Use of Palm Kernel Cake and Oil Palm By-Products in Compound Feed

M Wan Zahari* and A R Alimon**

INTRODUCTION

Compound feed is a mixture of feed ingredients obtained from various sources. A feed ingredient is only a constituent of a compound feed and if used as the sole ration fed, has to be enriched further. The composition of a compound feed is determined by three main criteria, *i.e.* price, nutritional composition and the animal characteristics. The nutritional composition of a compound feed varies depending on the type of livestock to be fed and on their stages of growth. This paper highlights the use of palm kernel cake (PKC) in compound feed for feeding livestock in Malaysia.

PKC UTILIZATION IN BEEF CATTLE AND BUFFALOES

PKC is widely used as the main ingredient in rations for feedlot cattle and buffaloes. In Malaysia, feedlot cattle are normally fed up to 80% PKC with live weight gain (LWG) of 0.6-0.8 kg day^{-1} and 1-1.2 kg day^{-1} for local (Kedah-Kelantan) and crossbred cattle respectively. PKC at almost 100% has been fed to feedlot cattle with no negative effect provided that the supply of Ca and vitamins (in particular, A, D and E) is sufficient to meet their requirements. Many studies have shown that supplementing the traditional rations of beef cattle with 30%-50% PKC gave improved performance and increased LWG. It is a common practice in Malaysia to produce complete feeds based on PKC, either as pellets, cubes or total mixed ration (TMR). Apart from PKC, other common ingredients are rice bran, brewer's grain, palm oil mill effluent (POME), tapioca waste, urea, salt and minerals (Wan Zahari *et al.,* 2000; 2003). Carcass analysis indicated that the beef cuts were of superior quality when compared to those for cattle fed on grass or pasture. An example formulation for beef cattle is PKC: 80%, grass/hay: 17.5%, limestone: 1.5% and mineral premix: 1.0%.

PKC UTILIZATION IN DAIRY CATTLE

In dairy cattle rations, PKC is used as a source of energy and fibre at the inclusion level of 30%-50%. PKC-based dairy cattle pellets are popular in Malaysia and are commonly fed together with grass and other concentrates. Grass and concentrates are fed at 50%-70% inclusion apart from PKC. Under Malaysian local conditions, a milk yield of 10-12 litres day^{-1} head^{-1} can be achieved and with good formulation even higher yields. Other common ingredients in rations, for dairy cattle are rice bran, brewers grain, palm oil sludge (POS) and POME, soyabean waste, bakery waste, salt and minerals. In some areas, grass and other forages high in protein are given *ad libitum.* An example of dairy cattle feed formulation is PKC: 50%, molasses: 5%, grass/hay: 42%, limestone: 1.5%, mineral premix: 1.0% and salt: 0.5%. Most of the PKC exported to Europe are used in dairy cattle rations, but the level of inclusion is rather limited, *i.e.* about 7%-15%.

PKC UTILIZATION IN SHEEP AND GOATS

The recommended inclusion level of PKC in sheep rations is 30%. Long-term feeding of PKC at high inclusion level (>80%) can cause Cu toxicity in sheep as sheep is known to be very susceptible to Cu poisoning. Some sheep breeds (especially crossbreds) accumulate Cu in their liver causing liver damage. Addition of 100 ppm of zinc sulphate or 5.2 mg kg^{-1} ammonium molybdate together with 440 mg kg^{-1} sodium sulphate in the rations can overcome the problem (Hair-Bejo, 1995). Cu toxicity does not appear in cattle, buffaloes, goats and other animals. An example of feed formulation for goat is PKC: 50%, grass/hay: 30%, rice bran: 10%, soyabean meal: 9%

