Evaluation of Local Feed Ingredients Based Diets on Growth Performance of African Catfish, *Clarias gariepinus*

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Abstract

Formulating the right feed based on the requirements of the fish species is the main solver to reduce the high cost of aquaculture production. In formulating suitable diet, factors such as the sustainability or availability of the feed sources used, quality of the feeds and price of raw materials, need to be taken into account as well so that the diets can be formulated at least cost. Low cost diets using local feed ingredients were formulated in pelleted and extruded forms and fed to juvenile African catfish, *Clarias gariepinus*, to determine their effect on the growth performance of the fish. Two formulations were tested: Diet A - Formula 1 MARDI and Diet B - Formula 2 MARDI, which were formulated to be iso-caloric and iso-nitrogenous with 32 % digestible protein and energy value of 14 MJ/kg. A commercial diet (Diet C) was included as a control. At 15 wk of culture, fish fed diet C showed the highest growth performance in terms of weight gain, feed conversion ratio (FCR) and specific growth rate (SGR). There were no significant differences ($P>0.05$) found among diets for weight gain and feed intake. However, FCR and SGR of Diet C were significantly better ($P<0.05$) compared to the experimental diets. The best FCR was recorded in Diet C at 1.17, followed by Diet A (1.42) and Diet B (1.46). Diet C also had the highest SGR with 1.99%/day followed by Diet B (1.70) and Diet A (1.67). Cost of both diets, A and B, was RM 2.50/kg compared to RM 3.50/kg for Diet C. Although the FCR of the commercial feed was lower than the experimental diets, the production cost of fish was RM4.11/kg for the commercial feed compared to RM 3.54-3.65/kg for the experimental diets. It is concluded that local feed ingredients can be used in formulating diets for catfish and they have no detrimental effect on the growth of African catfish.

Key words: African catfish, growth performance, feed conversion ratio, local ingredients

Introduction

Aquaculture is known to be the fastest growing food producing industry globally. Malaysia has prioritised aquaculture as one of the focussed areas for food security and the government has also gazetted some areas for aquaculture activities. The Malaysian government has targeted that 50% of the fish availability in Malaysia will come from the aquaculture sector, which is a great challenge to the industry. According to the Department of Fisheries (DOF) Malaysia, in 2014, about 520,514 metric tonnes of aquaculture produce were produced valued at about RM 3.47 billion (DOF, 2014). This industry has contributed 26% of the fish production in Malaysia. The aquaculture industry has shown a rapid growth with an annual growth rate of 8% in the last decade. Increasing

aquaculture volume will lead to an increase in the use of aquaculture feed.

In any aquaculture production, 60-80% of the cost of production comes from the cost of feed. In a survey done by Ng *et al.* (2013) on tilapia farms in Malaysia, 63% of the production cost was feed cost, with 90% of the farms surveyed used commercial tilapia feeds. Feed is the most crucial and costly factor in any aquaculture production. Lowering the cost of aqua feed will help to lower the production cost. Most of the fish feeds used in Malaysia are produced by large foreign owned feedmills. There are very few and limited locally based aquaculture feed manufacturing companies.

African catfish, *Clarias gariepinus*, is a hardy fish and can tolerate adverse water conditions. The remarkable growth rate of this fish coupled with its high survival rate, disease resistance and easy to culture has made this species one of the most promising food fish in this country. About 50,683 metric tonnes of catfish valued at RM 223 million were produced in 2015 making them the most cultured freshwater fish in Malaysia, followed by the red hybrid tilapia at 30,359 metric tonnes (DOF, 2015). This species is also cultured widely in many other countries and is of great economic interest in the United States (Dale, 2001). Catfish however is regarded as a low value fish in Malaysia even though the demand is high. In 2014, the wholesale price of the fish was reported to be in the range of RM 3.00-4.50/kg in Peninsular Malaysia and reached up to RM 6.00-12.00/kg in the West Coast of Peninsular Malaysia (DOF, 2014). African catfish fingerlings usually take an average of 3-4 mo to reach harvesting weight of 200-250 g. This however depends on the quality of feed and availability of nutrients for growth under captivity. Catfish are bottom dwellers and therefore, more active at the bottom of the pond or tank and they possess omnivorous feeding habits (Jan, 1995). The protein requirement is estimated at 40-50% at early growth stage (Degani *et al.*, 1989). *Clarias gariepinus* catfish seem to require more than 40% crude protein in their diet compared to other *Clarias* species (Jan, 1995). The protein requirement drops to 26-32% when they reach 27 g. According to NRC (2011), the requirement for catfish is 12.55 MJ/kg of digestible energy and 29% digestible protein.

