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Apparent Digestibility Coefficients of Pelleted Feed Incorporated with Water Hyacinth *Echhornia crassipes* Fed to Red Tilapia, [*Oreochromis mossambicus* (Peters, 1852) X *Oreochromis niloticus* (Linnaeus, 1758)]

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Abstract: A 3 weeks feeding trial was conducted to evaluate the Apparent Digestibility Coefficients (ADCs) of dry matter, protein, gross energy, nitrogen, crude lipid and fiber of Water Hyacinth (WH), *Echhornia crassipes* meal incorporated in pelleted test feeds (0, 10, 15, 20 and 25%, dry matter basis) for red tilapia fingerlings. Chromium dioxide (1%) was added as an inert bio-marker to iso-nitrogenous (35.00±0.20% crude protein) and iso-caloric (4.00±0.52 kcal kg^{-1}) feeds. Results showed that the maximum value (p = 0.05) of ADCs for dry matter (68.09%) was recorded for the control feed with 0% WH while the minimum value of 50.36% was recorded for the test feed 4 including 20% WH. Similarly, the maximum ADCs values (p = 0.05) for crude protein, gross energy, ether extract, crude lipid and crude fiber were also found in control feed while the minimum values were observed in test feed 4 including 20% WH. The study was clearly indicated that red tilapia fingerlings efficiently digest the nutrients when only the maximum inclusion of WH 20% in their feed does not exceed 20% of WH meal (on dry basis).

Key words: Apparent digestibility coefficients, red tilapia, water hyacinth meal, chromium dioxide, crude protein, Malaysia

INTRODUCTION

Intensification of global tilapia production has made it essential to develop nutritionally efficient and cost effective complete and supplemental feeds for different tilapia species. Tilapias are well known for its favorable culture attributes and are distributed widely all over the world. In recent years, tilapia production is mainly dominated by Asian countries which has substantially led tilapia to be the second largest food fish of the world. Even though, inland fisheries are not significantly developed in many countries include Malaysia, tilapias are present in most inland water bodies in these countries (De Silva *et al*., 2004). The red tilapia, a hybrid between strains of *O. mossambicus* x *O. niloticus* is currently considered to be the most important aquaculture species in Asia (Welcomme and Vidthayanom, 2003). The red tilapia was promptly accepted by farmers due to its high fertility rate and conspicuous color. From that point forward, the industry proliferated dynamically under the governments support. Feed production is one of the major problems faced by Malaysian aquaculture farmers. The reports of Malaysian Industrial Development Authority (MIDA, 2011) on their official website showed that animal feed was still one of the major food imported item in Malaysia. This scenario suggests that it would be a necessity for Malaysia to search for low cost and better nutrient component ingredients to replace partially or completely the most costly ingredients, fish meal as protein or energy source. Much critical analysis has been done in recent years on the requirement of fish for dietary protein including tilapia (El-Sayed, 1999; Falaye and Jauncey, 1999; Maina *et al*., 2002; Eusebio *et al*., 2004; Iluyemi *et al*., 2010). In fishes, the nutritive value of mixed rations depends on the nutrient composition of the individual feed components and the ability of the animal to digest and absorb the nutrients (Smith, 1979; Kirchgessner *et al*., 1986). Relatively, cheap energy yielding nutrients such as fats or carbohydrates have been widely used to reduce dietary requirement of protein.

Shiau and Peng (1993) evaluated the protein-sparing effects of three types of carbohydrates (glucose, starch and dextrin) at three different levels (33, 37 and 41%) in feeds with three protein dietary level (32, 28 and 24%). They found that fish fed starch and dextrin had significantly higher weight gain and feed efficiency ratio for all feed except for the feeds with 24% dietary protein.

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These finding can be considered helpful in lowering the feed production cost by utilizing carbohydrates to spare-protein in fish practical feeds. The utilization of water hyacinth meal, *Echhornia crassipes* in tilapia feeds has been reported by many researchers (Edwards *et al*., 1985; El-Sayed, 2003).

