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Utilization of Shrimp Shell Substitute Soybean for Hybrid Catfish (*Clarias macrocephalus* × *Clarias gariepinus*) Diet

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The objective was to investigate the effects of shrimp shell-powder inclusion and treatment on growth of Hybrid Catfish (*Clarias macrocephalus* × *Clarias gariepinus*). The 225 individuals Hybrid Catfish (11.19 ± 0.38 cm body length and 8.36 ± 0.61 g body weight) were fed with five practical diets containing 39% of crude protein for 45 days. Diet 1 was a control diet containing 100% soybean meal. Diet 2 -5 contained 25%, 50%, 75% and 100% shrimp shell powder substituted to soybean meal. Post experiment, fish growth (weight gain, length gain and average daily gain) did not show any significant differences ($p > 0.05$) between the treatments. Meanwhile, feed conversion ratio (FCR) and survival rate also showed the non-significant differences ($p > 0.05$) among treatments. The present study indicates that shrimp shell powder may be included in the hybrid catfish diet, up to 75% as a substitute for soybean meal without detrimental effects.

Keywords: Hybrid catfish, shrimp shell powder, diet, soybean meal replacement

Introduction

Among numerous protean sources, protein derived from aquatic animals such as fish are relatively cheap compared to other animal foods. They, also, have low cholesterol, high nutritional value and are easily digested. Fish protein comes from two sources, freshwater and marine environment. Currently, production from the wild, both freshwater and marine environment, have decreased due to various reasons such as the over exploitation and environment degradation. The decreased production from the wild has resulted aquaculture businesses rapidly growth and become to an important activity supporting economic growth and community development sector across numerous country worldwide (Panayotou *et al.*, 1982; Lin and Dian, 1995; Ungsethapan *et al.*, 2012).

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In aquaculture aspect, freshwater fish are now widely adopted and can be produced for most of the year. Among the numerous fresh water fishes in the tropical zone, Hybrid Catfish (*Clarias macrocephalus* × *Clarias gariepinus*) is an important target species for rearing in Southeast Asia, especially in Thailand (Yi *et al.*, 2001; Yi *et al.*, 2003; Plaipetch, 2014). Hybrid Catfish are produced from crossbreeding between Giant Catfish, *Clarias gariepinus*, and Broadhead catfish, *Clarias macrocephalus*. Hybrid catfish show good growth characteristics for aquaculture and their meat is also desirable (Plaipetch, 2014). They are also grown in many environmental conditions and are tolerant to parasites and disease.

From the farmer's point of view, the main consideration for selection of a fish feed is currently focused for increasing fish growth at a low cost. Thus, using inexpensive material in substitution of expensive material can help farmers reduce feed costs and, at the same time, maintain the nutritional value of fish feed. Currently, shrimp shell, is a by-product from shrimp processing (Meyers and Rutledge, 1971), that can be used in many ways, such as food for chicken, duck, etc (Rosenfeld *et al.*, 1997; Islam, *et al.*, 1994; Gernat, 2001; Fanimo *et al.*, 2004; Khempaka *et al.*, 2006). Shrimp shell contains chitin and chitosan, which are also nutritionally useful in many aspects (Collins and Gibson, 1999; Chen *et al.*, 2002; Okawa *et al.*, 2003). Shrimp shell also contains high protein content and minerals (Fanimo *et al.*, 1996; Rosenfeld *et al.*, 1997; Gernat, 2001; Fanimo *et al.*, 2004; Oduguwa *et al.*, 2004; Ojewola and Udom, 2005; Okoye *et al.*, 2005; Fanimo *et al.*, 2006; Khempaka, *et al.*, 2006; Ingweye *et al.*, 2008; Mahata *et al.*, 2008) that are suitable for aquaculture feed production. Most importantly, shrimp shell is cheap and readily available in Thailand.

In this study, an experiment was set, to investigate the possibility of using shrimp shells-powder as an alternative protein source material in Hybrid Catfish diet. We compared fish growth, feed conversion ratio and survival rate of Hybrid Catfish cultured with soybean meal substitution with different levels of shrimp shells powder. We also determined the optimum proportion of shrimp shells powder in the mixture of catfish hybrids diet.

Materials and methods

Experimental Diets

Five diets were formulated to contain various percentages of shrimp shell-powder as partial replacement of soybean meal. All diets contained around 39% protein. Diet 1 with 25% soybean meal served as the control. Diets 2-5 contained 6%, 12.5%, 19% and 25% shrimp shell powder and 19%, 12.5%,

6% and 0% soybean meal respectively, with ratio of shrimp shell powder to soybean meal, 25%, 50%, 75% and 100% respectively (table 1).

