Substituting De-hulled Soybean Meal for Fish Meal in Diets for Hybrid Tilapia Rearing in Water Re-circulating System

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Abstract

A feeding trial was conducted to evaluate the effect of replacing fish meal with de-hulled soybean meal in diets for pre-marketing size hybrid tilapia reared in a water re-circulating system. Hybrid tilapia with 155 g initial mean body weight were randomly assigned to 16 net pens that were placed in four quarters of a water re-circulating system. Four isonitrogenic and isocaloric diets were formulated to contain 0-20% fish meal (or 57-29% dehulled soybean meal) and fed to hybrid tilapia for 8 weeks. A randomized complete block design was used in the experiment. After 8 weeks feeding period, no significant difference ($P>0.05$) was found in percent weight gain (WG), feed conversion ratio (FCR), and protein efficiency ratio (PER) among fish fed different experimental diets. Muscle composition was not ($P>0.05$) influenced by the dietary treatments either. Feed utilization of large size fish in this trial, however, is somewhat better than the juvenile fish fed similar diets and reared in aquaria in a previous study. Large size hybrid tilapia may utilize de-hulled soybean meal better than juvenile fish.

Introduction

Tilapia is one of the major farmed fish species on the global scale. Among tilapia varieties, hybrid tilapia (*Oreochromis niloticus* × *O. aureus*) is the dominant one in Taiwan due to its fast growing rate. In Taiwan, there are two marketing-sizes for this fish. For domestic consumption, the marketing-size is about 600 g. For exporting fillet purpose, the marketing-size is approximately 1 kg. According to the Annual Fisheries Report published by the Council of Agriculture, the total production of cultured tilapia for 2003 was 85,351 tons. This would require approximately 128 thousand tons of feeds estimated by a feed conversion ratio of 1.5. From the economic point of view, it is beneficial to use as much low-cost protein as possible in animal diets. Experiments for replacement of fish meal with plant proteins in fish diets have been conducted with variable success for many fish species (Shiau et al., 1988; Gallagher, 1994; Webster et al., 1997; Adelizi et al., 1998; Xie and Jokumsen, 1998). Soybean meal is the most popular substitute for fish meal among plant sources. For hybrid tilapia, Shiau et al. (1987) has reported the effect of replacing fish meal with soybean meal on its growth. In a previous report (Wu et al., 2003), using de-hulled soybean meal (DSBM) to replace fish meal, we have demonstrated that the growth performance of juvenile hybrid tilapia was not significant different among fish fed diets containing some fish meal and the addition of methionine did not improve the growth. However, there is little information available regarding the use of DSBM in adult size of this species. DSBM (46% crude protein, 0.73% methionine, and 3.4% fiber) has the advantage of lower fiber and higher protein content than normal soybean meal (44% crude protein, 0.37% methionine, and 5.3% fiber). This property can be beneficial to the growth of tilapia. The success of incorporating these feed ingredients to replace fish meal in diets will certainly reduce the feed cost. Further, freshwater conservation is an important issue in the island of Taiwan. Rearing aquatic animals in water re-circulating system has been a key focus of both government and industry. The purpose of this study was to evaluate the efficiency of replacing some fish meal with DSBM in diets of pre-marketing size hybrid tilapia reared in a water re-circulating system.

Materials and methods

Pre-marketing hybrid tilapia (*Oreochromis niloticus* × *O. aureus*) were transferred from a fish farm in Chiayi County to our laboratory and reared in concrete ponds prior to the experiment. The control diet containing no fish meal was used to adjust the fish to the laboratory condition two weeks before the experiment. After the acclimation, hybrid tilapia with 155 g mean body weight were randomly assigned to 16 net pens of 10-12 fish per net in a water re-circulating system. A randomized complete block design (RCB) was used in this study. The net pens were placed in four blocks within the system. Four pens, randomly arranged within a block,

were assigned to each of the four test diets. Water temperature was between 25 and 29 °C throughout the experiment.

