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Effect of Replacing Fish Meal with Soybean Meal on Growth, Feed Utilization and Carcass Composition of Striped Catfish *Pangasius hypopthalmus*

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Abstract

Indra Suharman, Amararatne Yakupitiyage, C Kwei Lin and Peter Edwards. 2010. Effect of replacing fish meal with soybean meal on growth, feed utilization and carcass composition of striped catfish *Pangasius hypopthalmus. Aquacultura Indonesiana, 11 (2): 113–118.* The effect of replacing fish meal with soybean meal (SBM) in practical feeds for striped catfish *Pangasius hypopthalmus* was evaluated in an 8 week cage installed in the earthen ponds. The striped catfish fingerlings (initial body weight 11.1 g/fish) were fed six isonitrogenous feeds containing approximately 32% crude protein. The control feed was formulated to contain 50% fish meal, whereas in the other five feeds SBM was included at 40.0, 46.0, 53.0, 58.0 and 65% to replace 60, 70, 80, 90 or 100% of the fish meal. There were no significant differences in weight gain (WG), specific growth rate (SGR) and feed conversion ratio (FCR) between fish fed the control feed and fed in which SBM replaced 60% of the fish meal, but was higher than fish fed the feeds in which SBM replaced 70 to 100% of the fish meal. No significant differences in carcass protein, lipid and ash content was found among the treatments, but fish fed the feed in which SBM replaced 100% of the fish meal had higher moisture content in carcass than those of fish fed the control feed. Results of the present study appear to indicate that striped catfish has a limited ability to utilize SBM as a protein source in practical feeds.

Keywords: Diet, Evaluation, Fish meal, Growth, *Pangasius hypopthalmus*, Soybean meal

Substitusi tepung ikan dengan tepu[illegible] telah dilakukan untuk mengetahui respon pakan terhadap pertumbuhan ikan Jambal siam *Pangasius hypopthalmus*. Ikan uji (rata-rata 11,1 g/ekor) diberi pakan yang mengandung tepung kedelai 40%, 46%, 53%, 58% [illegible] sebagai pengganti tepung ikan sebesar 60%, 70%, 80%, 90% atau 100%. Sebagai pakan kontrol adalah pakan yang mengandung 100% tepung ikan. Pakan diberikan dua kali sehari sebesar 5% dari total bobot tubuh ikan selama masa pemeliharaan 8 minggu di keramba jaring apung berukuran 1x1x1,2 m^3. Hasil penelitian menunjukkan bahwa penggantian tepung ikan dengan tepung kedelai sampai 60% atau setara dengan 20% protein tepung ikan tidak berpengaruh nyata bila dibandingkan dengan perlakuan kontrol terhadap hasil pertambahan bobot, laju pertumbuhan harian dan rasio konversi pakan, tetapi lebih baik bila dibandingkan dengan perlakuan lainnya. Ikan Jambal siam mempunyai kemampuan terbatas untuk memanfaatkan tepung kedelai sebagai sumber protein dalam pakan. Diduga tepung kedelai cukup memadai sebagai substitusi tepung ikan dengan level substitusi kurang lebih 60% (20% protein tepung ikan) dalam pakan untuk memacu pertumbuhan ikan Jambal siam.

Kata kunci: Pakan, Evaluasi, Tepung ikan, Pertumbuhan, *Pangasius hypopthalmus*, Tepung kedelai

Introduction

Fish meal has been the protein source of choice in aqua feeds for many reasons, including its high protein content, excellent amino acid profile and high nutrient digestibility (Gatlin III *et al*., 2007), but costly protein source for fish feed formulation, and is generally incorporated at 50% in commercial feeds for carnivorous fish species (Hertrampf and Pascual, 2000). Reducing fish meal level is key to reducing feed cost for commercial fish farming and ensuring sustainability of this enterprise. It is essential to evaluate the suitability of alternate plant protein meal as dietary protein sources for freshwater carnivorous fish species. Soybean meal (SBM) is one of the most nutritious of all plant protein source (Lovell, 1988). SBM is a widely available, economical protein source with relatively high digestible protein and energy contents and good amino acid profile (Hertrampf and Pascual, 2000). The use of soybean proteins as a dietary protein has been examined for many commercial important fish species, such as rainbow trout (Dabrowski *et al.*, 1989; Pongmaneerat and Watanabe, 1992; Kaushik *et al.*, 1995; Bureau *et al.*, 1998), channel catfish (Wilson and Poe, 1985; Webster *et al.*, 1992), tilapia (Shiau *et al.*, 1989), Atlantic salmon (Refstie *et al.*, 1998) and Asian sea bass (Boonyaratpalin *et al.*, 1998; Tantikitti *et al.*, 2005).

