Researching the Use of Palm Kernel Cake in Aquaculture Feeds

Ng Wing Keong*

INTRODUCTION

The production of aquatic animals, aquaculture, is currently the fastest growing animal production sector in the world. The rapid expansion of the aquaculture industry is most pronounced in Asia, which contributes about 90% of the total global aquaculture production (by weight). This increase in aquaculture production must be supported by a corresponding increase in the production of formulated diets for the cultured aquatic animals. For most aquaculture systems, the cost of feed constitutes 30% to 60% of the operational costs of the farm, with protein being the most expensive dietary component. Even though fish meal continues to be used as a major source of dietary protein in commercial aquafeeds, its escalating cost have stimulated much research into the use of alternative plant protein sources (El-Sayed, 1999). Among the plant proteins tested, soyabean meal has enjoyed the most commercial success. Tropical countries import a large volume of soyabean meal for use as a source of protein in the production of animal feeds.

In recent years, the cost of imported feed ingredients used in commercial aquafeeds in many developing countries in Asia has continued to rise due to increased global demand and fluctuation in foreign currency exchange. The rising costs of imported ingredients such as fish meal, soyabean meal, corn flour and wheat flour greatly cuts into the profit margins of local fish farmers to such an extent that many local aquaculture enterprises are no longer profitable. This is especially true for the culture of lower-value fish species such as catfish, tilapia and carps. There is currently a great interest within the animal feed industry to reduce costs by using locally available feed ingredients.

PALM KERNEL CAKE

The global production of palm kernel cake (PKC), a by-product of oil extraction from palm kernel, is ever increasing due to the tremendous growth of the oil palm industry in many parts of Asia and Africa (PORLA, 2000). In Malaysia alone, about 3 million tonnes of palm kernel were produced in 2001 producing about 1.4 million tonnes of palm kernel oil together with 1.6 million tonnes of PKC as its by-product. Currently, most of the PKC produced in Malaysia is exported at a low price to Europe for use as cattle feed concentrates in dairy cows. PKC is an established feed ingredient for ruminants, supplying valuable dietary sources of protein, energy and fibre. PKC has also been successfully tested in poultry and swine feeds at low levels of incorporation (Onwudike, 1986; Agunbiade *et al.,* 1999). The low cost and availability of PKC in many tropical countries where aquaculture is practiced have recently generated much interest in its potential use in fish diets. Very little information is currently available on the use of PKC in fish diets.

RESEARCHING THE USE OF PKC IN FISH DIETS

As with most plant-based and oilseed meal ingredients, several factors can limit the incorporation of PKC in fish diets. These include (1) relatively low protein content, (2) possible amino acid deficiencies, and (3) presence of anti-nutritional factors. The Fish Nutrition Laboratory at Universiti Sains Malaysia has initiated a series of experiments to attempt to enhance the nutritive value of PKC by dealing with each of these three major challenges so that higher levels of PKC can be incorporated into fish feeds.

* Fish Nutrition Laboratory,
School of Biological Sciences,
Universiti Sains Malaysia,
11800 Penang, Malaysia.
E-mail: wkng@usm.my

Increasing the Protein Content of PKC

One way to increase the protein content of PKC is by solid state fermentation with fungus. We have screened about 100 isolates of micro-organisms obtained from soil samples for the optimal formation of fungal biomass and protein content when cultured on PKC as the substrate. A fungus, which was later identified to be *Trichoderma koningii*, was selected as a potential microorganism. This process almost doubled the protein content of raw PKC, from about 17% to 32% crude protein (*Table 1*; Ng *et al*., 2002). Since *T. koningii* is a cellulolytic fungus, the reducing sugar content of the fermented PKC was also higher compared to that in raw PKC. Solid-state fermentation of PKC with *Aspergillus flavus* or *T. koningii* significantly improved the nutrient digestibility of PKC (Lim *et al.,* in press). However, when the fermented biomass was incorporated into tilapia diets, a marked reduction in fish growth was observed. We believe that despite the higher protein and digestibility of the fermented PKC, mycotoxins might have been released during the fermentation. Further studies are being planned to use mycotoxin adsorbers to alleviate this problem in the use of fermented PKC (Lim *et al.,* 2001).

TABLE 1. CHEMICAL COMPOSITION (% dry weight) AND REDUCING SUGAR CONTENT (mg g^{-1}) OF RAW AND TREATED PKC

Ingredient	Composition						
	Moisture	Crude protein	Crude lipid	Crude fibre	Ash	NFE[1]	RS[2]
Palm kernel cake[3]	11.43	16.86	6.82	15.12	6.58	54.62	2.87
Enzyme-treated PKC[4]	10.15	17.11	5.15	14.59	5.40	57.75	9.25
Fermented PKC[5]	6.67	31.27	3.36	14.51	11.34	39.52	8.09

Notes:
[1] Nitrogen-free extract = 100 – (crude protein + crude lipid + crude fibre + ash).
[2] Reducing sugar (mg g^{-1}).
[3] Obtained as a by-product of screw-press palm kernel oil extraction at Palmco Oil Mill, Penang, Malaysia.
[4] Palm kernel cake pre-treated with 0.1% Allzyme Vegpro™ for 3 hr. Use of a trade name does not imply endorsement or recommendation and is solely for the purpose of providing specific information.
[5] Palm kernel cake fermented under sterile condition with *Trichoderma koningii* inoculate for 21 days.