Table 1. Composition and proximate analysis of experiment diets

Ingredient (g/100g)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	% Shrimp shell powder replacement				
	0	25	50	75	100
Shrimp shell powder	0	6	12.5	19	25
Fish meal	45	45	45	45	45
Soybean meal	25	19	12.5	6	0
Broken milled rice	4	4	4	4	4
Rice bran	20	20	20	20	20
Binder	2	2	2	2	2
Plant oil	2	2	2	2	2
Vitamin mix ¹	1	1	1	1	1
Mineral mix ²	1	1	1	1	1
Proximate composition analysed					
Crude protein (%)	39.16	39.43	39.57	39.70	39.97
Crude lipid (%)	3.38	3.54	3.63	3.71	3.87
Ash (%)	15.15	17.11	18.10	19.09	21.04

¹/Vitamin premix (mg/diet 1 kg) : Thiamine (B1) 10; Riboflavin (B2) 20; Pyridoxine (B6) 10; Cobalamin (B12) 2; Retinal (A) 4; Cholecalciferol (D3) 0.4; Phylloquinone (K1) 80; Folic acid 5; Calcium pantothenate 40; Inositol 400; Niacin 150; Tocopherol (E) 60; Choline 6,000; Ascorbic acid (C) 500; Cellulose 2,718.6

²/Mineral premix (g/diet 1 kg) : NaCl 0.25; MgO 1.1; KCl 4; Ca(H₂PO₄)₂ 9; FeSO₄ 0.72; Calcium lactate 0.88; ZnSO₄·7H₂O 0.088; MnSO₄·7H₂O 0.04; CuSO₄·5H₂O 0.088; CoSO₄ 0.0002; KI 0.0008; cellulose 1.183

Experiment procedure

Two hundred and twenty five individuals juveniles Hybrid Catfish (age 30 days, with average 11.19 ± 0.38 cm body length and 8.36 ± 0.61 g body weight) were stocked in the experiment cages (60×60×60 cm³) for 5 days before the beginning of the experiment regime, in order to condition the fish to the experiment system and handling procedures. At the start of the growth trial, uniform-sized fish were randomly distributed into 15 cages (15 fishes per cages), with 5 treatment (diets) and three replicates. Continuous aeration was provided to each cage through air stone connected to a central air compressor. Water quality parameters (i.e. water temperature, pH, Ammonia (NH₃N) and the nitrite (NO₂N)) were measured every 15 days.

Sampling Procedure and data analysis

The experiment was continued for 45 days. At the end of experiment, fish from each cage were collected, measured (nearest 0.1 cm) and weighed (nearest 0.1 g). The data obtained were analyzed for weight gain, length gain, average daily gain (ADG), feed conversion ratio (FCR) and survival rate (SR) using following formula:

$$\text{Weight gain} = \text{final weight}(g) - \text{ininitial weight}(g)$$

$$\text{Length gain} = \text{final length}(cm) - \text{ininitial length}(cm)$$

$$\text{Average daily gain} = \frac{\text{final weight}(g) - \text{ininitial weight}(g)}{\text{period of the experiment}(\text{day})}$$

$$\text{feed conversion ratio} = \frac{\text{Dry feed consumed}(g)}{\text{Wet weight gain}(g)}$$

$$\text{Survival rate} = \frac{\text{Number of survival fishes}}{\text{Total number of fishes}}$$

Each parameter was analyzed by one-way analysis of variance (ANOVA). Duncan's New Multiple Range Test (DMRT) was used to compare differences among means. The level of significance was at $p < 0.05$ and the results are presented as means $\pm$ standard deviation of mean. All data analyses were conducted by R Program (R Development Core Team, 2012).

Results

After 45 days, weight gain, length gain and average daily gain (ADG) are detailed in table 2. Among the treatments, all parameters did not show the significant difference ($p > 0.05$). In addition, average daily gains (ADG) of Hybrid Catfish fed with diet 4-5 were slightly high when compaired among treatments (i.e. diets). The feed conversion ratio (FCR) ranged from 2.03 (diet 4) to 2.50 (diet 5) and showed non- significant differences ($p > 0.05$) among treatments. The survial rates ranged from 80% (diet 1) to 89% (diet 4) (table 2).

For water quality results, during the experimental period, the water temperature varied between 29-30 °C and the pH ranged from 7.5-8.7. Ammonia (NH₃N) ranged from 0.5 - 0.25 mg/l and the nitrite (NO₂N) below 0.1 mg/l. All water quality parameters were within range for Hybrid Catfish culture.

The diet costs were 21.74, 21.40, 20.54, 19.94 and 19.34 THB/kg for diet 1,2,3,4 and 5 respectively. The result showed that, when increasing used shrimp shell-power proportion in diets, the cost of the diet also decreased.

