APPARENT DIGESTIBILITY OF SELECTED FEED INGREDIENTS IN DIETS FOR MUD CRAB (*Scylla paramamosain*)

Ketut Suwirya*), Nyoman Adiasmara Giri*), M. Marzuqi*), and Sophia Sagala*)

ABSTRACT

Cultured mud crabs (*Scylla* spp.) are commonly fed with 'trash' fish. Insufficient supply, high cost and variable quality of 'trash' fish has lead to a need to develop cost-effective and environmentally friendly formulated diets. This study was conducted to determine quality of selected feed ingredients as protein sources in mud crab diets based on their nutrient composition and digestibility coefficients for dry matter (ADMD), crude protein, lipid and energy. The digestibility coefficients for ADMD ranged from 82.46% to 89.20%. Animal-based feedstuffs such as shrimp head, tiny shrimp and squid liver meal had higher ADMD values than fish meal. Of the plant-based feedstuffs, soy bean meal had the highest ADMD values (89.20%) and corn gluten had the lowest (82.46%). Corn gluten had the lowest protein digestibility (78.81%) and soy bean meal had the highest (96.05%). The lowest energy digestibility (71.13%) was obtained in corn gluten meal. Soy bean meal had a higher energy digestibility value (98.48%) than fish meal (85.95%). All animal meal sources had similar energy digestibility values (85.86%—92.09%).

KEYWORDS: digestibility, feed ingredient, mud crab

INTRODUCTION

Mud crab has good potential for commercial culture. Cultured mud crabs are commonly fed with 'trash' fish. However, due to the insufficient supply, variable cost and quality of 'trash' fish, there is a need to develop cost-effective and environmentally friendly formulated diets. Cost effective feed can be produced through the formulation of inexpensive feed ingredients and inclusion of ingredients with high digestibility which is beneficial for the environment. Some potential ingredients available for formulated crab diets are: fish, squid liver, tiny shrimp, shrimp head, corn gluten, and soy bean meal. Effective incorporation of an ingredient, however, requires information on its digestibility by the target species.

A feed ingredient may appear from its chemical composition to be an excellent source of nutrients but may have little actual value unless it can be digested and absorbed by the target species. Consequently, knowledge of nutrient digestibility of various feed ingredients used in formulating diets for the target species is important. Lee & Lawrence (1997) recommended the use of chromic oxide (Cr_2O_3) as an inert indicator to measure digestibility of feed ingredients for crustaceans and many researchers have reported the apparent digestibility of dry matter, protein, lipid, carbohydrate using Cr_2O_3 (Forster & Gabbott, 1971; Fennuci e*t al*., 1982; Akiyama *et al*., 1989; Tuan *et al*., 2006; Catacutan *et al*., 2003).

Digestibility studies of some ingredients by *Scylla serrata* have been reported by Tuan *et al*. (2006) and Catacutan *et al*. (2003). These results indicated that *S.serrata* can efficiently utilize certain feed ingredients. Apparent dry matter digestibility of both studies was 85.2%—93.6% (Catacutan *et al*., 2003) and 70.0%—95.7% (Tuan *et al*., 2006). This information is not yet

*) Research Institute for Mariculture, Gondol, Bali, Indonesia

available for *Scylla paramamosain.* This study was conducted to determine the suitability of selected feed ingredients as protein sources for *S. paramamosain* diets based on their nutrient composition and the digestibility coefficients for dry matter, crude protein, lipid and energy.

MATERIAL AND METHODS

A total of 48 mud crabs (mean body weight 120.5 ± 7.1 gram) were used to test the suitability of the following test ingredients for inclusion in mud crab diets: local fish meal, shrimp head meal, tiny shrimp meal, squid liver meal, corn gluten meal, defatted soybean meal, and feather meal.

The methods of Cho *et al.* (1982) and Forster (1999) were adapted for this study and used a ratio of 70:30 of the reference diet to test ingredient (Table 1). The reference diet was formulated to meet known nutrient requirements of mud crabs. All experimental diets contained 1% Cr_2O_3 as an external indicator and 2% carboxymethylcellulose (CMC) as a binder. The mud crabs were acclimated with a reference diet (without Cr_2O_3) for 2 weeks after which they were fed experimental diets twice daily (08.00 h and 15.00 h) at a rate of 5% body weight per day. After acclimation, all mud crabs were assigned to the experimental diets groups. Six crabs were included for each group with triplicates. Faeces were pooled from crabs in each replication until enough was obtained for analysis. All samples were stored in a refrigerator until required for analysis. The feeds and faeces were analyzed for proximate analysis using standard methods (AOAC, 1990) and for Cr_2O_3 (Furukawa & Tsukahara, 1966).