Pangasius hypopthalmus is commonly known as Thai catfish or Striped catfish, which belongs to family Pangasid catfish. Among the various species of cultivable catfishes, Thai catfish is particularly well known for its good taste, faster growth rate, easy culture system, high disease resistance, tolerance of wide ranges of environmental parameters and high market demand.

Feed cost is generally the major operating cost of rearing fish in semi-intensive aquaculture system, especially dietary protein supplied by fish meal. Feeding raw fish results in high feed costs and a high amount of nitrogenous waste. Feed formulae that have high nutritive value, are cost effective, and produce less waste outputs are needed to improve economical and environmental sustainability of Thai catfish culture. Knowledge concerning fish meal replacement by SBM for Pangasids catfish is still limited. The present study aimed at evaluating the effect of replacing fish meal with SBM on growth, feed utilization and carcass composition of Thai catfish reared in net cages.

Materials and Methods

Experimental Diets

Experimental diets were based on proximate analysis of ingredients (Table 1). Six isonitrogenous (containing about 32% crude protein) experimental diets were formulated; proximate analysis of the diets is given in Table 2. The experimental diets were formulated to produce diets in which 0% (D1/control), 60% (D2), 70% (D3), 80% (D4), 90% (D5), and 100% (D6) of proteins from fish meal were

Table 1. Proximate composition of the ingredients (% of dry matter basis).

Ingredient	Moisture	Crude protein	Crude lipid	Crude fiber	Ash	NFE
Fish meal	11.6	55.7	8.6	2.4	30.3	3.0
Soybean meal (SBM)	11.0	43.0	5.9	8.3	8.3	34.5
Rice bran	9.7	13.4	10.3	11.5	12.7	52.1
Corn meal	10.8	8.5	3.5	2.1	1.7	84.2
Cassava meal	10.7	1.9	0.4	0.1	0.0	97.6

NFE = 100 – (% Crude protein + Crude lipid + Fiber + Ash)

Table 2. Formulation and proximate analysis of the experim[illegible] diet).

Replacement of fish meal (%)	0	60	[illegible]	80	90	100
	Diets					
Ingredients (%)	D1 (control)	D2	D3	D4	D5	D6
Fish meal	50.0	20.0	15.0	10.0	5.0	0.0
Soybean meal (SBM)	0.0	40.0	46.0	53.0	58.0	65.0
Corn meal	10.0	10.0	10.0	10.0	10.0	10.0
Rice bran	10.0	10.0	10.0	10.0	10.0	10.0
Cassava starch	28.0	18.0	17.0	15.0	15.0	13.0
Vitamin premix	1.0	1.0	1.0	1.0	1.0	1.0
Mineral premix	1.0	1.0	1.0	1.0	1.0	1.0
Proximate composition						
Moisture	8.0	10.6	14.2	12.4	12.9	9.4
Crude protein	31.6	30.3	30.2	30.0	30.1	29.3
Crude lipid	9.8	7.3	7.5	5.8	4.5	3.4
Crude fiber	2.8	5.1	4.0	4.5	4.1	4.6
Ash	14.6	8.6	7.3	7.0	6.4	6.6
NFE	41.2	48.7	51.0	52.7	54.9	56.1

replaced with that from SBM. The diets were prepared by weighing the proportion of ingredient separately. All of the dry ingredients were thoroughly mixed until homogenous in a A-200 Hobart-type mixer, and then water was added and thoroughly mixed. Next, 2.0 mm diameter pellets were wet-extruded, dried in oven at 40°C, and sealed in vacuum-packed plastic bags and kept in refrigerated at 4°C until use. Samples of experimental diets were analyzed for crude protein, crude lipid, crude fibre, ash and moisture contents (AOAC, 1990).

Fish, Rearing Conditions, and Feeding

An 8-weeks feeding trial was carried out in net cages installed in earthen ponds at the Aquaculture Research facilities, Asian Institute of Technology, Thailand. Thai catfish (*P. hypopthalmus*) fingerlings were obtained from a local Thai catfish breeding farm. Prior to the start of the feeding trial, fish were acclimated to the experimental conditions and fed a commercial diet for two weeks. At the beginning of the feeding trial, fish (initial weight 11.1 g) were weighed and stocked in cages at stocking density of 10 fish per cage. Ten fish were collected from the remaining acclimated fish for the determination of initial carcass composition. Three replicate groups of fish were used for each diet. Experimental diets were assigned to each cage and each group of fish was fed at 5% body weight per day in two equal portions at 0800-0900 and 1700-1800 h. The diets were placed in feeding trays which were suspended in the column water. All fish were individually weighed from each cage every 14 days and batch weighed and the amount of feed was adjusted accordingly.

