Feature Article

Application of Palm Kernel Cake for Livestock Animals

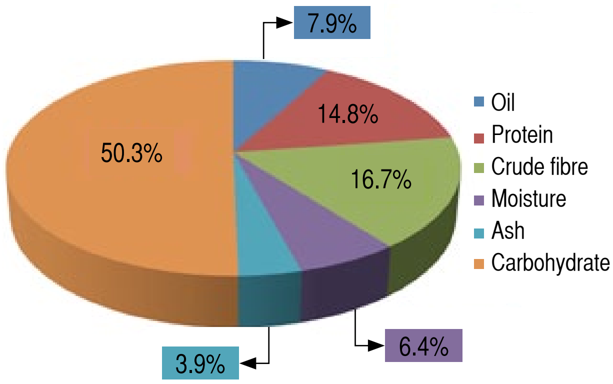
Mohd Firdaus Othman* and Rohaya Mohammed Halim*
*Malaysian Palm Oil Board (MPOB),
6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia.
E-mail: fidos@mpob.gov.my

INTRODUCTION

Palm kernel cake (PKC) is the residue left after oil extraction from palm kernel through mechanical process using screw press, which is abundantly produced throughout the year in kernel crushing plant. In 2019, the amount of PKC produced from 19.86 million tonnes of crude palm oil (CPO) was 2.59 million tonnes (Ghulam *et al.,* 2020; Malaysian Palm Oil Board, 2020). Hence, PKC is mostly traded globally as animal feed but its acceptance level varies due to chemical compositions and animal digestive system. For example, cow can accept up to 60% PKC, while layer and broiler chicken can tolerate up to 50% and 30% PKC, respectively. However, pigs have the least tolerance for PKC as it can only consume 5% PKC in their diet formulation. This articles provides an overview and potential application of PKC as part of raw material in animal feed formulation.

CHEMICAL COMPOSITION OF PALM KERNEL CAKE

Utilisation of PKC as feed for livestock animals mostly depending on its chemical composition, which is most likely varies according to type of oil palm fruits, palm kernel sources and extraction process (mechanical or solvent). According to Nuzul Amri (2013), PKC produced in Malaysia typically contains 7.9% oil, 14.8% protein, 16.7% crude fibre, 6.4% moisture, 3.9% ash and 50.3% carbohydrate as depicted in *Figure 1*. PKC also contains 15% dirt and shell content (Rohaya *et al.,* 2017) and the metabolisable energy of PKC is in the range of 1479–1792 kcal kg^{-1} as reported by Alimon (2004) and Sundu *et al.* (2005). Although PKC supplies both protein and energy, it has low metabolise energy for poultry due to high fibre content (Kperegbeyi and Ikperite, 2011).



Source: Nuzul Amri (2013)

Figure 1. Chemical composition of palm kernel cake.

APPLICATION OF PALM KERNAL CAKE IN CHICKEN FEED

PKC could be used to substitute conventional feed ingredients such as maize and soyabeans in poultry diets owing to their low cost and availability (Onuh *et al.,* 2010). However, the use of commercial PKC for chicken feed is currently limited due to the high fibre and shell content (Rohaya *et al.,* 2017), where fibre is accounted for 18%-21% (Lawal *et al.,* 2010). The insoluble mannose-based polysaccharide (mannan) in the fibre is not favourable for nutrient digestibility (Saenphoom *et al.,* 2013) for monogastric animals. Mannan possesses anti-nutritional property which hinders full nutrient utilisation of PKC, resulting in feed conversion ratio depression and reduction in weight gains by 20%-25% in monogastric animals (Dusterhoft and Voragen, 1991). Other factor that influences the limitation is lignin content (15%) originated from shells in PKC (O'mara *et al.,* 1999; Cerveró *et al.,* 2010).

Nevertheless, a few researchers have delved into the potential of PKC to be utilised in chicken feed. According to Ezieshi and Olomu (2004; 2008), the broiler chickens can be fed with 30% PKC in the starter diet to replace up to 50% corn without any negative effect on their growth performance. Besides, the feed intake and feed ratio to chicken growth was found to be higher in the PKC diet and this factor could increase feed cost per kg weight gain. Furthermore, broiler chickens could consume 30% PKC in finisher diet at 21 days age, substituting 50% soya as protein source (Ezieshi and Olomu, 2004; Okuedo *et al.,* 2006; Ezieshi and Olomu, 2008) (*Figure 2*). Besides, insignificant difference was reported between diets incorporated with PKC and without PKC on sensory analysis such as juiciness and meat texture (Okuedo *et al.,* 2006).