* Strategic Livestock Research Centre, Malaysian Agricultural Research and Development Institute, P. O. Box 12301, General Post Office, 50774 Kuala Lumpur, Malaysia.
E-mail: wzm@mardi.my
**Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

and mineral premix: 1.0%

PKC UTILIZATION IN POULTRY

Owing to its high fibre content, the use of PKC in poultry rations is very limited. There exist wide variations in the optimum inclusion level of PKC in poultry rations. The main reasons are due to the origin and variations in the oil and shell content of the PKC used. Broilers can tolerate up to 20% PKC in their diets without affecting their growth performance and feed efficiency (Yeong, 1980). A feed conversion ratio of 1:0.48 was reported for broilers fed palm kernel expeller (PKE) at 35 days of age (Onifade and Babatunde, 1999). In layer rations. PKC can be included up to 25% without any deleterious effects on egg production and quality (Radim *et al.,* 1999). Inclusion of PKC at levels >20% was reported to reduce egg production and egg quality (Yeong *et al., 1*981) but in another study, reduced egg production was observed only at levels >40% (Onwudike, 1988). Muscovy ducks can be fed PKE at 30% level without any deleterious effects on their performance (Mustafa *et al*., 2002). Apart from PKC, the locally available raw materials normally used in mixing feed for poultry are rice bran, wheat pollard, sago, tapioca and broken rice.

Examples of poultry formulations are as follows: (i) for broilers (finisher diet): PKC: 20%, palm oil: 6%, maize: 39.8%, soyabean meal: 25%, fish meal: 5%, lucerne leaf meal: 2%, dicalcium phosphate: 1.5%, salt: 0.25%, vitamin-mineral premix: 0.30 and DL-methionine: 0.15%. (ii) for layers: PKC: 20%, palm oil: 2%, maize: 45.4%, soyabean meal: 14.5%, fish meal: 7.0%, lucerne leaf meal: 20%, dicalcium phosphate: 1.5%, limestone: 3%, oyster shell: 4.0%, vitamin-mineral premix: 0.3% and salt: 0.3% and (iii) for meat ducks: PKC: 25%, palm oil: 5.3%, maize: 45.1%, soyabean meal: 17.3%, fish meal: 3%, salt: 0.25%, dicalcium phosphate: 1.56%, limestone: 0.12, DL-methionine: 0.06% and lysine: 0.06%.

PKC UTILIZATION IN SWINE

PKC is also suitable for swine at 20%–25% inclusion for growers and finishers. In some areas in Peninsular Malaysia, PKC is used at lower levels (about 5%-10%). An example formulation for swine is PKC: 20%, maize: 65.5%, soyabean meal: 9.5%, fish meal: 3%, dicalcium phosphate: 1.5%, mineral premix: 0.2% and salt: 0.3%. In Nigeria, PKC is fed to swine at from 15%-40% without any negative effects on performance (Codjo *et al.,*1995). In Ghana, PKC was included at 25%–35% in the rations of grower and finisher pigs, respectively (Rhule, 1996).

PKC UTILIZATION IN AQUACULTURE

Research on the use of PKC in aquaculture feed in Malaysia is very limited. Earlier studies indicated that PKC can be tolerated up to 30% in catfish (*Clarias gariepinus*) and 20% in tilapia (*Oreochromis niloticus*) rations with no deleterious effects on growth and performance (Sukkasame, 2000; Saad e*t al*., 1994). An example formulation for African catfish is PKC: 30%, fish meal: 20%, cassava flour: 15%, soyabean meal: 31%, sago: 1%, minerals and vitamins: 2% and vegetable oil: 1%.

