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Replacement of soybean meal with *Moringa oleifera* leaf meal in the formulated diets of tilapia (*Oreochromis niloticus*) fingerlings

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Abstract. The objective of the present study was to evaluate the optimum composition of *Moringa oleifera* leaf meal for partial replacement of soybean meal in the formulated diets of tilapia (*Oreochromis niloticus*) fingerlings. A completely randomized design with five treatments of *Moringa* meal composition (0, 8, 16, 24 and 32%) was utilized in this study. The formulated diets had 32% crude protein content. The fingerlings were fed 5% of their body weight three times a day at 8 AM, 12 PM, and 5 PM for 30 days. The ANOVA test showed that the composition of *Moringa* meal in the diets of the tilapia fingerlings did not have a significant effect on growth performance, survival rate, feed conversion ratio or feed efficiency. This indicates that the result obtained with a diet composed of *Moringa* meal were not significantly different from when the diet was composed of soybean meal. Therefore, soybean meal is replaceable with *Moringa* meal and the recommended compositionis 16-32%.
Key Words: soybean meal, plant protein, aquaculture, fish diet.

Introduction. Fish diet must be high in nutrients, in particular crude protein. Plant protein sources including soybean meal, cottonseed meal, groundnut meal, sunflower seed, rapeseed, sesame seed, copra, macadamia nut, and palm kernel have been investigated for fish diets (Ogunji 2004; El-Sayed 1999; El-Sayed & Tacon 1997), especially for herbivorous and omnivorous fish as displayed in tilapia, *Oreochromis niloticus*. Soybean meal is considered the most nutritious plant ingredient in terms of protein, and is widely used in fish diet (Swick et al 1995), but the high cost of this raw material, especially in Indonesia, has caused problems for farmers of tilapia culture. Therefore, study of alternative plant protein sources for fish diets is important in order to reduce dependence on soybean meal.

This study considers *Moringa oleifera* leaf meal as a plant protein source in the formulated diets of tilapia fingerlings. This plant protein source is not only considerably cheaper than soybean meal but also available in abundance in almost all areas in Indonesia. *Moringa* is an aboriginal plant of the Indian subcontinent and has become naturalized in tropical and subtropical areas around the world (Farooq et al 2012). The protein content of *Moringa* meal analyzed in this study is approximately 29.2% (Bello & Nzeh 2013) reported that the addition of *Moriga* meal (0-50%) into the formulated diets of catfish increased the specific growth rate up to 1.15%. Therefore, *Moringa* was promising as an alternative plant protein source as a feed ingredient for tilapia fingerlings. Hence, the objective of the present study was to evaluate the optimum composition of *Moringa* meal for partial replacement of soybean meal in the formulated diets of tilapia fingerlings.

Material and Method

Experimental design. A completely randomized design was utilized in this study. Five concentrations of *Moringa* leaf meal (MLM) in the diet were tested i.e. 0% (A), 8% (B), 16% (C), 24% (D), and 32% (E), and every treatment was done in three replicates. The MLM was mixed with soybean meal, fish meal, fine brand, vitamins and minerals homogenously in a mixer and then finally corn oil were added and mixed together and made into dough by added the water gradually. The formulated diet has approximately 32% cure protein (Table 1).

Table 1

The composition of experimental diets fed to *Oreochromis niloticus* (%). The feed contained 32% crude protein

Ingredients	*Diet composition (%)*				
	A	*B*	*C*	*D*	*E*
Moringa meal (29.2% crude protein)*	0	8	16	24	32
Soybean meal (44% crude protein)**	32	24	16	8	0
Fish meal (50% crude protein)**	30	33	36	39	42
Fine bran (7.6% crude protein)***	35	32	29	26	23
Vitamins mix	1	1	1	1	1
Mineral mix	1	1	1	1	1
Corn oil	1	1	1	1	1
Total	100	100	100	100	100

* value obtained in this study; ** Dersjant-Li (2002); ***Tillman et al (1998).

Diet preparation. The *M. oleifera* leaves were collected from Empetreing village, Aceh Besar District, Aceh Province, Indonesia. The *M. oleifera* leaves were dried in the sun for three to five days prior to being ground into flour. The flour was then formulated for the fish diet with other materials resulting in 32% crude protein (Table 1). All dry materials were mixed and stirred homogeneously, and then water was added gradually. The mixed materials were pressed into pellets using an extruder machine. The pellets were dried in the sun for two days prior to being used in the experiment.

Experimental fish and feeding. The research was conducted at laboratory of Marine and Fisheries, Syiah Kuala University from June to July 2014. The tilapia (*O. niloticus*) fingerlings were obtained from the Brackish Water Aquaculture Development Center, Aceh Besar District, Aceh Province, Indonesia. The initial weight of the experimental fish ranged from 5.2 to 12 g, with an average weight of 8.5 g. The fish were acclimated in one tank for four hours. Then the fingerlings were selected randomly and stocked in 15 experimental aquariums (45 cm x 35 cm x 30 cm) at a stocking density of 10 fish per aquarium. The aquariums were equipped with water recirculation systems and filters.

The feces and unconsumed feed were siphoned two hours after every feeding and approximately 50% of the water was changed every three days. The fish were fed a ration of 5% of their body weight three times a day at 8 AM, 12 PM, and 5 PM for 30 days. Body weight and body length were measured every 7 days.

