with size grade as shown in Table 1.

Table 1. Size grades and price of farmed Nile tilapia in Egyptian fish markets

Size Grade	Super grade	1st grade	2nd grade	3rd grade	4th grade
Weight (g)	>300	200 – 300	100 - <200	50 - <100	<50
Price ($/kg)	1.36	1.18	1.01	0.7	0.26

Economic performance of the four feeding strategies was compared in terms of total cost, return (from selling fish) and net return (gross return - total cost).

Biweekly water samples were collected from each pond to be analyzed for different water physico-chemical parameters. Water samples were analyzed according to methods described by Boyd and Tucker (1992). In addition, total ammonia nitrogen (TAN) and pH were measured in pond water weekly while dissolved oxygen levels were followed on daily basis.

Ponds were harvested after 25 weeks of stocking. Yield fish were sorted to different marketing size classes. Fish yield of each size class was weighed and counted then the survival rate was calculated.

Obtained data for fish production, total cost and net return were statistically analyzed using statistical analysis system software, ver. 9.1. (SAS, 2005). Analysis of variance (ANOVA) and Duncan's Multiple Range Test were performed to evaluate the differences among treatments means and standard errors of means. The significance level of 0.05 was considered in all statistics.

RESULTS AND DISCUSSION

Production patterns

Data in table 2 showing the effects of the four treatments namely, 17% FM, 25% FM, 25% SBM and 32% SBM on the total tilapia production, total fish production and survival rate. No significant differences were found among treatments with respect to the survival rate. Tilapia production and total fish production were significantly lower in case of 17% FM treatment compared with the other three treatments (25% FM, 25% SM and 32% SBM). No significant difference was noticed in tilapia production or total fish production of both 25% FM and 25% SBM treatments as well as the 32% SBM. Maximum tilapia production (3984.7 kg/ha) was obtained from the 25% SBM treatment while the lowest (3089 kg/ha) was obtained from the 17% FM treatment.

Percentages of tilapia of the total yield were so close in all treatments and ranged from 82.2 to 86.1%. There were significant differences among the treatments when compared on basis of different size grades of produced fish. In the first treatment (17% FM), the super and first grade yields were the least compared with the other three treatments. While second and third grade yields didn't show any significant difference among all treatments. 17% FM treatment yielded the highest amount of the small size fish (4^{th} grade) among treatments. Highest super grade yield (675 kg/ha) was obtained from the 25% FM treatment.

Economical evaluation

The cost estimation was based on local market prices of fingerlings, fertilizers, feed and labor. Data in table 3 showing that the total cost of both 25% FM and 25% SBM treatments were not significantly different. While both 17% FM and 32% SBM treatments were significantly different either from each other or from other treatments. 17% FM was the least cost treatment while 32% SBM has the highest cost mainly due to the wide difference in price of the two feeds. Based on gross return, 17% FM treatment came significantly lower than the other three treatments. With the exception of 17% FM, no significant differences in gross return were found among treatments.

When comparing between treatments on basis of net return, it was found that the high and low protein diets (17 and 32%) did not show significant differences, while both of them were significantly lower than the two 25% SBM treatment. Regarding the net return, the four treatments could be arranged in a descending order as follows: 25% SBM > 25% FM > 32% SBM > then 17% FM.

Table 2. Production data (mean ± standard error kg/ha) of Nile tilapia fed different

Treatment	Super grade	1st grade	2nd grade	3rd grade	4th grade	Fingerling size	Others*	Total tilapia	Total production	Survival (%)
17% FM	126 b** ± 82	995.5 b ± 137	1268.5 a ± 96.5	466.5 a ± 18	232.5 a ± 80.5	232.5 b ± 80.5	346 a ±110.5	3089 b ± 85	3760 b ± 39	73.9 a ±2.2
25% FM	675 a ±209.9	1366 a ±44.8	1112.5 a ± 232.8	457 a ± 34.7	149.4 b ± 38.55	149.4 ab ±38.55	239.2 b ±51.4	3760 a ±152.1	4367.9 a ±100.05	77.2 a ±7.34
25% SBM	474.9 ab ±109.8	1555 a ±59.5	1398.9 a ± 130.7	477.7 a ±48.65	78.15 b ± 17.25	78.15 ab ±17.25	226.2 b ± 7.95	3984.7 a ± 30	4646.2 a ±26.45	82.0 a ±1.04
32% SBM	504.4 ab ±103.8	1395 a ±126.05	1347.3 a ± 120.3	399.8 a ±26.75	100.8 b ±31.4	100.8 a ±31.4	215.7 b ±26.5	3747.2 a ±73.75	4513.8 a ±100.75	73.9 a ±2.76