RECOMMENDED LEVELS OF PKC IN LIVESTOCK RATIONS

Table 1 summarizes the recommended levels of PKC in livestock rations. Although studies have shown that PKC can be fed at levels up to 100% in ruminants, it is recommended that PKC be given only at levels ranging from 50%–80%, especially for beef cattle. It is important to include grass or hay or other fibrous resources at levels between 10%-15% in order to overcome the occurrence of metabolic diseases or digestive disorders in ruminants. Special attention needs to be given to Ca supplementation when utilizing PKC at high levels owing to the low Ca: P ratio in PKC. Limestone (calcium carbonate) is the most appropriate Ca supplement to be used as it is cheap and easily available. Most important is to ensure that the ratio of Ca: P in the rations is within 1:1 to 3:1 in order to overcome skeletal deformities. Sodium chloride, vitamins A and D should be supplemented at the appropriate levels to meet requirements. Feeding PKC at 100% inclusion level may cause wet faeces and digestive disorders. Addition of grasses or other forages will reduce the rate of passage of PKC in the gastrointestinal tract of ruminants so that retention and digestibility of nutrients are increased. On the other hand, dairy cattle need high fibre to encourage chewing, hence, salivation, which is important in maintaining the rumen pH. Furthermore, crude fibre plays an important role in the production of acetic acid in the rumen, which is required for milk fat synthesis. Inclusion of PKC has been shown to increase milk fat in dairy cows.

The recommended level for sheep is less than 30% and goats is between 30%-50%. Supplementation of Mo or Zn and S is necessary to overcome Cu toxicity in sheep, especially when PKC is fed at higher levels (>70%). Goats generally can tolerate higher levels of PKC in their diets as the occurrence of Cu toxicity is rare. The optimum levels for broiler chickens, layer chickens and ducks appear to be 20%, 25% and 30%, respectively. Higher levels of PKC in poultry rations may result in energy deficiency due to the high fibre content. It is anticipated that an inclusion level of 10%-20% is safe for freshwater fish.

TABLE 1. RECOMMENDED LEVELS OF PKC* IN LIVESTOCK FEEDS

Livestock	Recommended level (%)
Beef cattle	50 – 80
Dairy cattle	30 – 50
Sheep	Maximum 30
Goat	30 – 50
Poultry – broiler	15 – 20
Poultry – layer	15 – 25
Swine	15 – 25
Freshwater fish	10 – 20

Note: *Specification based on MEOMA Standard.

CURRENT RESEARCH ON THE UTILIZATION OF PKC FOR POULTRY FEEDING

In Malaysia, studies related to the degradation of fibre components in PKC for poultry feeding are in progress. Several methods are used which include improving the availability of energy through fungal treatment and the use of enzymes (such as mannanase to degrade mannose) (Noraini *et al*., 1999; 2002). Commercially available enzymes can hydrolyze only limited amounts of mannan in PKC (Mohd Jaafar *et al.,* 1997) and a pre-treatment on PKC is necessary before it can be used as poultry feed (Mohd Jaafar and Jarvis, 1991). Enzymic depolymerization of PKC releases digestible sugars that can be fully absorbed and metabolized by monogastric animals. Chemical treatments using sodium hydroxide and formaldehyde have also been investigated but with variable results.

UTILIZATION OF OTHER OIL PALM BY-PRODUCTS FOR COMPOUND FEED

Apart from PKC, there are several by-products from the oil palm industry, which can be used as components in compound feeds. These include oil palm fronds (OPF), palm press fibre (PPF) and POME. These by-products are obtained either during harvesting of the fruits, extraction of palm oil or refining of palm kernel oil (PKO). Many of these by-products need further processing before they can be used effectively in livestock rations. Information on chemical compositions, nutritive values, improvement methods and feeding responses of ruminants fed oil palm by-product-based diets available and widely documented (*Table 2*) (Wan Zahari *et al*., 2003). Compound feeds based on OPF and PKC have been successfully processed as pellets and cubes. OPF alone is a good source of fibre (containing about 45% CF) with a nutritive value generally between straw and hay. Optimum inclusion level in the rations for beef and dairy animals is 30%. With good formulations, LWG and milk yields of 0.6-0.8 kg day^{-1} and 22 litres day^{-1}, respectively, can be maintained. OPF–PKC-based cubes are generally preferred to OPF–PKC pellets as the longer fibre length in the former allows a better rumen fermentation environment, resulting in better performances.