Figure 2. Broiler chicks can tolerate up to 30% palm kernel cake (PKC) in the diet.

A study by Perez *et al.* (2002) indicated that the layer chickens aged 18 weeks were fed with PKC up to 50% and surprisingly there were no differences observed in feed intake, mortality, feed conversion ratio (FCR) and weight of eggs in all PKC diets. However, 50% PKC inclusion in the diet exhibited adverse effect on egg production which could be due to high fibre content in PKC. Thus, it can be inferred that the inclusion of PKC in layer chicken diets should not be more than 50%. In another study, probiotics were included in the diets containing PKC for layer chicks and the results were promising as inclusion up to 1.0 g kg^{-1} probiotic has increased the body weight, haemoglobin concentration, leucocyte and lymphocyte (Ezema *et al.,* 2011). Moreover, layer chicks which consumed probiotics have laid eggs earlier at 18 weeks age compared to the chicks consuming control diet that laid eggs starting at week 20. The study also showed that the inclusion of probiotic has induced cell immunity mechanism in the layer chicks as the monocyte and eusinophyl counts were higher in the control diet than the diet with PKC.

On another note, Abiola and Adekunle (2002) utilised PKC from 18%-27% together with water melon skin to substitute 30% corn in the rooster chicken diets of 120 days old. It was found out that the diet containing 18% PKC and 10% watermelon skin gave negative results in terms of body weight gain, feed intake and feed efficiency as compared to the control diet (18% PKC only). This was because the increment of high polysaccharide in the chicken due to the inclusion of watermelon seed skin led to the decrease in the body weight gain. The presence of non-starch polysaccharide (NSP) contributes to the low digestibility of nutrient by poultry. To break down the NSP, supplementation of poultry diets with specific enzyme will facilitate the process (Joziefak *et al.,* 2004). Several studies have shown that enzyme inclusion on diets containing PKC could improve its nutritive quality and make it more available to poultry (Daud *et al.,* 1997; Chong *et al.,* 2008; Sekoni *et al.,* 2008). Supplementation of complex multienzymes at 0.05% had successfully increased weight, feed gain, total tract dry matter, fat and NSP digestibilities, and ileal fat digestibility in broilers chicken and rooster chicken (Meng and Slominski, 2005; Tisch, 2005; Slominski *et al.,* 2006). The enzymes contained 63 600 U/g xylanase, 48 300 U/g glucanase, 10 000 U/g pectinase, 10 900 U/g mannanase and 340 U/g cellulose. The enzymes were included up to 0.05% in broiler chickens and 1% in rooster chicken diets that contained soyabean of 32% (w/w) and 15% (w/w), respectively, in feed formulation (Slominski *et al.,* 2006). The enzyme complex also successfully increased true metabolise energy from 2717-3751 kcal kg^{-1} and fat digestibility in the rooster chicken.

In addition, fermented PKC through biological pre-treatment could lower the fibre content in PKC and thus could be given to broiler chicks up to 30% Noraini *et al.,* 2009; Mohd Firdaus 2014. Fermented PKC was included in the broiler chicks' diet and was given to the chicks for 21 days. However, it was found that the body weight gain (BWG), average daily gain (ADG), feed intake and FCR of broiler treated with 30% fermented PKC diet were 308.9 g per bird, 22.07 g per bird per day, 382.3 g per bird and 1.24, respectively, without significant difference relative to the broiler fed with the control diet (without PKC) which were 319.2 g per bird, 22.8 g per bird per day, 388.3 g per bird and 1.22, respectively.

APPLICATION OF PALM KERNEL CAKE INRUMINANT FEED

Nutritionally, PKC is an ideal feed for most ruminants due to the protein and crude fibre content in the range of 15%-20% (Chong *et al.,* 2008). Cows showed higher tolerance towards PKC compared to other livestock animals at 60% without deleterious effect on growth, average daily feed intake, body score and nitrogen digestibility (Umunna *et al.,* 1980). Daily body weight gain (DBWG) for calf that received 60% PKC basal diet was 0.41 kg higher than the control (0.31 kg). The FCR was 6.29, lower than the control (9.29) which indicated good acceptance on PKC (Umunna *et al.,* 1980). In contrary, goats and sheeps could not consume up to 90% PKC. The studies carried out on sheeps and goats fed with PKC up to 90% for 20 weeks showed fatality of animals due to copper toxicity (Hair-Bejo and Alimon, 1995; Akpan *et al.,* 2005). Anatomy analysis had been carried out and it was found out that high copper in the blood had led to enlargement of kidney, hepatic fibrosis on periportal and nicrosis inside epithelial tubule cell in cortex renal of the goat. According to Akpan *et al.* (2005), high level of copper was detected in the blood (3.02 µg ml^{-1}), heart (1058 µg g^{-1}) and cortex renal (430.5 µg g^{-1}) of lamb that was fed with 90% PKC. High copper level was also detected in heart (1089 ppm), testis (10.6 ppm) and blood plasma (0.63 ppm) of the Sumatran serow that was fed only with 60% (w/w) PKC and palm frond (Yaakub *et al.,* 2009).