Apparent digestibility coefficients (ADCs) of dry matter, protein, energy and lipid were then measured using the methods of Cho *et al.* (1982) and Forster (1999) with chromic oxide as the inert marker. Apparent digestibility coefficients (ADCs) of each nutrient were calculated from the equation:

$$ADC = 100 - (100 \times Md/Mf \times Nf/Nd),$$

Where M and N are the percentage of marker and nutrient, respectively, and d and f are diet and faeces, respectively. When ingredients are partially substituted into the reference diet to give a combined diet, the equation for any given nutrient becomes:

Table 1. The composition of reference and test diets for *in vivo* digestibility experiments on various feed ingredients (g/100 g feed)

Ingredients	Reference diet (%)	Test diet (%)
Fish meal	44.1	30.5
Head shrimp meal	10.0	6.9
Squid liver meal	5.0	3.5
Defatted soybean meal	10.0	6.9
Casein	6.0	4.1
Wheat flour meal	5.5	3.8
Soybean oil	2.5	1.7
Fish oil	1.2	0.8
Lecithin	2.0	1.4
Min Mix	2.0	1.4
Vit Mix	2.5	1.7
Dextrin	6.2	4.3
CMC	2.0	2.0
Cr_2O_3	1.0	1.0
Test ingredients	-	30.0
	100.0	100.0

$$ADC = [(a + b) \times ADCcom - (a) \times ADCref]b^{-1}$$

Which takes into account the different nutrient composition of the reference diet and test ingredient, where a = level of nutrient in reference diet x (100 – level of test ingredient in combined diet), and b = level of nutrient in test ingredient x level of test ingredient in combined diet.

All data were analyzed by one-way ANOVA and differences between means treatment were considered significant at $P<0.05$ (Steell & Torrie, 1960).

RESULTS

The proximate composition (g/100 g dry weight) of various feed ingredients is shown in Table 2. Protein levels in fish meal and other feedstuffs of animal origin used in this experiment were generally high (34.69%—86.30%). Protein content of feed ingredients from plant sources ranged from 54.13% to 60.89%. Likewise, the levels of ash in fish meal and shrimp head meal were higher (19.38%—33.42%) than those in feed ingredients of plant origin (1.29%—6.92%). The level of fiber in fish meal was lower than that of other ingredients tested. Squid liver meal had the highest lipid content (17.76%).

Table 3 shows the apparent digestibility coefficients (ADCs) for dry matter (ADMD), protein, lipid, and energy. The digestibility coefficients for ADMD ranged from 82.46% to 89.20%. Of the feedstuffs of animal origin head shrimp, tiny shrimp and squid liver meal had higher ADMD values than fish meal. Soy bean

Table 2. Proximate composition of various ingredients for in vivo digestibility experiment (g/100 dry weight)

Ingredients	Protein	Lipid	Fiber	NFE[1]	Ash
Fish meal	64.36	7.61	1.85	6.80	19.38
Shrimp head meal	34.69	4.47	5.61	21.81	33.42
Tiny shrimp meal	59.97	4.23	4.80	5.85	25.15
Squid liver meal	46.60	17.76	2.30	25.73	7.61
Poultry feather meal	86.30	6.71	2.51	1.71	2.77
Corn gluten meal	60.89	15.22	3.36	19.24	1.29
Soy bean meal (defatted)	54.13	3.31	3.62	32.02	6.92

[1] Nitrogen free extract = 100- (% crude protein + % crude lipid + % crude fiber + % ash)

Table 3. Digestibility of some feed ingredients on mud crab

Ingredients	Dry matter digestibility* (%)	Protein digestibility* (%)	Lipid digestibility* (%)	Energy digestibility* (%)
Local fish meal	84.25^{b}	86.12^{b}	57.62^{abc}	85.95^{b}
Head shrimp meal	85.74^{d}	$88,05^{bc}$	71.25^{bc}	85.86^{b}
Tiny shrimp meal	85.32^{c}	90.66^{c}	34.33^{a}	93.01^{bc}
Squid liver meal	87.15^{c}	90.02^{bc}	89.14^{c}	91.36^{bc}
Corn gluten	82.46^{a}	78.81^{a}	51.37^{ab}	71.13^{a}
Soy bean meal	89.20^{f}	96.05^{d}	43.25^{a}	98.48^{c}
Poultry feather meal	87.19^{e}	95.14^{d}	23.50^{a}	92.09^{bc}

* Values in the same column followed with similar superscript are not significantly different ($P>0.05$)

meal had the highest ADMD value and corn gluten was the lowest.