Final Sampling and Chemical Analysis

Prior to final weighing and sampling for chemical analysis, fish were starved for 24 h. At the termination of the experiment, five fish from each cage were randomly collected for proximate analysis. Fish were sacrificed by keeping in plastic box. Fish carcass samples were analysed for crude protein, crude lipid, ash, and moisture contents according to the methods described by the Association of Official Analytical Chemists (AOAC, 1990). Moisture content was measured by drying samples at 105°C to constant weight in an oven. Crude protein was determined indirectly by measuring the total nitrogen by the standard Kjeldahl method modified from Yoshida multiplied by an empirical factor of 6.25. Crude lipid was determined using Soxhlet apparatus (Tecator Soxtex System HT2 1045) with using petroleum ether and ash by heating at 550°C for 8 h in muffle furnace.

Calculation of Fish Performance and Statistical Analysis

Weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were calculated as follows:

Weight gain (WG) (g) = mean final weight (FW) (g) - mean initial weight (IW) (g).

Specific growth rate (SGR) (% body weight/day) = [(ln FW (g) – ln IW (g))/duration of feeding trial (days)] × 100.

Feed conversion ratio (FCR) (g/g) = Feed intake (g)/WG (g).

Protein efficiency ratio (PER) (g/g) = WG (g)/protein intake (g).

Table 3. Growth performance and nutrient utilization of *P. hypopthalmus* fed experimental diets for 8 weeks[1].

	Diet					
	D1 (control)	D2	D3	D4	D5	D6
Initial weight (g/fish)	10.9±0.97 ^{ab}	11.3±0.39 ^{b}	11.4±0.62 ^{b}	11.1±0.26 ^{ab}	11.8±0.22 ^{b}	10.3±0.29 ^{b}
Final weight (g/fish)	60.0±11.3 ^{c}	46.9±5.58 ^{b}	31.6±5.94 ^{a}	30.8±3.81 ^{a}	29.1±2.76 ^{a}	27.5±4.18 ^{a}
Weight gain (g/fish)	49.1±10.4 ^{c}	35.6±5.29 ^{b}	20.2±5.44 ^{a}	19.7±4.05 ^{a}	17.3±2.93 ^{a}	17.2±3.98 ^{a}
SGR (%/day)	3.03±0.21 ^{b}	2.53±0.17 ^{b}	1.80±0.27 ^{a}	1.82±0.27 ^{a}	1.61±0.19 ^{a}	1.74±0.24 ^{a}
FCR	1.33±0.14 ^{a}	1.55±0.05 ^{a}	2.31±0.18 ^{b}	2.32±0.31 ^{b}	2.51±0.09 ^{b}	2.48±0.29 ^{b}
PER	2.40±0.21 ^{b}	2.12±0.07 ^{b}	1.44±0.12 ^{a}	1.51±0.23 ^{a}	1.42±0.05 ^{a}	1.39±0.17 ^{a}
ANPU (%)	31.3±3.26 ^{b}	27.6±2.64 ^{b}	18.1±3.75 ^{a}	18.5±0.40 ^{a}	16.5±1.03 ^{a}	12.3±2.61 ^{a}
Survival rate (%)	96.7	100.0	96.7	100.0	100.0	100.0

[1] Data are mean values of three replicates. Values are mean ± SD. Means within a row having different superscripts were significantly different ($P<0.05$).

Apparent net protein utilization (ANPU) (%) = [(Fish final body protein) – (Fish initial body protein)]/(protein intake) x 100.

Data were analyzed by one-way analysis of variance (ANOVA) using SPSS (release 7.5 for window). The LSD's multiple-range test was used to determine the differences among means (Steel and Torrie, 1980). The level of significance was chosen at (P<0.05) and the results are presented as means ± standard deviation of the mean (SD).

Results and Discussion

Results

Growth performance and feed utilization

Weight gain (WG) response and feed performance data of *P. hypopthalmus* fed diets containing different percentages of SBM and fish meal are shown in Table 3. Survival of fish was greater than 96% and not affected by feed composition. WG linearly declined with the decrease of fish meal inclusion level. Specific growth rate (SGR) in fish fed the control diet was significantly different from fish fed the diets in which SBM replaced 60 to 100% of the fish meal (P<0.05). Fish fed the control diet had lower FCR than fish fed the diets in which SBM replaced 60 to 100% of the fish meal (P<0.05). Protein efficiency ratio (PER) in fish fed the control diet was not significantly different from fish fed the diet in which SBM replaced 60% of the fish meal, but was higher than fish fed the diets in which SBM replaced 70 to 100% of the fish meal (P<0.05). Similarly, apparent net protein utilization (ANPU) in fish fed the control diet was not significantly different from fish fed the diet in which SBM replaced 60% of fish meal, but was higher than fish fed the diets in which SBM replaced 70 to 100% of the fish meal (P<0.05).