It is well known that not all of the protein supplied in the feed is successfully digested and utilised by the fish. In any livestock and fish culture, formulating feed based on its digestible value is more efficient in terms of the absorption of the nutrients in the animal. In many cultured fish, fishmeal is the main feedstuff used due to its excellent source of indispensable amino acids, fatty acids and other nutrients essential for fish growth (Hussain *et al.*, 2011). However, due to the dwindling and depleting source of fishmeal and competing demand from other livestock species (Millamena, 2002), other alternative sources of protein should be explored as substitutes in aquafeed. Moreover escalating prices of these imported feedstuffs have resulted in an urgent need for more research to overcome the problem. The use of local feedstuffs in fish diet to substitute for imported feed ingredients is seen to be an alternative to reduce the cost of fish feed in Malaysia. Hence this study was conducted to evaluate the effects on growth performance of the African catfish juveniles fed on low cost fish feed formulated using digestible protein and energy values from local feedstuffs.

Materials and Methods

Digestibility Study

African catfish juveniles of average body weight of 20 g were used in this digestibility study. Catfish juveniles were acclimatized

for 2 wk prior to the digestibility trial. The fish were reared in a 100-litre glass aquarium, and were fed to satiation daily. Catfish juveniles were assigned to seven treatments (fishmeal, PKE, wheat pollard, rice bran, soybean meal, corn, copra cake) with three replications and 10 fish in each replication. All feed ingredients used in this study were purchased from a local supplier. The reference diet used in this study consisted of fishmeal as the sole protein source (Table 1). The test ingredients used in this study were conventional (fishmeal, soybean meal, corn) and local (palm kernel expeller, wheat pollard, rice bran, copra cake) feed ingredients. The test diets were prepared by mixing the reference diet and each of the test ingredients at a ratio of 70:30 (Lim *et al.,* 2005). Fish were fed once daily at 0900 and the residual feed were removed an hr after feeding time. Faeces were collected by siphoning them gently from the bottom of the aquarium after 4 hr of feeding and an hr before the next feeding on the next day until the amount was sufficient for analysis. At the end of the 14-day collection period, the faecal samples were dried in an oven at 60˚C and ground for analysis. The diets and the faecal samples were then analysed for dry matter (DM), crude protein (CP) and energy (GE) value to determine their digestibility coefficients. The apparent digestibility coefficients (ADCs) were determined following the formula of Bureau *et al. (*1999):

ADC of nutrient (%)
= 100 x [(amount of nutrient ingested - amount of nutrient egested)/amount of nutrient ingested]

ADC of test ingredient (%)
= ADC of test diet + [(0.7/0.3) x (% nutrient in reference diet / % nutrient in test ingredient) x (ADC of test diet - ADC of reference diet)]
where ADC = Apparent Digestibility Coefficient

Feeding Trial

A total of 1,500 *Clarias gariepinus* catfish juveniles (average weight of 16 g) were purchased from a local hatchery in Sungai Buloh, Selangor. The fish were then randomly assigned to 3 diets: Diet A - Formula 1 MARDI, Diet B - Formula 2 MARDI and Diet C - commercial diet, with 5 replicates per diet of 100 fish per diet. The commercial feed (Dindings, 32% CP) was used as a control diet. All diets (Formulas 1 and 2 MARDI) were formulated using 32% digestible protein and 14 MJ/kg energy value and incorporated local (palm kernel cake, copra cake, wheat pollard, rice bran) and conventional (corn, soybean meal, fishmeal) feed ingredients. Diet B, however, did not include soybean meal. Fish were reared in a 1-tonne polytank for a 15-week duration and 30% of the water was replaced twice a wk. Aeration was supplied continuously throughout the experiment. Fish were fed twice daily (0830 and 1600) with the feeding rate set at 2-4% of body weight. Water parameters (temperature, pH, ammonia levels) were observed throughout the feeding experimental period to ensure that they were within the range for cultured freshwater fish requirements.