Analysis of variance (Table 3) showed that protein, lipid and energy digestibility values of some ingredients were significantly different from one another ($P<0.05$). Corn gluten had the lowest protein digestibility value while soy bean meal had the highest ($P<0.05$). Protein digestibility values of local fish, head shrimp, and squid liver meal were not significantly different from one another ($P>0.05$).

Lipid digestibility values of squid liver and head shrimp meal were higher than soy bean meal ($P<0.05$). Lipid digestibility values of local fish, head shrimp, and corn gluten meal were not significantly different from one another ($P>0.05$).

Energy digestibility values of all ingredients were relatively high (71.13%—98.48%). The lowest energy digestibility value was obtained with corn gluten meal. Soy bean meal had a higher energy digestibility value than fish meal. All animal meal sources had similar energy digestibility values (Table 3).

DISCUSSION

Protein quality of dietary ingredients is generally a leading factor affecting mud crab performance, and protein digestibility is the first measure of its availability by mud crab. Protein quality of dietary protein sources depends on the composition of amino acids and their digestibility. Deficiency of an essential amino acid leads to poor utilization of dietary protein and consequently reduces growth and decreases feed efficiency (Halver & Hardy, 2002). The present study showed that ADCs of dry matter, protein, lipid, and energy in the test ingredients for mud crab, *S. paramamosain* were affected by test ingredients ($P<0.05$). The differences in ADCs of nutrients and energy may be explained by differences in chemical composition, origin, and the processing of these feed ingredients (Table 2).

The test ingredients were efficiently utilized by mud crab, *S. paramamosain* as indicated by the high ADMD values (82.46% to 89.20%). Akiyama *et al*. (1989) reported in *Penaeus vannamei* that purified feedstuffs were efficiently digested compared with practical feedstuffs, which ranged from 21.4% to 91.4%. The other result in *P. setiferus* showed that ADMD tended to decrease as dietary ash content of ingredients increased (Reigh *et al*., 1990). Soy bean meal protein is considered to be highly digestible to many crustacean species (Catacutan, 1997; Mu *et al*., 2000). In this study, the ADMD and ACPD of corn gluten were lower than for soy bean meal and similar results have been found for *Penaeus setiferus* (Brunson *et al*., 1997). However, the opposite was observed in crayfish, *Procambarus clarkii* (Reigh *et al*., 1990) and mud crab, *S. serrata* (Catacutan *et al*., 2003).

We therefore suggest that fish, head shrimp, and squid meal are suitable protein sources for mud crabs. Other ingredients, especially of soy bean meal, also appeared to be good dietary protein sources for mud crabs. It is therefore suggested that shrimp head meal and corn gluten meal are suitable dietary lipid sources for mud crabs (Table 3).

Fish meal is one of the most expensive and sought after ingredients for aquaculture diets and has become the most critical ingredient in aquafeed production. Increasing cost and demand of fish meal have encouraged feed manufacturers to search for cheaper alternative protein source such as plant protein. Fish nutritionists have tried to use less expensive plant protein to partially or totally replace fish meal. However, substitution of fish meal with other ingredients, especially of plant origin, is likely to compromise nutrient balance. Because of the increasing cost of fish meal and doubts concerning its long-term availability, much research has been carried out to find an alternative protein source.

Tuan *et al*. (2006) found that soy bean meal gave the highest ADMD ($P<0.05$) for juvenile mud crabs (*S. serrata,* Forskal 1775). In another study (Catacutan *et al*., 2003) showed that soy bean gave lower ADMD than corn meal for juvenile mud crabs (*S. serrata*). Moreover, protein digestibility for shrimp meal was not significantly different from fish meal (Pe”0.05); nevertheless, it was lower than that of soybean meal. Findings such as these indicate that plant-based nutrient sources can be exploited to substitute fishmeal in formulated diets for mud crabs. In particular, the current findings suggest that soybean meal may be a useful component for formulating diets for *S. paramamosain.*

Based on its digestibility values, it is proposed that soy bean meal is a suitable ingredient to substitute for fish meal in

formulated diets for mud crabs. However, further research is needed to asses its performance in term of growth and survival of cultured mud crab.

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