To reduce copper toxicity in sheeps and goats, an addition of zinc with or without ammonium molibdate, *i.e.* 23 ppm ammonium molibdate with 600 mg kg^{-1} natrium sulphate, could reduce copper level to half in the organs and blood plasma (Hair-Bejo and Alimon, 1995; Yaakub *et al.,* 2009). Unfortunately, continuous usage of zinc could lead to increase in zinc concentration in the heart and kidney. Akpan *et al.* (2005) proposed a solution to eliminate zinc accumulation and to reduce copper through phytase inclusion. Phytase is important to increase phosphorus, protein, amino acid, carbohydrate and energy adsorption (Rani and Ghosh, 2011). Their study proved that the enzyme reduced copper level in the goat's blood by 1.97 µg ml^{-1}, inside the heart by 627.7 µg g^{-1} of copper and inside the renal cortex by 396.3 µg g^{-1} copper. Moreover, the phytase enzyme increased more body weight gain than PKC diet with zinc and the control diet which had corn, fish meal and grass in the formulation. The ADG for PKC diet with enzyme was 55.3 g, while PKC diet with zinc and PKC only were 50.3 g and 40.1 g, respectively (Akpan *et al.,* 2005). *Figure 3* shows feed formulated with PKC given to cow and Boer's goat.

APPLICATION OF PALM KERNEL CAKE IN OTHER ANIMALS FEED

Apart from poultry and ruminant, there were several studies conducted to evaluate the effect of PKC inclusion in other animals feed formulation. A study by Orunmuyi *et al.* (2006) reported that PKC could be given up to 30% to rabbits weighing an average of 922 g. PKC based diets were prepared from 0% to 40% and formulated isonitrogenusly with 20% crude protein. The findings showed that the daily feed intake and daily body weight gain of rabbits fed with PKC up to 30% did not differ from the control diet. In fact, there was no difference in carcass weight among all treatments. In another study carried out by Carrión *et al.* (2011), the inclusion of 20% PKC did not adversely affect the feed intake and energy digestibility for rabbits aged 35 days. Moreover, no mortality was

(a) (b)

Figure 3. Feed formulated with palm kernel cake (PKC) given to (a) cow and (b) Boer's goat.

recorded throughout the study. On the other hand, Ng and Chong (2002) studied the application of PKC in fish feed formulation to completely substitute soy. It was found that only 20% PKC could be included in the diet of small fish (*Oreochromis* sp.) with average weight of 8 g. Final body weight, weight gain and FCR for fish fed with 20% PKC were 30.5 g, 280.4% and 1.73 g, respectively, and there were no significant differences with the control diet (without PKC) in terms of final body weight (32.1 g), weight gain (300.3%) and FCR (1.63). In the study, 1.6% of enzyme was added into 40% PKC diet but the inclusion of the enzyme did not alter the growth and feed intake.

In contrary, pigs are among the animals that are less tolerant towards PKC than other livestock animal. In fact, pigs with average body weight of 25 kg could not consume 0.4% PKC as they showed low ADG and high FCR (Rhule, 1996; Adesehinwa, 2007). For pigs with the average body weight of 36.5 kg, they could tolerate up to 0.3% PKC inclusion only when the corn was fully substituted with PKC in the formulation (Adesehinwa, 2007). Although PKC reduces the feed cost per day and feed cost per kg live body weight, it only works on starter diet.