Four isonitrogenous, isocaloric diets containing 0, 29.2, 43, and 57% DSBM (20, 10, 5, and 0% fish meal) were formulated (Table 1). Proximate compositions of the diets, analyzed using methods of the Association of Official Analytical Chemists (1984), were 9-10% moisture, 28.3-29.9% crude protein, 5.7-6.1% crude lipid, and 6.6-9.8% ash. The ingredients were mixed in a multi-functional mixer and then stored in a -20°C freezer until the time of feed dough preparation. Water was added to the feed in a 1:2 (v/w) ratio to produce feed dough, divided to several portions, and fed to the fish.

The experimental fish were fed to apparent satiation twice a day at 9:00 and 17:00 for 8 weeks. Body weights were measured every 2 weeks. Growth performance indicators measured were weight gain (WG), feed conversion ratio (FCR), protein efficiency ratio (PER). These indicators were calculated as:
WG (%) = 100(final body weight - initial body weight)/initial body weight
FCR = dry feed intake/wet weight gain
PER = wet weight gain/protein intake

At the end of the experiment, after the final weighing, all fish were sacrificed. Fish muscle were ground and pooled according to the net pen for muscle proximate composition determination. Moisture, crude protein, and ash were determined following methods of the Association of Official Analytical Chemists (1984). Crude protein was determined by Kjeldhal procedure using Kjeltec System from Tecator, Sweden. Crude lipid was extracted using the method of Folch et al. (1957).

Experimental data were analyzed statistically by one-way analysis of variance (Steele and Torrie 1960) using SigmaStat statistical software from SPSS Inc. Duncan's new multiple comparison test was used to compare treatment means at 5 % probability level.

Results

Table 2 presents the percent weight gain (WG), feed efficiency ratio (FCR), and protein efficiency ratio (PER) of tilapia fed different test diets for 8 weeks. The survival was excellent. Only two fish died of non-diet related course. WG of tilapia fed diet containing no fish meal was not significantly ($P>0.05$) different among fish fed diets containing different level of DSBM. The average percent WG is about 80% (120-140 g per fish absolute weight gain). FCR ranged

from 1.17 to 1.29. PER ranged from 2.36 to 2.59. No significant difference (P>0.05) was found in FCR or PER among fish fed different test diets.

Muscle composition including moisture, crude protein, crude lipid, and ash content was not affected (P>0.05) by the level of DSBM in diets. However, the fish muscle from fish fed test diets for 8 weeks generally contains less moisture and higher crude protein than the original fish (Table 3).

Discussion

Unlike previous trial for juvenile tilapia (Wu et. al., 2003), growth performance of tilapia fed fish meal-free diet was the same (P > 0.05) as those fed diets containing fish meal in the present study. The major factors normally affecting the growth performance in fish meal replacing trial are quality of dietary protein and palatability of the diets. Although one previous report has indicated that the addition of methionine to a 32% protein diet in which 30% of the protein from fish meal was replaced by soybean meal, improved the WG of hybrid tilapia to similar level as fish fed all fish meal diet (Shiau, et al., 1987), we demonstrated that the protein quality of DSBM was not a problem for tilapia and the methionine supplementation was not necessary for this fish (Wu et. al., 2003)

We also suggested that the palatability of DSBM might have been the major factor affecting the low performance of fish meal-free diet in that study. However, in the present study, with pre-marketing size tilapia as the target animal and reared in a water re-circulating system, we found that total replacement of fish meal with DSBM did not impose any negative impact on feed consumption of our fish.

No significant difference on growth parameters such as WG, FCR or PER among fish fed diets containing 57 to 29% of DSBM (0 to 20% of fish meal). The feed consumption of fish fed diet with 100% substitution of DSBM for fish meal was similar to those fed diets containing fish meal. The fish meal-free (57% DSBM) diet in this study appeared to be palatable to large size tilapia. These results indicate that both the palatability and the quality of the protein in the diets were equally satisfactory for growth.