Table 2. Mean initial body length and weight, final length and weight, Length and weight gain, average daily gain (SGR), feed conversion ratios (FCR) and survival rates of Hybrid Catfish fed with test diets containing different ratios of shrimp shell powder for 45 days

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	% Shrimp shell powder replacement				
	0	25	50	75	100
Initial length (cm/fish)	11.23±0.53 ^{ns}	11.21±0.35 ^{ns}	11.17±0.36 ^{ns}	11.18±0.31 ^{ns}	11.17±0.36 ^{ns}
Initial weight (g/fish)	8.64±0.80 ^{ns}	8.37±0.61 ^{ns}	8.24±0.58 ^{ns}	8.25±0.43 ^{ns}	8.28±0.57 ^{ns}
Final length (cm/fish)	23.47±2.72 ^{ns}	24.33±1.11 ^{ns}	24.13±1.64 ^{ns}	24.23±1.61 ^{ns}	23.70±2.36 ^{ns}
Final weight (g/fish)	139.51±45.22 ^{ns}	131.28±20.46 ^{ns}	130.34±19.89 ^{ns}	144.13±31.97 ^{ns}	141.48±35.03 ^{ns}
Length gain (cm/fish)	12.24±2.72 ^{ns}	13.12±1.11 ^{ns}	12.96±1.64 ^{ns}	13.05±1.61 ^{ns}	12.53±2.36 ^{ns}
Weight gain (g/fish)	130.91±45.22 ^{ns}	122.91±20.46 ^{ns}	122.10±19.89 ^{ns}	135.88±31.97 ^{ns}	133.20±35.03 ^{ns}
ADG	2.91±1.01 ^{ns}	2.73±0.46 ^{ns}	2.72±0.44 ^{ns}	3.02±0.71 ^{ns}	2.96±0.78 ^{ns}
FCR	2.25±0.70 ^{ns}	2.18±0.30 ^{ns}	2.18±0.32 ^{ns}	2.03±0.44 ^{ns}	2.50±0.79 ^{ns}
Survival rate (%)	80.00	82.22	84.44	88.89	86.67

^{1/} Data are mean ± SD values of all individuals in each treatment.

^{2/} Means within a row having “^{ns}” were non-statistical significantly different ($p>0.05$)

Discussion

The results from this study showed that the replacement of soy bean meal with shrimp shell-powder from 25% (diet 2) up to 100 % (diet 5) did not affect the growth rate of Hybrid Catfish when compared all growth parameters with the control diet (diet 1). The results imply that shrimp shell-powder can be used as a ingredient in Hybrid Catfish diet, which is agree with results obtained from several species such as Red Tilapia (Chimsumg *et al.*, 2006) and Channel Catfish (Robinette *et al.*, 2011).

Many studies also reported the high level of protein, mimeral, n-3 fatty acids, cholesterol and astaxanthin were found in shrimp by-products (Fanimio *et al.*, 1996; Rosenfeld *et al.*, 1997; Lovell, 1998; Hertrampf and Piedad-Pascual,

2000; Gernat, 2001; Fanimo *et al.*, 2004; Oduguwa *et al.*, 2004; Ojewola and Udom, 2005; Okoye *et al.*, 2005; Fanimo *et al.*, 2006; Khempaka, *et al.*, 2006; Ingweye *et al.*, 2008; Mahata *et al.*, 2008). For the protein, shrimp by-product were reported contain up to 40% of protein but the real protein value should be lower than 40%, because of 10-15 % of nitrogen in shrimp by-product was chitin, β -(1 $\rightarrow$ 4)-N-acetyl-D-glucosamine (Lovell, 1998). The increasing chitin level in fish diet can be decrease dry matter digestibility and lipid digestibility of fishes (Shiau and Yu, 1999) and consequently decreased fish growth. Thus, the optimum level of shrimp by-products used in fish diet was approximately 20% for carnivorous fishes and 10% for omnivorous and herbivorous fishes (Hertrampf and Piedad-Pascual, 2000), agree with this present results, the diet 3 which contains 19% shrimp shell-powder showed the highest average daily gain (ADG) and survival rate, meanwhile the lowest feed conversion ratio (FCR) were found, table 2. The results suggest that the replacement soy bean meal with shrimp shell-powder in Hybrid Catfish can be up to around 75%.

The cost of soy bean meal in Thailand was around 13-21 THB/kg and was contained at least 25% in Hybrid fish diet, and, that increasing the cost of Hybrid Catfish diet up to around 21.74 THB/kg. Meanwhile, the raw shrimp shell showed the cost around 5 THB/kg in Eastern region of Thailand, lower than soy bean meal. The replacement soy bean meal with shrimp shell-powder in Hybrid Catfish up to around 75% can be decrease the cost of Hybrid Catfish diet down to around 19.94 THB/kg. The decrease rate was calculated approximately 8% lower than the control Diet cost.

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