Finisher pigs with average body weight of 50.5 kg exhibited low acceptance of 5% PKC as the final body weight, ADG, growth performance and nutrient digestibility decreased (Ao *et al.,* 2011). Although Rhule (1996) stated that the ADG between control diet and PKC diet indicated no significant difference and the lowest FCR was obtained by PKC diet, the study only used a small quantity of PKC by 0.4% or 400 g kg^{-1}. In addition, there was no significant difference on pig's meat quality, meat color, sensory test and pH between the control diet and diet with 5% PKC (Ao *et al.,* 2011). The digestibility energy of pigs weighing between 40 kg and 76 kg did not increase although palm kernel oil was added up to 120 g kg^{-1} (Agunbiade *et al.,* 1999; Ao *et al.,* 2011). Nevertheless, enzyme could be added in PKC-based diet for pigs. In a study by Ao *et al.* (2011), cocktail carbohydrase enzymes were introduced between 0.1% and 0.2% in 5% PKC diet and the result showed that the final body weight, ADG and nutrient digestibility did not differ with the control diet without PKC. It was also found that there was no difference between PKC diet with without enzymes in terms of lymphocytes, white blood cells and red blood cells. Overall, the maximum tolerance level of PKC inclusion in livestock animals feed formulation is summarised in *Figure 4*.

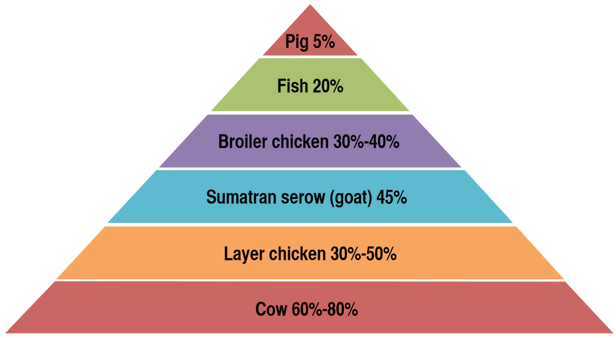


Figure 4. Maximum tolerance level of palm kernel cake (PKC) inclusion in livestock animals feed formulation.

CONCLUSION

In conclusion, numerous studies have been conducted on the effect of PKC on livestock animals and proved that most of livestock animals were able to consume PKC at their maximum tolerance level without negative impact on the growth performance of the animals. The potential use of PKC can also be extended to pets as there are several studies conducted on pets such as rabbits.

REFERENCES

Abiola, S S and Adekunle, A O (2002). Nutritive value of melon husk in the diet of chickens. *Bioresource Technology, 81(3)*: 265-267.

Adesehinwa, A O K (2007). Utilization of palm kernel cake as replacement for maize in diets of growing pigs: Effects on performance, serum metabolites, nutrient digestibility and cost of feed conversion. *Bulgarian J. Agricultural Science, 13*: 593-600.

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 Technology, 80*: 165-181.

Akpan, H D; Udosen, E O; Udofia, A A; Akpan, E J and Joshua, A A (2005). The effect of phytase and zinc supplementation on palm kernel cake toxicity in sheep. *Pakistan J. Nutrition, 4(3)*: 148-153.

Alimon, A R (2004). The nutritive value of palm kernel cake for animal feed. *Palm Oil Developments, No. 40*: 12-16.

Ao, X; Zhou, T; Meng, Q; Lee, J; Jang, H and Cho, J (2011). Effects of a carbohydrase cocktail supplementation on the growth performance, nutrient digestibility, blood profiles and meat quality in finishing pigs fed palm kernel meal. *Livestock Science, 137(1-3)*: 238-243.

Cerveró, J M; Skovgaard, P A; Felby, C; Sørensen, H R and Jørgensen, H (2010). Enzymatic hydrolysis and fermentation of palm kernel press cake for production of bioethanol. *Enzyme Microb Technol., 46(3-4)*: 177-184.

Carrión, S; De Blas, J C; Méndez, J; Caídas, A and García-Rebollar, P (2011). Nuritive value of palm kernel meal in diets for growing rabbits. *Animal Feed Science and Technology, 165*: 79-84.

Chong, C H; Zulkifli, I and Blair, R (2008). Effects of dietary inclusion of palm kernel cake and palm oil, and enzyme supplementation on performance of laying hens. *Asian-Aust. J. Anim. Sci., 21(7)*: 1053-1058.

Daud, M; Samad, J N and Rasool, S (1997). Specific commercial enzymes for nutritive value improvement of palm kernel cake of poultry diets. Proceedings of the 19th Malaysian Society of Animal Production (MSAP), Johor Baharu, Johor, Malaysia. p. 137-138.

Dusterhoft, E M and Voragen, A G J (1991). Non-starch polysaccharides from sunflower Helianthus annus) and palm kernel (*Elaeis guineensis*) meal preparation of cell wall material and extraction of polysaccharides fractions. *J. Sci. Food Agri., 55*: 411-422.