It should be noted that the FCR and PER (1.2 and 2.5) for pre-marketing size fish in the present study are better than those of the previous study (1.6 and 2.0) using juvenile fish as the target animal and reared in aquaria. Adult tilapia seems to be able to utilize DSBM more efficiently than juveniles. Further, the muscle of fish fed our experimental diets was high in

protein content compare to the original fish. This suggests that the diets for fish reared in commercial farm prior to this trial might contain less protein or lower protein quality ingredients than our test diets.

In the present study, based on growth performance and feed utilization data, a diet containing 57% DSBM (no fish meal) performed equally well as those fed diets containing 10 to 20% fish meal with great feed utilization.

Recommendations

For large hybrid tilapia (155 g) reared in a water re-circulating system, a diet containing DSBM as the major protein source achieved same growth performance and feed utilization as those fed fish meal-containing diets. Protein quality and palatability of DSBM appeared to satisfy the needs of pre-marketing size hybrid tilapia. DSBM should be able to totally replace fish meal in adult tilapia diets. Complaints from fish farmers due to feed color changes from dark to light may be another issue for feed producers to dealt with. Incorporating with small amount of other dark color ingredients such as blood meal may improve the color. However, the best solution is to educate the farmer that the diets formulated with DSBM are as good as those containing fish meal.

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Table 1. Feed formula of experiment

	Diet			
	D57	D50	D43	D29
Ingredient (%)				
Fish meal	0	5	10	20
Dehulled soybean meal	57	50	43	29.2
Wheat flour	10	10	10	10
α-Starch	18	19	21	24
Lipids[1]	5	4.5	4.0	3
α-Cellulose	3	4.5	5	6.8
Vitamin[2]	2	2	2	2
Mineral[3]	5	5	5	5

[1] Lipid source is a one to one mixture of menhaden fish oil and soybean oil.
[2] One kg vitamin premix contained 2,000,000 IU vitamin A, 400,000 IU vitamin D_3, 4 g vitamin K_3, 20 g α-tocopherol acetate, 5 g thiamin-HCl, 5 g riboflavin, 10 g calcium pantothenate, 20 g niacin, 0.6 g biotin, 4 g pyridoxine-HCl, 1.5 g folic acid, 10 mg B_{12}, 200 g inositol, 50 g ascorbyl-monophosphate-Mg, and 400 g choline chloride.
[3] One kg mineral premix contained 130.6 g calcium phosphate dibasic, 327 g calcium lactate, 29.7 g ferric citrate, 137 g magnesium sulfate, 239.8 g potassium phosphate dibasic, 87.2 g sodium phosphate dibasic, 43.5 g sodium chloride, 0.15 g aluminum chloride hexahydrate, 0.15 g potassium iodine, 0.1 g cupric chloride, 0.8 g manganese sulfate monohydrate, 1 g cobalt chloride hexahydrate, and 3 g zinc sulfate heptahydrate.

Table 2. Percent weight gain (WG), feed conversion ratio (FCR), and protein efficiency ratio (PER) of tilapia fed test diets for 8 weeks.

	WG (%)	FCR	PER
D57	79±3	1.23±0.02	2.53±0.04
D50	91±8	1.18±0.03	2.59±0.14
D43	69±6	1.29±0.02	2.36±0.04
D29	85±4	1.22±0.03	2.50±0.07

There is no significant difference among treatment means±SE ($P>0.05$). Survival is 97-100%.

Table 3. Muscle composition (%) of tilapia fed test diets for 8 weeks.

	Moisture	Crude protein	Crude lipid	Ash
D57	75.1±0.2	22.7±0.2	0.8±0.2	1.32±0.02
D50	75.7±0.1	22.7±0.3	1.4±0.2	1.31±0.01
D43	75.5±0.4	21.2±1.2	1.3±0.1	1.28±0.01
D29	75.4±0.2	23.2±0.1	1.3±0.2	1.34±0.02

There is no significant difference among treatment means±SE ($P>0.05$). Original fish muscle contains 79.3% moisture, 19.1% crude protein, 1.11% ash, and 1.6% crude lipid.