* The term Others means silver carp and/or African catfish.

** Means with same letter within a column are not significantly different types of feed

Table 3. Economics of Nile tilapia production fed different types of feed

Treatment	FCR	Total Cost $/ha	Gross Return $/ha	Net Return $/ha
17% FM	1.5 a	2746.7	3270.4	523.7 c*
25% FM	1.3 b	2910.8	4188.8	1278.1 ab
25% SBM	1.3 b	2953.6	4415.0	1461.4 a
32% SBM	1.2 b	3200.6	4157.3	956.7 bc

* Means with same letter within a column are not significantly different

Feed conversion ratio (FCR)

FCR value of the 17% FM treatment was significantly higher than those of the other three treatments (table 3). No significant variations were found in FCR values among the other three treatments; 25% FM, 25% SBM and 32% SBM. This is reflecting the similarity of performance with both FM and SBM. Also it reflects that increasing protein content in the diet did not reduce the consumed amount of feed.

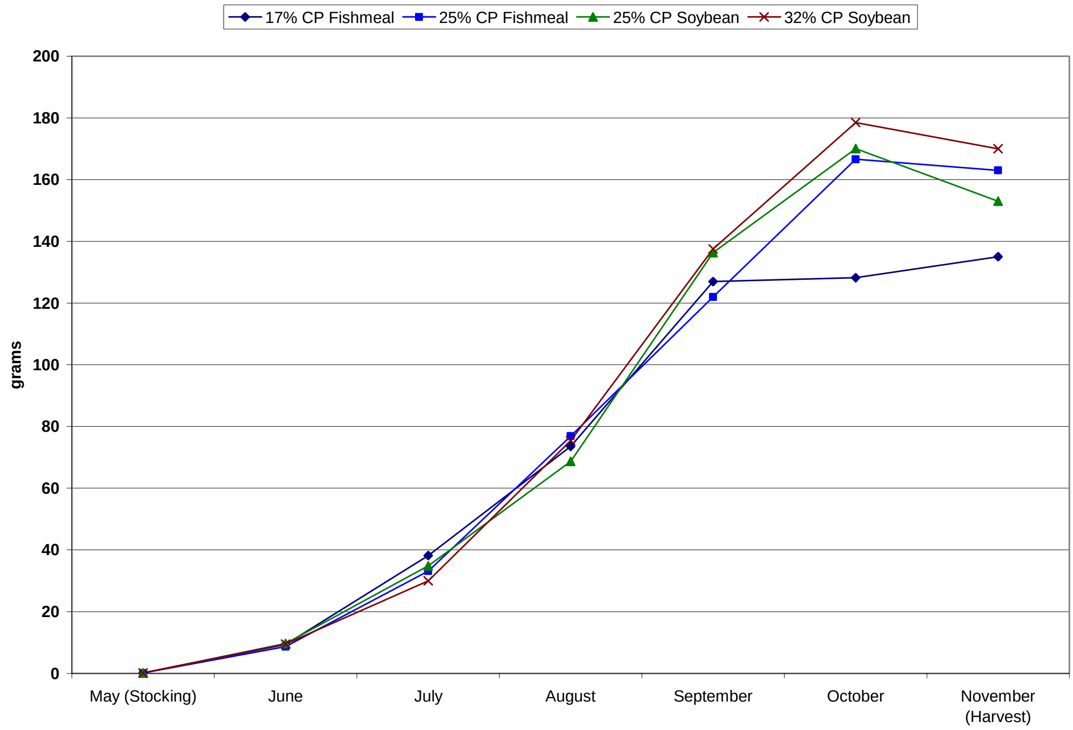
Growth patterns

Figure 1 illustrates the growth patterns of Nile tilapia in the four treatments throughout the experimental period. It is obvious that fish's body weight of the four treatments didn't vary in the first four months. After four months of stocking, fish body weight in all treatments ranged between 122 and 137.5 grams (table 4). Variation in body weight among treatments took place after four months of stocking until harvest. Low protein content diet treatment (i.e., 17%) ranked away of the other three treatments of high protein levels (25 and 32%). The high protein diet treatments (both 25% and 32%) ranked, however, in the same path with minor variations throughout the experimental period. Feeding fish on high protein diet (32%), however, did not reflect better growth performance in Nile tilapia.

Table 4. Growth data of Nile tilapia fed different diets with different protein sources and levels

Date of sample	Treatment			
	17 % FM	25% FM	25% SBM	32% SBM
Initial stocking weight (g) 10-May-06	*0.13*			
12-Jun-06	9.35	8.67	9.70	9.50
10-Jul-06	38.17	33.14	34.84	30.01
24-Jul-06	53.68	50.12	54.28	50.29
10-Aug-06	73.53	76.87	68.68	75.46
28-Aug-06	104.65	117.60	108.95	118.40
10-Sep-06	126.94	122.00	136.34	137.52
26-Sep-06	131.80	156.60	158.46	162.82