Carcass composition

There was no significant difference in carcass protein content among fish fed the different diets (P<0.05, Table 4). Fish fed the control diet had lower carcass moisture and lipid content than those of fish fed the diets in which 60 to 100% of the fish meal was replaced (P<0.05). Fish fed the diets in which SBM replaced 60 to 100% of fish meal had higher carcass content than that of fish fed the control diet (P<0.05).

Discussion

The results of the present study indicate that SBM could be incorporated in diets for juvenile Thai catfish up to a level 40%, which would replace 60% of the protein of fish meal, without having a significant negative effect on growth or feed utilization. The WG, SGR, PER and ANPU of Thai catfish fed diets in which all of fish meal was replaced by SBM were significantly lower than those in the other dietary groups, including the control; this findings indicates that Thai catfish cannot be cultured successfully using a diet containing SBM as the single protein source. These findings agree with the results obtained by Shimeno *et al.* (1993) reported that yellowtail (marine [illegible] fish) showed reduced growth and feed [illegible] of fish meal protein replacement [illegible] was greater than 20%. Juvenile [illegible] Japanese flounder were shown to [illegible] of the protein from fish meal [illegible] SBM up to 50% (Reigh and Ellis, 1992) and 45% (Kikuchi, 1999).

The poor growth and feed utilization of fish fed the feeds containing high level of SBM protein may be due to the presence of anti-nutritional factors (Wilson and Poe, 1985; Bureau *et al.*, 1998 and Refsties *et al.*, 1998), low protein digestibility

Table 4. Whole-body composition (% wet weight) of *P. hypopthalmus* fed experimental diets for 8 weeks[1].

	Diet					
	Control	D1	D2	D3	D4	D5
Moisture	72.4±2.03[a]	72.5±1.50[a]	73.5±1.89[ab]	73.1±2.07[ab]	75.3±1.72[bc]	76.6±0.92[c]
Crude protein	49.8±1.53[a]	49.8±1.15[a]	51.3±4.47[a]	49.2±1.56[a]	53.8±0.86[a]	51.1±4.28[a]
Crude lipid	26.3±1.09[a]	29.7±0.38[b]	28.6±1.04[ab]	29.6±2.36[b]	29.0±1.14[b]	28.5±1.76[ab]
Ash	11.7±0.21[a]	12.8±1.19[a]	13.0±1.45[a]	12.0±0.70[a]	11.8±0.93[a]	12.1±1.09[a]

[1] Data are mean values of three replicates. Values are mean ± SD. Means within a row having different superscripts were significantly different (P<0.05).

(Refsties *et al*., 1998), and essential amino acid deficiency (Chong *et al*., 2003 and Tantikitti *et al*., 2005) in the SBM feeds. The SBM used in the present study was a widely used commercial product without any additional treatment. Protein digestibility of the test diets was not measured in the feeding trial, thus we could not evaluate the effects of anti-nutritional factors and protein digestibility from inclusion SBM on growth and feed utilization of *P. hypopthalmus*. Methionine is generally the limiting amino acid of SBM (Hertrampf and Pascual, 2000), and methionine deficiency of SBM feeds has been observed in other studies (Chong *et al*., 2003 and Chou *et al*., 2004). In the present study, methionine was not added in the test diets. Therefore, it is presumed that methionine deficiency may be one of the reasons responsible for low growth performance and poor feed utilization of *P. hypopthalmus* fed the diets that contain high levels of SBM.

Moisture and lipid content usually vary inversely in fish flesh, while the protein is more constant (Belal and Assem, 1995). In this study, carcass moisture content increased and carcass lipid decreased with increasing dietary SBM as has been reported for channel catfish (Mohsen and Lovell, 1990), Atlantic salmon (Olli *et al*., 1995), Japanese flounder (Kikuchi *et al*., 1994), and Asian sea bass (Tantikitti *et al*., 2005). Lower carcass lipid content and high moisture and ash contents of fish fed the diets in which SBM was included to replace the fish meal, in the present study, is attributed to the reduced growth of these fish. The lower carcass lipid content of fish fed the SBM-based diet is responsible for the highest feed intake of the fish, because feed intake of fish regulated by their body lipid storage.

Conclusion

This study demonstrates that SBM may be used as a source of protein in combination with the fish meal in the diet for juvenile *P. hypopthalmus*. The results of this experiment suggest that a diet containing 32% crude protein with 20% fish meal and 40% SBM in the diet was adequate for normal growth in *P. hypopthalmus*. It is recommended that further evaluation of SBM and other soybean product in high percentages in diets supplemented with amino acids or other protein sources on growth of *P. hypopthalmus* should be conducted in the future.

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