Data collected were analysed using analysis of variance (ANOVA) with significant differences among means separated by Tukey test using the SAS Version 9.3.

Results and Discussion

Table 1 shows the nutritive value of the feed ingredients used in formulating the experimental diets. The main protein ingredients were fish meal (60.58% CP) and soybean meal (42.29% CP) (Table 1). Fish meal has been used traditionally as the major feed ingredient in fish feeds due to its high quality nutrient and is palatable. In many studies done for *Clarias* feed, fish meal constituted the main protein source, while in other studies, it was partially replaced with other protein alternatives, mainly plant based protein (Jan, 1995). Soybean meal is one of the highly rich protein sources of plant based protein (El-Sayed, 1999), consisting of around 42-48% crude protein, and is the most promising candidate to replace fish meal in fish diets (Boonyaratpalin *et al.*, 1998). Various studies using soybean meal as a feed ingredient either processed or used in raw form had also been reported with other types of fish such as tilapia and seabass (Boonyaratpalin *et al.*, 1998). However, fish meal and soybean meal were imported, thus the cost of fish feed production could not be reduced unless locally available feed ingredients are used to replace them. Copra cake, palm kernel expeller, rice bran and wheat pollard were the local feed ingredients used in this study. However, these local feed ingredients could only be incorporated in the diet at certain levels depending on the digestible values of each feed ingredient.

Table 1. Proximate composition of feed ingredients (as fed basis) incorporated in the experimental diets

Sample	Fish meal	Rice bran	Soybean meal	Corn	Copra cake	PKE	Wheat pollard
Dry matter, %	92.00	90.62	89.12	88.99	89.91	91.79	89.0
Crude protein, %	60.58	11.76	42.29	8.31	21.63	16.59	16.14
Crude fiber, %	4.37	26.37	32.72	13.40	48.71	13.02	9.9
Ash, %	23.00	9.74	9.35	0.85	9.81	8.24	4.6
Lipid, %	5.97	7.18	0.42	1.22	6.44	1.80	3.4
Gross energy, MJ/kg	16.21	16.43	16.85	14.64	19.27	17.18	16.00

The apparent digestibility coefficients for crude protein and gross energy of the feed ingredients from the digestibility study are shown in Table 2. Soybean meal was found to have the highest ADC of crude protein (92.83%) but not significantly different (P>0.05) from fish meal, PKE, rice bran, wheat pollard and copra cake. Corn had the lowest crude protein digestibility at 32.30% and was the lowest compared to the other feed ingredients. However the ADC of gross energy for corn (82.98%) was significantly higher (P<0.05) than PKE, rice bran, wheat pollard and copra cake but not significantly different (P>0.05) when compared to fishmeal and soybean meal. Corn is suitable to be used as an energy source rather than as a protein source. Li and Robinson (1994), also mentioned that corn has been generally used as typical source of energy in catfish feed manufacturing in the United States. The ADC of crude protein of corn result from this

study was found to be lower than the 60% (Cruz, 1975) and 97% (Wilson and Poe, 1985) reported in channel catfish, *Ictalurus punctatus*. There are many factors that may contribute to the differences in digestibility for a particular feed ingredient. Raw material quality, feed intake, fish size, and water temperature were among the variables that may affect digestibility (NRC, 2011).

Table 2. Mean values of apparent digestibility coefficients of crude protein and energy of feed ingredients

Ingredients	Apparent digestibility coefficient (%)	
	Crude protein	Gross energy
Fish meal	90.79[a]	91.33[a]
Palm kernel expeller	81.10[a]	70.99[b]
Corn	32.30[b]	82.98[a]
Rice bran	77.42[a]	62.81[b]
Wheat pollard	68.66[ab]	69.41[b]
Copra cake	84.17[a]	70.91[b]
Soybean meal	92.83[a]	87.80[a]

[ab]Means with different superscripts within the same column differ significantly (P<0.05).