9-Oct-06	128.21	166.60	170.08	178.46
29-Oct-06	130.44	185.63	176.44	171.23
Final Harvest weight; individual weight gain (g)	*135.00*	*163.00*	*153.00*	*170.00*
Overall average of condition factor (K)	*2.20*	*2.25*	*2.13*	*2.14*

Fig. 1. Growth patterns of Nile tilapia fed different diets with different protein sources and levels.



Overall mean of weight-length condition factor (K) of the fishmeal based diet treatments were higher than those of the soybean based diet treatments. That figure reflects the better condition of fish body fed on fishmeal based diets regardless of the protein level.

Effect on water quality

Water parameters are shown in table 5. Minor variation could be noticed in some water parameters due to the different protein levels in diets or the different protein sources. In all means water parameters were however, within the desirable range for freshwater fish. Data showed that pH in ponds ranged between 8.5 and 9.1 throughout the experimental period. Total ammonia nitrogen (TAN) ranged between 0.21 and 0.42 mg/L throughout the experimental period. Both low levels of pH and TAN reflect a low level of the harmful un-ionized ammonia. Highest un-ionized level were calculated to be 0.09 mg/L which in the safe rate. With respect to protein source, slight increase in pH levels was noticed with SBM treatments when compared to those of FM. Water total hardness and alkalinity of all treatments were, however, almost similar and in acceptable ranges for fish. Obvious increase in both available phosphorus and nitrate levels could be noticed in all treatments in the first ten weeks (fertilization period) then started to decrease after that until the end of the experimental period to reach its initial levels before stocking or even little higher. It is obvious that chlorophyll a was high in the initial water sample of all treatments then started to decline after stocking of fish due to the consumption of the green cells from the water by fish (Table 5). Chlorophyll a content was decreased in pond water after stocking of fish due to the consumption of green cells by fish in the period of fertilization. Levels of chlorophyll a started to increase after 10 weeks when fish switched to artificial feed.