Figure 1. *Hybrid catfish.*

Another way to increase the protein content of PKC is to extract the protein using chemical and physical processes. Isolating proteins from PKC will essentially eliminate the problem of low nutrient digestibilities. Despite the high costs of such processes, we are currently conducting some initial studies to see if the protein isolate is of high enough nutritive value for high value marine fish such as seabass (Suhaimee *et al.,* unpublished).

Amino Acid Supplementation

Some studies have reported that amino acid supplementation can improve the growth of fish fed with plant-based diets. PKC is low in sulphur amino acids and probably lysine, which are essential amino acids for optimal fish growth. A feeding trial conducted with hybrid catfish (*Figure 1*) showed that up to 20% raw PKC could be incorporated in catfish diets without any negative effects on growth performance (Ng and Chen, 2002). However, at 40% PKC, growth was significantly depressed and this was not alleviated with the addition of 1.2% dietary L-methionine. One possible reason could be that methionine is not the first limiting essential amino acid in the PKC-based diets. Further studies involving the use of other essential amino acids and combinations thereof are currently being planned.

Utilization of Feed Enzymes

The low digestibility of PKC is commonly attributed to the high levels of non-starch polysaccharides (NSP) in the cell wall materials (Dusterhoft and Voragen, 1991). These anti-nutritional factors impair the digestibility and utilization of nutrients in PKC either by direct encapsulation of the nutrients or by increasing the viscosity of the intestinal content thereby reducing the rate of hydrolysis and absorption of nutrients in the diet. The adding of proteolytic, fibrolytic or carbohydrate-degrading enzymes to PKC-based diets have great potential in releasing unavailable nutrients and energy.

Studies have shown that tilapia fed PKC pre-treated with commercial feed enzymes consistently showed better growth and feed utilization efficiency compared to fish fed similar levels of raw PKC (Ng *et al.,* 2002). Up to 30% enzyme-treated PKC could be incorporated into red tilapia diets without significantly depressing growth. However, direct inclusion of exogenous enzymes in diets for tilapia has so far not been successful (Ng and Chong, 2002). Research is currently being carried out in our laboratory to further optimize the use of feed enzymes in PKC-based diets, varying parameters such as the type, levels and application method (direct, pretreatment, post-extrusion coating).

CONCLUSION

Initial laboratory studies on the use of PKC in tilapia and catfish diets have generated encouraging results with fish growing well on dietary levels as high as 20%. Studies with grass carp were even more encouraging in terms of higher levels of raw PKC being used in their diets (Ng and Teoh, unpublished data). It is anticipated that with further research on enhancing the nutritive value of PKC, this low cost locally available oilseed meal can be used as a viable partial substitute for many of the imported feed ingredients resulting in savings in feed costs for local fish farmers. Pilot scale feeding trials under commercial fish farm settings must be conducted to further evaluate the potential of PKC as an ingredient in aquaculture feeds.

REFERENCES

AGUNBIADE, J A; WISEMAN, J and COLE, D J A (1999). Energy and nutrient use of palm kernels, palm kernel meal and palm kernel oil in diets for growing pigs. *Animal Feed Science and Technology, 80*: 165-181.

DUSTERHOFT, E M and VORAGEN, A G J (1991). Non-starch polysaccharides from sunflower (*Helianthus annuus*) and palm kernel (*Elaeis guineensis*) meal – preparation of cell wall material and extraction of polysaccharide fractions. *J. Science Food Agriculture, 55*: 411-422.

EL-SAYED, A F M (1999). Alternative dietary protein sources for farmed tilapia, *Oreochromis* spp. *Aquaculture, 179*: 149-168.

LIM, H A; NG, W K; LIM, S L and IBRAHIM, C O (2001). Contamination of palm kernel meal with *Aspergillus flavus* affects its nutritive value in pelleted feed for tilapia, *Oreochromis mossambicus*. *Aquaculture Research, 32*: 895-905.

LIM, H A; BAI, S C C and NG, W K. Apparent nutrient digestibility and amino acid availability of several novel protein sources for tilapia, *Oreochromis mossambicus. J. Aquaculture in the Tropics.* In press.

NG, W K; LIM, H A; LIM, S L and IBRAHIM, C O (2002). Nutritive value of palm kernel meal pretreated with enzyme or fermented with *Trichoderma koningii* (Oudemans) as a dietary ingredient for red hybrid tilapia (*Oreochromis* sp.). *Aquaculture Research, 33*: 1199-1207.

NG, W K and CHEN, M L (2002). Replacement of soybean meal with palm kernel meal in practical diets for hybrid Asian-African catfish, *Clarias macrocephalus* x *C*. *gariepinus*. *J. Applied Aquaculture 12*: 67-76.

NG, W K and CHONG, K K (2002). The nutritive value of palm kernel meal and the effect of enzyme supplementation in practical diets for red hybrid tilapia (*Oreochromis* sp.). *Asian Fisheries Science, 15*: 167-176.

ONWUDIKE, O C (1986). Palm kernel meal as a feed for poultry: 1. Composition of palm kernel meal and availability of its amino acids to chicks. *Animal Feed Science and Technology, 16*: 179-186.

PORLA (2000). *Palm Oil Statistics.* Ministry of Primary Industries, Kuala Lumpur, Malaysia.