However, there is still insuffient data on the digestibility of this product when incorporated in tilapia feeds. A number of studies have been done for evaluating the utilization potential of *E. crassipes* in aqua-feeds for tilapia (Edwards *et al*., 1985; El-Sayed, 2003). However, there is still insufficient data on the digestibility of this product when incorporated in tilapia feeds. Such information is of paramount importance in the assessment of the economical use of this aquatic plant in fish feed production. Hence, a comprehensive study was undertaken to determine the apparent digestibility of dry matter, crude protein, ether extract, gross energy, crude lipid and crude fiber in pelleted feeds supplimented with different percentage of water hyacinth, *E. crassipes* fed to red tilapia fingerlings (*Oreochromis mossambicus* x *Oreochromis niloticus*).

MATERIALS AND METHODS

Feed preparation: Five iso-nitrogenous and iso-caloric feeds supplemented with different levels of water hyacinth *E. crassipes* (0, 10, 15, 20 and 25%) were formulated and the protein level in all experimental feeds were maintained at 35±0.3% crude protein (on dry matter basis) as described by Jauncey and Ross (1982). Fish meals of 10% (Tal and Ziv, 1978) and chicken byproducts (20%) were used as animal protein source while soya meal (40%) was used as plant protein source. Wheat brand was replaced at different levels by WH, *E. crassipes* (Table 1). Chromic oxide (1%) was used as an inert biomarker. Water hyacinth was collected from different location of water canals near to the Universiti Malaysia Terengganu. The plants were washed under running tap water and the roots were removed before being chopped into small pieces and finally oven dried at 60°C for 72 h. Dried materials were finely ground using motor grinder (FRITSCH, puluersette, Germany), sieved and stored at room temperature until needed. Fish meal, soya meal and wheat bran weren purchased from local mill factory. Chicken byproducts were also collected from local chicken slaughter shops, properly cleaned, boiled, oven dried at 60°C for 48 h and ground finely. All these ingredients were made into a powder form similar to WH. Chromium oxide was used as inert bio-marker (1%) as referred by Eusebio *et al.* (2004) in all feeds. Feeds were prepared at the Laboratory of Fresh Water Fish Hatchery, Faculty of Agro-Technology and Food Sciences (FASM). Feed formulation ratio was determined using excel software program (on dry matter basis). Macro and micro ingredients were mixed and homogenized separately. Water was added to the homogenous content in a bio-mixer till a dough-like material was formed. Pellet of 2.5 mm diameter were made using meat mincer (ORIMAS, TBS200 model, China) and then were air dried for 15 min before being oven dried at 60°C for 24 h and were stored frozen at -4°C until fed as suggested by Zhou and Yue (2010). The chemical compositions of the feeds are shown in Table 2.

Table 1: Composition of test feeds incorporated with graded amounts of WH (on dry basis)

Ingredients (%)	Control feed	Feed 1	Feed 2	Feed 3	Feed 4
Fish meal	10.0	10.0	10.0	10.0	10.0
Chicken by product meal	20.0	20.0	20.0	20.0	20.0
Soya meal	40.0	40.0	40.0	40.0	40.0
Water hyacinth meal	0.0	10.0	15.0	20.0	25.0
Wheat bran	25.0	15.0	10.0	5.0	0.0
Palm oil	2.0	2.0	2.0	2.0	2.0
Ascorbic acid	0.6	0.6	0.6	0.6	0.6
Choline chloride	0.5	0.5	0.5	0.5	0.5
Calcium diphosphate	0.6	0.6	0.6	0.6	0.6
Chromium dioxide	1.0	1.0	1.0	1.0	1.0
*Vitamin mixture	0.1	0.1	0.1	0.1	0.1
**Mineral mixture	0.1	0.1	0.1	0.1	0.1
***Binder (Tapioca)	0.1	0.1	0.1	0.1	0.1
Total (%)	100.0	100.0	100.0	100.0	100.0

*Vitamin premix (mg g^{-1} vitamin mixture): thiamine (B_1) 5 mg; riboflavin (B_2) 5 mg; pyridoxine (B_6); 4 mg; pantothenate, 10 mg; nicotic acid, 6.05 mg; folic acid, 1.5 mg; meadione, 4 mg; alpha-toco-pherol acetate, 40 mg; inositol, 200 mg; para-abenzonic acid, 5 mg; retinyl acetate, 60 μg; biotin, 0.6 mg; **Mineral premix (g/100 g mineral mixture): Calcium lactate, 32.7 g; ferric citrate, 2.97 g; magnesium phosphate, 13.7 g; potassium phosphate, 13.58 g; sodium biphosphate, 8.72 g; sodium chloride, 4.35 g; $AlCl_3.6H_2O$, 0.015 g; KI, 0.015 g; $CuCl_2$, 0.01 g; $MnSO_4.H_2O$, 0.08 g; $COCl_2.6H_2O$, 0.1 g; Zn $SO_2.7H_2O$, 0.3 g. ***Binder = Tapioca starch purchased from local market