A low cost fattening programme in beef cattle can be developed based on PKC and PPF with LWG between 0.60-0.75 kg day^{-1}. A simple feedlot ration containing 30% PPF is the most economical for beef steers feeding because of its lowest cost per kilogramme LWG. Rations containing 50% PPF and 30% PKC for dairy cattle provide the cheapest source of energy compared with other commercial available cattle pellets on an equal starch equivalent. At higher levels of inclusion, the use of PPF can result in bolus formation and impairment of rumen activity.

Combining PKC with POME can partly provide complete-based diets for low cost feeding systems, particularly fattening rations for beef cattle. The use of 50% PKC, 30% OPF and 20% POME, for example, can produce a reasonably good diet for moderate growth rate and acceptable meat quality in beef cattle. On the other hand, a combination of POME and sago meal (40%:45%) has successfully been used for feeding local sheep with LWG between 59.1-64 kg in the males and 50.5-54.3 kg in the females. Field trials with cattle and pigs in estates have shown improved LWG with PKC-POME feeding. Satisfactory gains of between 0.18 to 0.43 kg day^{-1} and 0.47 to 0.78 kg day^{-1} for buffaloes and cattle, respectively, were obtained with PKC-POME-PPF-based diets.

Optimum POME levels in diets for broilers and layers are 15% and 10%, respectively. The level has also been confirmed with studies on pigs. The value of POME in diets for poultry and pigs is dependent on perfect nutrient balance, of which the high ash content is critical. Local and Peking ducks can utilize 10% POME efficiently without exhibiting any adverse effect on growth and feed efficiency.

In Malaysia, CPO is traditionally used at 5% level in diets for pigs and poultry as a source of vitamins A and D and to reduce the dustiness of rations. Higher levels of CPO of up to 10% have also been used successfully in diets for

TABLE 2. CHEMICAL COMPOSITION OF PALM PRESS FIBRE (PPF), PALM OIL MILL EFFLUENT (POME) AND OIL PALM FRONDS (OPF)

Nutrient	PPF	POME	OPF
Dry matter (%)	86.2	91.1	36.4
Crude protein (%)	5.9	11.1	5.8
Crude fibre (%)	48.6	17.0	44.8
Ether extract (%)	5.8	12.0	1.2
Ash (%)	3.3	9.0	6.6
N-free extract (%)	36.5	50.5	43.3
Ca (%)	0.32	0.70	0.55
P (%)	0.27	0.50	0.09
TDN (%)	29.8	45.0	35.1
ME (MJ kg^{-1})	4.02	6.52	4.90

growing and finishing pigs in Malaysia and Africa. The percentage of lean cuts and back-fat measurements are increased with increasing levels of CPO. In lactating cattle, supplementation of 2%-8% of CPO in compound feeds increases both the yield and content of milk fat.

UTILIZATION OF RUMEN PROTECTED FATS IN COMPOUND FEED

Other locally available oil palm-based by-products of importance are targeted at increasing dietary energy content and improving nutrient digestibility. The vast majority of today's market for by-pass fats consumption is the dairy cow. High producing cows, especially in early lactation, are typically in negative energy balance. The loss in appetite and the effect on live weight caused by the dietary nutrient intake being insufficient to meet the demands of milk output, will subject the high yielding cow to considerable weight loss over the first 60-80 days of lactation and this can have substantial effects on its subsequent performance. Consequently, the cow mobilizes its body reserves such as body fat to meet the energy demand. Fats (free oils) in their crude form have only limited application in ruminant feeds because they become hydrolyzed in the rumen into free fatty acids, which may cause many problems. The greatest of these is in their tendency to reduce greatly the rate and level of fibre digestion in the rumen.