Table 5. Monthly average values of water parameters in ponds contain Nile tilapia fed different types of feed

	pH	TAN	Hardness	Alkalinity	Available P	NO3	Chlorophyll a
17% FM							
Initial	8.5	0.28	206	220	0.13	0.21	64.38
May	8.6	0.31	200	229	0.41	0.33	16.37
June	8.9	0.29	221	269	0.85	0.80	35.80
July	8.7	0.26	187	237	0.81	0.91	--
August	8.5	0.25	197	252	0.66	0.48	--
September	8.5	0.31	223	299	0.38	0.61	59.83
October	8.6	0.26	220	266	0.32	0.65	52.61
25% FM							
Initial	8.7	0.23	235	265	0.17	0.44	106.60
May	8.6	0.32	205	243	0.48	0.39	28.75
June	8.8	0.27	268	310	0.74	0.53	30.89
July	8.8	0.23	224	294	0.88	0.75	--
August	8.7	0.23	233	307	0.92	0.38	--
September	8.8	0.28	255	358	0.64	0.50	41.89
October	8.8	0.21	238	312	0.58	0.45	52.26
25% SBM							
Initial	8.8	0.30	252	246	0.07	0.10	108.43
May	8.8	0.37	195	216	0.25	0.41	12.42
June	9.1	0.25	199	254	0.48	1.06	50.41
July	9.0	0.27	194	263	0.63	0.85	--
August	8.8	0.23	211	279	0.66	0.50	--
September	8.8	0.26	245	332	0.45	0.83	21.04
October	8.9	0.21	226	286	0.42	0.67	32.54
32% SBM							
Initial	8.8	0.25	238	261	0.08	0.32	122.00
May	8.6	0.42	204	240	0.40	0.04	30.53
June	8.9	0.31	214	303	0.68	0.34	27.23
July	8.9	0.37	206	276	0.76	0.98	--
August	8.7	0.23	212	281	0.70	0.38	--
September	8.9	0.27	240	338	0.68	0.42	53.12
October	9.0	0.21	226	326	0.06	0.45	48.25

This study results clearly demonstrate that soybean meal could completely replace the fish meal in diets for Nile tilapia reared in earthen ponds without negative effects on growth, total production or net return. Numerous studies have been conducted using processed SBM as a FM replacer within tilapia feeds. The inclusion level depending upon a variety of different factors, including fish species and size, SBM source and processing method, manufacturing method, and culture system employed. SBM, with or without methionine supplementation successfully replaced up to 75% of FM within diets fed to *O. niloticus* fry (Pantha, 1982; Tacon *et al.,* 1983), *O. mossambicus* (Jackson *et. al.,* 1982), and tilapia hybrids (Shiau *et al.,* 1989).

Shiau *et al.*, (1990) suggested that either defatted soybean meal or full-fat soybean meal can be used to replace 30% fishmeal protein in a diet for *Oreochromis niloticus× O. aureus* fingerling hybrids when the dietary protein level is low (24%).

It is also of interest to note that the dietary inclusion of SBM in tilapia feeds is affected by the dietary protein level. For example, Davis and Stickney (1978) fed *O. aureus* SBM-based diets at dietary protein levels ranging from 15 to 36%, and found that whilst SBM impaired fish growth at 15% crude protein levels, that SBM could totally replace FM within diets containing 36% crude protein. In contrary, Shiau *et al.,* (1987) with *O. niloticus* ***X*** *O. aureus* hybrids, reported that FM could be partially replaced by SBM within diets containing sub-optimal protein levels (24%), whereas at optimum protein levels (32%) the dietary replacement of FM with 30% SBM significantly depressed fish performance. Our study also suggested that the medium protein level (25%) performed well (non significant) compared to the high one (32%).

Hybrid GIFT tilapia exhibited excellent growth (500 g net gain in 131 days) and FCR (1.19:1) with the ASA extruded, soy-based feed and 80:20 pond technology. The ASA feed maintained good water quality, and no pond water flushing was required (Cremer *et. al.,* 2002). Replacement of fishmeal with a complex mixture of plant ingredients may allow a greater replacement of fishmeal in diets fed to Nile tilapia. Borgeson *et al.*, (2006) examined the effect of replacing fishmeal with simple or complex mixtures of plant proteins including SBM in tilapia diets. The average daily gains, specific growth rates and feed efficiencies of fish fed diets with 0 g kg^{-1} fishmeal were significantly lower than fish fed diets with the 330 g kg^{-1}, 670 g kg^{-1} or 1000 g kg^{-1} fishmeal levels.