Table 2: The mean proximate composition and gross energy of the test feeds (dry matter (%))

Contents	Control feed	Feed 1	Feed 2	Feed 3	Feed 4
Moisture	4.80±0.58[a]	4.60±0.58[ab]	4.20±0.10[c]	4.40±0.06[bc]	4.90±0.06[a]
Crude protein	35.30±0.06[a]	35.00±0.06[b]	35.40±0.06[a]	35.00±0.06[b]	35.20±0.06[ab]
Crude lipid	5.30±0.12[a]	5.00±0.12[a]	5.10±0.06[a]	5.00±0.12[a]	5.40±0.06[a]
Ash	8.20±0.06[d]	10.00±0.00[c]	9.70±0.17[c]	10.60±0.06[b]	11.30±0.12[a]
Crude fiber	7.50±0.06[c]	7.70±0.06[c]	8.30±0.00[b]	8.60±0.06[a]	8.70±0.06[a]
NFE[1]	38.90±0.06[a]	37.70±0.06[b]	37.30±0.17[b]	36.40±0.06[c]	28.80±0.06[d]
GE (kcal kg^{-1})	4580.00±1.15[a]	4550.00±1.15[b]	3730.00±0.56[e]	4500.00±0.67[c]	4470.00±0.66[d]

Values in the same row followed by the same letters are not significantly different (p = 0.05); [1]NFE = 100 - (crude protein+crude lipid+crude fiber+ash+moisture (%)); Mean±SE, n = 3

Feeding trial and feces collection: A total of 225 red tilapia fingerlings of mean body weight 6.2±0.3 g were used for the present study. Initially, fish were acclimatized and they were fed on commercial feeds (28% crude protein and 8% crude fat) in a circular concrete tank (250 m^3 capacity) for 3 weeks. For the experiment, the fish were randomly distributed into 25 L plastic transparent aquarium (15 fish/aquarium). Each triplicate group of fish were fed to the visual satiety twice daily (at 09:30 and 18:00 h) with different experimental feeds. Fecal collection were done by simple siphoning 2 h after feeding following a modified method as described by Zhou *et al*. (2004). The collected feces were pooled in a clean dried glass vials and were stored at -20°C (Usmani *et al*., 2003) for chromium and proximate composition analysis.

Chemical analysis: Crude protein, moisture, gross energy, ether extract and fiber contents in the diets and feces were determined following the standard laboratory methods (AOAC, 1995). The Nitrogen Free Extract (NFE) in the feeds was calculated by difference {100 - (moisture +crude protein+crude lipid+crude fiber+ash%)}. The chromic oxide content in feed and feces were measured spectrophotometerically using the methods of Furukawa and Tsukahara (1966).

Digestibility determination: Apparent Digestibility Coefficients of dry matter (ADC_{dm}), protein (ADC_p) and energy (ADC_e), ether extract (ADC_{ee}) and fiber (ADC_{cf}) was performed by indirect method using the chromic oxide as inert marker method as described by Cho and Kaushik. (1985). The Apparent Digestibility Coefficients (ADC) for the nutrients and energy of the test and reference diets were calculated as follows (Cho *et al*., 1979):

$$ADC = 100\times[1- (F/D)\times(Di/Fi)]$$

Where:

ADC = Apparent Digestibility Coefficient of feed
F = Nutrient in feed
Fi = Marker (Cr_2O_3) in faces (%)
D = Nutrient in feces (%)
Di = Marker (Cr_2O_3) in feed (%)

Statistical analysis: All data were subjected to statistical analysis including Analysis of Variance (one-way ANOVA) using SPSS (15) software program. The levels of significance between the means of groups were assessed using Turkey's Honest Significance Difference (HSD) and the significance level was assessed at p<0.05.