There are several protected fats available in the market, which include formaldehyde protected fat, calcium soaps, calcium salts and palm fatty acid distillate (PFAD). Some of these products are oil palm-based and can be used as ingredients in compound feeds, especially for dairy animals. In Europe, PFAD or Optifat (rumen by-pass fat) have been well received as one of the dietary ingredients in making compound feeds for beef and dairy cattle.

CONCLUSION

PKC has been shown to be a very promising source of energy and protein in the compound feeds for ruminants and non-ruminants. PKC is a high energy source and is a cost-effective ingredient to be utilized in ration formulations for various livestock. The abundant availability of PKC in Malaysia throughout the year is well suited for increasing the domestic beef and milk supply. PKC-based compound feeds either in the form of pellets or cubes, as well as TMR, continue to be popular for livestock feeding in Malaysia. Beef production utilizing PKC-based diets is more economical under local dietary and management systems compared to non-PKC-based diets. The optimum inclusion levels of PKC in the rations as well as example formulations for beef cattle, dairy cattle, sheep, goats, poultry, swine and freshwater fish are given for references if PKC is going to be utilized as an ingredient in the compound feeds. The availability of other oil palm by-products like PPF, OPF and POME provides avenues for more practical and cost-effective rations combined with PKC. Specialty fats can be used to boost the energy content in PKC-based feed for dairy products. The most important benefit to be gained from increasing utilization of palm oil by-products is the substantial savings that can be made on the total feed bill for livestock in Malaysia. Improvement in feed efficiency with accelerating use of local feedstuffs represents a potential area of application to reduce this high cost. Increased utilization of feedstuffs from the oil palm, in particular PKE, and improved nutrition management offer challenging opportunities in Malaysia.

REFERENCES

CODJO, A B (1995). *Proc. of the First Symposium on Integration of Livestock with Oil Palm Production* (Ho, Y H; Vidyadaran, M K and Sanchez, M D eds.). Malaysian Soc. Anim. Prod. p. 91-94.

MOHD JAAFAR, M D; SAMAD, N and RASOL, S (1997). *Proc. of the 19th Malaysian Soc. Anim. Prod*. Johor Bahru. p. 137-138.

NORAINI, S; MOHD JAAFAR, D; AHMAD, A and SEVAGAM, P (1999). *Proc. of the 23rd Malaysian Soc. Anim. Prod.* Langkawi. p. 176-177.

NORAINI, S; SURAINI, A A and GAN, S H (2002). *Proc. of the 24rd Malaysian Soc. Anim. Prod*. Pulau Pinang. p. 39-40.

MUSTAFA, M F (2002). Personal communication.

NWOKOLO, E N; BRAGG, D B and SABEN, H S (1977). *Tropical Sci., 19*: 147-154.

ONWUDIKE, O C (1988). *Anim. Feed Sci. and Technol., 20: 279-286.*

RADIM, D; ALIMON, A R and YUSNITA, Y (2000). *Proc. of the 22nd Malaysian Soc. Anim. Prod.* Kota Kinabalu. p. 177-178.

SAAD, C R; CHEAH, C H and KAMARUDDIN, M S (1994). *Science and Technol. Cong.* 15 -18 August 1994, Kuala Lumpur. p. 167-171.

WAN ZAHARI, M; O M ARIFF; I MOHD SUKRI; A, OSHIBE and H HAYAKAWA (2000). *Third Asean Buffalo Congress*. Kandy, Sri Lanka. p. 8.

WAN ZAHARI, M; ABU HASSAN, A; WONG, H K and LIANG, J B (2003). *Asian-Aust. J. Anim. Sci. 2003, Vol. 16, No. 4*: 625-634.

YEONG, S W (1980). *Proc. of the Conf. Anim. Prod. and Health in the Tropics*. p. 217-222.

YEONG, S W; MUKHERJEE, T K and HUTAGALUNG, R I (1981). *Proc. of the National Workshop on Oil Palm By-Product Utilization.* 14-15 December 1981. p.100-107.