Assessment of parameters. The daily growth rate (DGR) was examined based on De Silva & Anderson's (1995) formula as follows: $DGR = (W_t-W_0)/t$, where, DGR = daily growth rate (g day^{-1}), W_t = final body weight (g), W_0 = initial body weight (g) and t = feeding duration (days). The specific growth rate (SGR) was evaluated according to Morais et al's (2001) formula: SGR (% per day) = $(\ln W_t - \ln W_0)/t \times 100\%$, where t = experiment duration time (days). The absolute growth rate (AGR) was evaluated according to Jones' (2002) formula: $AGR = (L2-L1)/\Delta t$, where L1 = initial length, L2 = final length and Δt = feeding period. The survival rate (SR) was evaluated according to Hseu et al's (2003) formula: SR = [(final mortality – early mortality)/early mortality] x 100%. Food conversion ratio (FCR) and feed efficiency (FE) were examined based on

Tutas et al (2013) formulas as follows: FCR = $F/(W_t–W_o)$, where F = the amount of given feed (g), and FE = (1/FCR) x 100%. The hepatosomatic index (HSI) was evaluated according to Ogunji et al's (2008) formula: HSI = liver weight (g)/total fish weight (g) × 100.

Statistical analysis. The data was subjected to one-way analysis of variance (ANOVA) and followed by a comparison of means using Duncan's multiple range test. The tests used SPSS software, version 15.0.

Results and Discussion. The protein requirement of tilapia ranges from 25 to 35% (Meyer & Pena 2001). The crude protein content of the formulated diets in this study reached 32%, therefore fulfilling this requirement. Surprisingly, the ANOVA test showed that the differences in *Moringa* meal composition in the diets did not have a significant effect on the measured parameters ($p > 0.05$), where the control group (a diet with no *Moringa* meal) was not significantly different from the experimental group (a diet with *Moringa* meal). However, a higher SGR value was obtained with 32% *Moringa* meal, while higher DGR, AGR and SR values were obtained with 16% *Moringa* meal. The best FCR and FCE values occurred with the control group. In addition, a higher HSI value was obtained with 24% *Moringa* meal (Table 2). Yet, these values were not significantly different ($p > 0.05$) among the different treatments. This study revealed that when the soybean meal was completely replaced by *Moringa* meal in the tilapia (*O. niloticus*) diet the tilapia could tolerate the *Moringa* meal up to 32% as tested in this study.

Table 2

The growth performances, survival rate, feed conversion ratio, feed conversion efficiency and hepasomatic index of tilapia fingerlings fed at different concentration of moringa leaf meal

Parameter	*Experimental diet*				
	A	*B*	*C*	*D*	*E*
Specific growth rate (% day^{-1})	1.23±0.44	1.19±0.20	1.43±0.23	1.29±0.35	1.45±0.09
Daily growth rate (g day^{-1})	0.13±0.05	0.12±0.03	0.15±0.04	0.14±0.05	0.14±0.00
Absolute growth rate (g)	3.78±1.43	3.72±0.94	4.59±1.12	4.16±1.41	4.25±0.09
Survival rate (%)	66.67±5.77	76.67±5.77	93.33±5.77	90.00±2.11	90.00±1.99
Feeding conversion ratio	7.50±1.10	11.98±2.82	11.48±3.04	11.11±4.46	9.96±0.13
Feeding conversion efficiency (%)	0.15±0.02	0.09±0.03	0.10±0.03	0.12±0.04	0.10±0.00
Hepatosomatic index (%)	0.28±0.11	0.31±0.10	0.44±0.07	0.65±0.30	0.45±0.05

The SGR value for the tilapia (1.45%) obtained in this study was better than with *Leucaena leucocephala* leaf meal, where the highest SGR value was 1.36% (Widyanti 2009). The SGR value in this study was even better when compared to the fermented *Azolla* sp. meal, where the highest SGR value was 0.85% (Handajani 2011). However, the SGR value for the tilapia obtained in this study was lower compared to what was reported by Yanti et al (2013) who tested the *Salix tetrasperma* leaf meal (3.50%), and *Hidrylla verticillata* and *Lemna minor* (5.36% and 8.47%), respectively, reported by Sait (2006).

The FCR and FCE values in the control group were better than the treatments, probably due to the presence of some antinutrients in the *Moringa* meal such as phenol, tannin and saponin (Richter et al 2003). The levels of antinutrients in *Moringa* meal are most likely higher compared to the levels in soybean meal. Tripsyn inhibitor, antigens, lectins, saponins and oligosaccharides also reduce the digestibility of nutrients (Dersjant-Li 2002). *Moringa* leaves have other antinutrient components such as oxalates and

oligosaccharides (Yang et al 2006), but these antinutrients did not have a negative effect on the measured parameters when up to 32% *Moringa* meal was in the formulated diet.

The HSI value increased up to 0.65% when the composition of *Moringa* meal in the diet increased to 24%. The study revealed that the presence of *Moringa* meal in the diet increased the hepatic weight of the tilapia fingerlings. The HSI describes the status of energy reserve in an animal (Sadekarpawar & Parikh 2013). The increase in hepatic weight is due to the increase in nutrient accumulation in the hepar (Yandes et al 2003). In addition, Yildiz (2004) states that a higher HSI value could be attributed to a higher lipid content in a fish, which may contribute to a greater lipid accumulation in the hepar. Moreover, Ali et al (2000) reported that differences in HSI values are a function of protein, lipid and carbohydrate levels in fish. However, *Moringa* has shown significant hepato protective activity in several studies (Farooq et al 2012). Therefore, the results of this study are promising for tilapia culture in relation to reducing the feed cost, especially to avoid soybean meal dependence.

Conclusions. There were no differences in the results obtained between diets with soybean meal and diets with *Moringa* meal. Therefore, soybean meal in the formulated diet of tilapia is replaceable with *Moringa* meal. The recommended composition of *Moringa* meal in the formulated diet of tilapia (*O. niloticus*) is between 16-32%.

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