RESULTS AND DISCUSSION

No rejection to any tested feed by any group of fish was observed throughout the experimental period and all the fish showed active feeding with all feeds tested ADC of crude protein was significantly highest in comparison to ADCs dry matter, gross energy, crude lipids and crude fiber for all feed (Table 3). Control feed showed significantly higher ADCs values 68.09±0.23, 92.07±0.53 and 82.07±0.93 for dry matter, crude protein and lipid, respectively. While there was not much significant difference between the values of control group with feed 1 in ADCs values 79.30±0.10 and 78.27±0.12 for gross energy and 34.34±0.67 and 32.73±0.37 for crude fiber, respectively. Among the tested group the feed 4 was recorded the lowest ADCs value (50.36±0.76, 60.47±0.27, 65.52±0.43, 59.23±0.88 and 18.53±0.46) for dry matter, crude protein, gross energy, crude lipid and crude fiber, respectively. Control feed and feed 1 was not significantly different (p = 0.05) in ADCs of crude fiber (34.34±0.67 and 32.73±0.37, respectively). Similarly, the test feeds 2 and 3 also did not showed much significant difference in ADCs of crude fiber.

The crude protein ration did not varied much between the various feed tested and all the feeds tested have shown a level of crude protein of 35±0.3%. The gross energy also did not showed much variation among the various feeds tested, except feed 2 showed the lowest of 3730 Kcal kg^{-1} (Table 2).

Fish vary widely in their ability to utilize the carbohydrate. This variability reflects the anatomical and functional differences of gastrointestinal tract and associated organ in fish (Krogdahl *et al*., 2005). Herbivorous and omnivorous fish are capable of

Table 3: The mean values of apparent digestibility coefficients for dry matter and nutrients of control and test feeds with different percentage of water hyacinth

Contents	Control feed (0% WH)	Feed 1 (10% WH)	Feed 2 (15% WH)	Feed 3 (20% WH)	Feed 4 (25% WH)
$Digestibility^{dm}$	68.09±0.23[a]	65.16±0.03[b]	62.29±0.02[c]	60.47±0.32[d]	50.36±0.76[e]
$Digestibility^{cp}$	92.07±0.53[a]	89.13±0.38[b]	84.83±0.34[c]	81.17±0.17[d]	60.47±0.27[e]
$Digestibility^{ge}$	79.30±0.10[a]	78.27±0.12[a]	7200±0.12[b]	67.33±0.33[c]	65.52±0.43[c]
$Digestibility^{cl}$	82.07±0.93[a]	76.20±1.42[b]	70.27±0.73[c]	66.83±1.12[c]	59.23±0.88[d]
$Digestibility^{cf}$	34.34±0.67[a]	32.73±0.37[a]	29.96±0.06[b]	28.27±0.19[b]	18.53±0.46[c]

Values in the same row followed by the same letters are not significantly different (p = 0.05), dm = Dry matter, cp = Crude protein, ge = Gross energy, ee = Ether extract and cf = Crude fiber; Mean±SE, n = 3

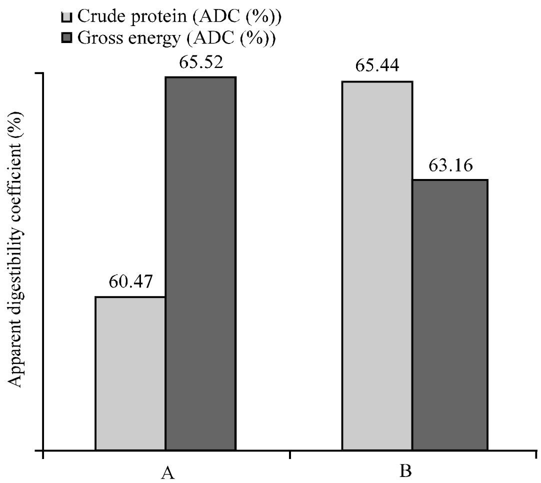

Fig. 1: ADCs comparison of crude protein and gross energy of test feeds incorporate with 25 and 26.72% whole plant water hyacinth, Echhornia crassipes fed to A. red tilapia (present study) and B. African catfish (Sotolu and Sule, 2011), respectively

hydrolyzing a great variety of carbohydrate-containing feedstuffs in comparison to carnivorous fish. Studies suggest that tilapias can digest carbohydrates better than catfish and carps (Degani and Revach, 1991). The ADCs of crude protein, gross energy and crude lipid were significantly higher as compared to ADCs of dry matter and crude fiber in all the groups tested (Table 3). It was also observed that ADC values for nutrients and gross energy decreased when WH meal in feeds increased from 0-25%. This could be because of the increased availability of insoluble fiber content in the feed tested in the present study with red tilapia.