The growth performance result of the African catfish fed the tested diets is shown in Table 3. The practical diets used in this study were formulated based on the digestible protein and energy values of the selected feed ingredients (palm kernel cake, copra cake, wheat pollard, rice bran, corn, soybean meal and fish meal). There were no significant differences (P>0.05) between diets for weight gain and feed intake (Table 3). However, feed conversion ratio (FCR) and specific growth rate (SGR), of the experimental diets were significantly lower (P<0.05) compared to the commercial feed. The best FCR was recorded in diet C at 1.17, followed by diet A (1.42) and diet B (1.46). Diet C also had the highest SGR with 1.99%/day followed by diet B (1.70%/day) and diets A (1.67%/day).

The cost of production for the experimental MARDI diets was RM2.50/kg compared to the commercial feed of RM3.50/kg. Although the FCR of the fish fed the commercial feed was lower than the experimental diets, the production cost of fish meat was RM4.11/kg of fish compared to RM 3.54-3.65/kg for the experimental diets (Table 3).

Table 3. Comparison of growth performance of African catfish fed diets with local and conventional feed ingredients

Diet[1]	Weight gain (g)	Feed intake (g)	FCR*	SGR*	Production cost (RM /kg fish)
A	90.23[a]	126.82[a]	1.42[a]	1.67[b]	3.54
B	70.11[a]	101.89[a]	1.46[a]	1.70[b]	3.65
C	108.64[a]	127.39[a]	1.17[b]	1.99[a]	4.11

[ab]Means with different superscripts within the same column differ significantly ($p<0.05$).
*FCR – Feed conversion ratio, *SGR – Specific growth rate
[1] A) Formula 1 MARDI, B) Formula 2 MARDI and C) Commercial diet

Fish have different capabilities in digesting feed ingredients compared to terrestrial animals. Feed ingredients particularly cereals and their by-products which contain high amount of fiber and starch are poorly digested by carnivorous fish (Bureau and Cho, 1999). The catfish, which possess omnivorous feeding habit and in some extent could be a voracious predatory fish, are capable of digesting wheat pollard and rice bran, by-products from cereal grains, with digestibilities of about 68-77% for protein and 62-69% for energy (Table 2). In another study, the ADC of protein for channel catfish was found to be comparable with the present study with protein ADC of 73% while the digestible energy was found to be slightly lower (Wilson and Poe, 1985). This indicates that rice bran and wheat pollard may be used in formulating diets for catfish, although their inclusion is limited. Rice bran contains high amount of fiber and fat, and can only be used at 3-5% levels in catfish diet (Li and Robinson, 1994).

Other by-products used in the present study were copra cake and PKE which showed high value of ADC of protein of 84.17% and 81.10%, respectively. Ng and Chen (2002) reported that 20% of palm kernel meal (PKM) inclusion was the optimum inclusion for efficient growth in hybrid Asian-African catfish. It was also reported that not more than 20% incorporation of PKM to partially substitute soybean meal can be used in tilapia diet (Ng and Chong, 2002). If the PKM was intended to replace fishmeal, Omoregie and Ogbemudia (1993) suggested that the inclusion should not be more than 15%. In this study however, only 10% of copra cake and 8% of PKE were incorporated in the diet. Feed ingredients containing more than 20% crude protein are potential sources of protein in the fish diet, whereas feed ingredients that contain less than 20% crude protein are more suitable to be energy sources (Li and Robinson, 1994).

Conclusion

The results in the use of local feedstuffs as protein substitutes or protein alternatives for imported ingredients in aquaculture feeds showed promising results and did not have any adverse effect on the growth performance of fish. The cost of feed could also be reduced resulting in the reduction of cost per kg of fish produced. This proved that local by-products in Malaysia can be utilised in formulating diets for catfish.

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