No significant differences in growth, production or survival were observed between the 25% FM and 25% SBM treatments. The ASA feeds with or without fishmeal gave excellent performance relative to commercial feeds (Swick, 2001).

Major water quality parameters measured during the experiment remained in the favorable range for tilapia (Boyd, 1990), suggesting that tilapia growth performance was not limited by any of the water quality parameters. High rates of pH and ammonia in the first two months of the study could be attributed to fertilization which resulted in high loads in the form of die-off plankton and other organic matter; organic matter settled to the pond bottom is mineralized by microbial activities to inorganic nutrients such as ammonia which stimulate algal growth in ponds (Boyd, 1985).

In conclusion, tilapia growth was better in the treatment with higher protein rate regardless the source of protein in the diet. Net return was better in both treatments of 25% CP than those of 17 and 32% CP. The study results demonstrate that soybean meal could replace the fish meal in diets for Nile tilapia reared in earthen ponds without negative effects on growth, or on total production and even leading to high net economic returns in case of using diets with 25% protein from plant source (25%SBM).

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أثر استبدال مسحوق السمك بمسحوق الصويا في علائق أسماك البلطي النيلي المرباة في أحواض سبق تسميدها

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المركز الدولي للأسماك، المركز الإقليمي لإفريقيا وغرب آسيا، العباسة، محافظة الشرقية، ٤٤٦٦٢ مصر

أجريت هذه الدراسة لاستقصاء تأثير استبدال مسحوق السمك بمسحوق الصويا استبدالاً كلياً في عدد من العلائق مختلفة المحتوى البروتيني على اقتصاديات إنتاج سمك البلطي النيلي (*Oreochromis niloticus* Linn.). استخدم لهذه التجربة ستة عشر حوضاً ترابياً بمساحة ٠,٢ هكتار/حوض في المركز الدولي للأسماك بالعباسة، أبو حماد، محافظة الشرقية، مصر. تم توزيع الأحواض عشوائياً في مجموعات تضم كل مجموعة أربعة أحواض وتمثل كل مجموعة معاملة من المعاملات الأربعة التالية: الأولى/ تغذية الأسماك على عليقة ذات ١٧٪ محتوى بروتين من أصل حيواني (مسحوق سمك)؛ الثانية/ تغذية الأسماك على عليقة ذات ٢٥٪ محتوى بروتين من أصل حيواني (مسحوق سمك)؛ الثالثة/ تغذية الأسماك على عليق ذات ٢٥٪ محتوى بروتين من أصل نباتي (مسحوق الصويا)؛ والرابعة/ تغذية الأسماك على عليقة ذات ٣٢٪ محتوى بروتين من أصل نباتي (مسحوق الصويا). استمرت التجربة لمدة ١٧٥ يوم حتى الحصاد (تغذية طبيعية عن طريق التسميد لمدة ٧٠ يوم، ثم ١٠٥ يوم تغذية صناعية على العلائق المختبرة). أوضحت النتائج أن أداء البلطي تحسن بزيادة المحتوى من البروتين في العليقة سواء كان نباتي أو حيواني المصدر. أظهرت النتائج أن صافي الربح كان أفضل باستخدام العليقة ذات المحتوي المتوسط من البروتين (٢٥٪) عن كل من ذات المحتوى المنخفض والمرتفع حيث يمكن ترتيب المعاملات تنازلياً على أساس صافي الربح كالتالي: ٢٥٪ بروتين صويا > ٢٥٪ بروتين مسحوق سمك > ٣٢٪ بروتين صويا ثم ١٧٪ بروتين مسحوق سمك. وجد أن معايير جودة المياه في أحواض المعاملات الأربعة كانت، في أغلب الأحيان، ضمن المدى المفضل لأسماك المياه العذبة. هذه الدراسة أوضحت أنه يمكن إحلال مسحوق الصويا محل مسحوق السمك كمصدر للبروتين في علائق سمك البلطي النيلي دون تأثير سلبي على النمو والإنتاج الكلي وبمعدل ربحية أعلى في حالة استخدام عليقة تحتوي على ٢٥% بروتين من أصل نباتي (مسحوق الصويا).