Similar observations were reported by Hilton *et al.* (1983) and Shiau *et al.* (1989). This increased available insoluble fiber might have increased the stomach emptying time in fishes (Hilton *et al.*, 1983). Moreover, the binding capability of the dietary fiber might have affected the fish gut to absorb the nutrients including that of proteins (Shah *et al.*, 1982). Several other researchers also reported the low dry matter digestibility coefficients in plant meals with high carbohydrate contents (Allan *et al.*, 2000; Laining *et al.*, 2003). It has been found that the values of ADC of crude protein and gross energy of test feed 4 which was incorporated with 25% of WH meal in this study, look somewhat similar to ADCs values for the same nutrients as reported by Sotolu and Sule (2011) (Fig. 1). They prepared feeds incorporated with 26.72% of whole WH meal for African catfish, *Clarias gariepinus*. Irrespective of the variations in the quantity, source of feed ingredients and fish species tested in the present study and research by Sotolu and Sule (2011), the results reported by them strongly support the finding of the present study that the inclusion rate of WH meal >20% would ultimately raise the crude fiber content in the feed and certainly, this would negatively affect the ADCs of crude protein and gross energy of the fish.

CONCLUSION

The study indicates that fresh water hyacinth can be used at 20% inclusion level in red tilapia feed with accepted level of nutrients digestibility. This study would certainly give the future direction for the proper utilization of this free-floating perennial aquatic plant as a cheaply and readily available plant source material to replace slowly the global demand of fish meal.

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REFERENCES

AOAC, 1995. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemists, Arlington, VA., USA.

Allan, G.L., S. Parkinson, M.A. Booth, D.A.J. Stone, S.J. Rowland, J. Frances and R. Warner-Smith, 2000. Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus*: I. Digestibility of alternative ingredients. Aquaculture, 186: 293-310.

Cho, C.Y. and S.J. Kaushik, 1985. Effects of Protein Intake on Metabolizable and Net Energy Values of Fish Diets. In: Nutrition and Feeding in Fish, Cowey, C.B., A.M. Mackie and J.G. Bell (Eds.). Academic Press, USA, pp: 95-117.

Cho, C.Y., S.J. Slinger and H.S. Bayley, 1979. Apparent digestibility measurement in feedstuffs for trout. Proceeding of World Symposium on Finfish and Feed Technology, (SFFT'79) Heeinman, Berlin, pp: 239-247.

De Silva, S.S., R.P. Subasinghe, D.M. Bartley and A. Lowther, 2004. Tilapias as Alien Aquatics in Asia and the Pacific: A Review. FAO, Rome, ISBN: 9789251052273, Pages: 65.

Degani, G. and A. Revach, 1991. Digestive capabilities of three commensal fish species: Carp, *Cyprinus carpio* L., tilapia, *Oreochromis aureus* x *Oreochromis niloticus* and African catfish, *Clarias gariepinus* (Burchell 1822). Aquacult. Res., 22: 397-403.

Edwards, P., M. Kamal and K.L. Wee, 1985. Incorporation of composted and dried water hyacinth in pelleted feed for the tilapia *Oreochromis niloticus* (Peters). Aquacult. Res., 16: 233-248.

El-Sayed, A.F.M., 1999. Alternative dietary protein sources for farmed tilapia, *Oreochromis* spp. Aquaculture, 179: 149-168.

El-Sayed, A.F.M., 2003. Effects of fermentation methods on the nutritive value of water hyacinth for Nile tilapia, *Oreochromis niloticus* (L.) fingerlings. Aquaculture, 218: 471-478.

Eusebio, P.S., R.M. Coloso and R.E.P. Mamauag, 2004. Apparent digestibility of selected ingredients in diets for juvenile grouper, *Epinephelus coioides* (Hamilton). Aquacult. Res., 35: 1261-1269.

Falaye, A.E. and K. Jauncey, 1999. Acceptability and digestibility by tilapia, *Oreochromis niloticus* of feeds containing cocoa husk. Aquacult. Nutr., 5: 157-161.

Furukawa, A. and H. Tsukahara, 1966. On the acid digestion of chromic oxide as an index substance in the study of digestibility of fish feed. Bull. Jap. Soc. Sci. Fish., 32: 502-506.

Hilton, J.W., J.I. Atkinson and S.I. Slinger, 1983. Effect of increased dietary fiber on the growth of rainbow trout (*Salmo gairdneri*). Can. J. Fish Aquat. Sci., 40: 81-85.

Iluyemi, F.B., M.M. Hanafi, O. Radziah and M.S. Kamarudin, 2010. Nutritional evaluation of fermented palm kernel cake using red tilapia. Afr. J. Biotechnol., 9: 502-507.

Jauncey, K. and B. Ross, 1982. A Guide to Tilapia Feeds and Feeding. Institute of Aquaculture, University of Stirling, Scotland, UK.

Kirchgessner, M., H. Kurzinger and F.J. Schwarz, 1986. Digestibility of crude nutrients in different feed sand estimation of their energy contents for carp (*Cyprinus carpio* L.). Aquaculture, 58: 185-194.

Krogdahl, A., G.I. Hemre and T.P. Mommsen, 2005. Carbohydrates in fish nutrition: Digestion and absorption in postlarval stages. Aquacult. Sci., 11: 103-122.

Laining, A., Rachmansyah, T. Ahmad and K. Williams, 2003. Apparent digestibility of selected feed ingredients for humpback grouper, *Caromileptes altivelis*. Aquaculture, 218: 529-538.

MIDA, 2011. Report on food industry: Industries in Malaysia. Malaysian Industrial Development Authority, MIDA.

Maina, J.G., R.M. Beames, D. Higgs, P.N. Mbugua, G. Iwama and S.M. Kisia, 2002. Digestibility and feeding value of some feed ingredients fed to tilapia *Oreochromis niloticus* (L.). Aquauc. Res., 33: 853-862.

Shah, N., M.T. Atallah, R.R. Mahoney and P.L. Pellett, 1982. Effect of dietary fiber components on fecal nitrogen excretion and protein utilization in growing rats. J. Nutr., 112: 658-666.

Shiau, S.Y. and C.Y. Peng, 1993. Protein-sparing effect by carbohydrate in diets for tilapia, *Oreochromis niloticus* x O. *aureus*. Aquaculture, 170: 71-78.

Shiau, S.Y., C.C. Kwok, C.J. Chen, H.T. Hong and H.B. Hsieh, 1989. Effects of dietary fibre on the intestinal absorption of dextrin, blood sugar level and growth of tilapia, *Oreochromis niloticus* x O. *aureus*. J. Fish Biol., 34: 929-935.

Smith, R.R., 1979. Method for determination of digestibility and metabolizable energy of feedstuffs for finfish. Proceedings of world Sympsium on Finfish nutrition and Feed Technology, June 20-23, Berlin, Heenemann GMBH, pp: 453-459.

Sotolu, A.O. and S.O. Sule, 2011. Digestibility and performance of water hyacinth meal in the diet of African catfish (*Clarias gariepinus*; Burchell, 1822). Tropical Subtropical Agroecosyst., 14: 245-250.

Tal, S. and I. Ziv, 1978. Culture of Fishes in Israel. In: Culture of Exotic Fish, Smitherman, R.O., W.L. Shelton and J.H. Grover (Eds.). American fisheries Society, Auburn, pp: 1-9.

Usmani, N., A.K. Jafri and M.A. Khan, 2003. Nutrient digestibility studies in *Heteropneustes fossilis* (Bloch), *Clarias batrachus* (Linnaeus) (Burchell) and C. *gariepinus*. Aquacult. Res., 34: 1247-1253.

Welcomme, R.L. and C. Vidthayanom, 2003. The impacts of introductions and stocking of exotic species in the Mekong Basin and policies for their control. Mekong River Commission (MRC). MRC Technical Paper N 9, pp: 38. http://www.mrcmekong.org/download/free_download/Technical_paper9.pdf.

Zhou, Q.C. and Y.R. Yue, 2010. Effect of replacing soybean meal with canola meal on growth, feed utilization and haematological indices of juvenile hybrid tilapia, *Oreochromis niloticus* x *Oreochromis aureus*. Aquacult. Res., 41: 982-990.

Zhou, Q.C., B.P. Tan, K.S. Mai and Y.J. Liu, 2004. Apparent digestibility of selected feed ingredients for juvenile cobia *Rachycentron canadum*. Aquaculture, 241: 441-451.