Ezema, C; Ihedioha, O C; Ihedioha, J I; Okorie-Kanu, C O and Kamalu, T N (2011). Probiotic effect of yeast (*Saccharomyces cerevisiae*) on haematological parameters and growth performance of pullets fed palm kernel cake based diet. *Comparative Clinical Pathology*. p. 1-4.

Ezieshi, E V and Olomu, J M (2004). Comparative performance of broiler chickens fed varying levels of palm kernel cake and maize offal. *Pakistan J. Nutrition, 3(4)*: 254-257.

Ezieshi, E V and Olomu, J M (2008). Nutritional evaluation of palm kernel meal types: 2. Effects on live performance and nutrient retention in broiler chicken diets. *African J. Biotechnology, 7(8)*: 1171-1175.

Ghulam, K A P; Elina, H; Soh, K H; Meilina, O A; Kamalrudin, M S; Mohd, N I Z Z B; Shamala, S; Zafarizal, A A H and Zainab, I (2020). Oil palm economic performance in Malaysia and R&D progress in 2019. *J. Palm Oil Res., Vol. 32(2)*: *159-190.*

Hair-Bejo, M and Alimon, A R (1995). The protective role of zinc in palm kernel cake (PKC) toxicity in sheep. *Malaysian J. Nutrition, 1*: 75-82.

Józefiak, D; Rutkowski, A and Martin, S A (2004). Carbohydrate fermentation in the avian ceaca. *Anim. Feed Sci. Technol., 113*: 1-15.

Kperegbeyi, J I and Ikperite, S E (2011). The effectiveness of replacing maze with palm kernel cake in broilers' starter diets. *J. Env. Issues and Agri. In Dev. Count., 3(1)*: 145-149.

Lawal, T E; Lyayi, E A; Adeniyi, B A and Adaramoye, O A (2010). Biodegradation of palm kernel cake with multienzyme complexes from fungi and its feeding value for broilers. *Int. J. Poult. Sci., 9(7)*: 695-701.

Meng, X and Slominski, B A (2005). Nutritive values of corn, soybean meal, canola meal, and peas for broiler chickens as affected by a multicarbohydrase preparation of cell wall degrading enzymes. *Poultry Science, 84(8)*: 1242-1251.

Malaysian Palm Oil Board (2020). Production of crude palm kernel oil and palm kernel cake. http://bepi.mpob.gov.my/index.php/en/production/production-2018/production-of-crude-palm-kernel-oil-2018.html

Noraini, S; Sarah, R; Mohd Fazli, F A; Rosnizah, I and Norham, I (2009). Response of young broiler chickens fed increasing levels of fermented palm kernel expeller (FPKE). Prosiding Seminar Kebangsaan Kedua Agro-Environment 2009. Malaysian Agriculture Research and Development Institute (MARDI). Johor Bahru.

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.

Nuzul Amri, I (2013). Characteristics of Malaysian palm kernel and its product. *J. Oil Palm Res., Vol. 25(2)*: 245-252.

Okuedo, N J; Onyike, I L; Okoli, C V and Chielo, I L (2006). Production performance, meat quality and feed cost implications of utilizing high levels of palm kernel cake in broiler finisher diets. *International J. Poultry Science, 5(12)*: 1160-1163.

O'Mara, P P; Mulligan, F J; Cronin, E J; Rath, M and Caffrey, P J (1999). The nutritive value of palm kernel meal measured in vivo and using rumen fluid and enzymatic techniques. *Livest Prod Sci., 60(2-3)*: 305-316.

Onuh, S O; Ortserga, D D and Okoh, J J (2010). Response of broilers chickens to palm kernel cake and maize offal mixed in different ratios. *Pakistan J. Nut., 9(6)*: 516-519.

Orunmuyi, M; Bawa, G S; Adeyinka, F D; Daudu, O M and Adeyinka, I A (2006). Effects of graded levels of palm-kernel cake on performance of grower rabbits. *Pakistan J. Nutrition*, *5(1)*: 71-74.

Perez, J F; Gernat, A G and Murillo, J G (2000). The effect of different levels of palm kernel meal in layer diets. *Poultry Science, 79*: 77-79.

Rani, R and Ghosh, S (2011). Production of phytase under solid-state fermentation using Rhizopus oryzae: Novel strain improvement approach and studies on purification and characterization. *Bioresource Technology, 102*: 10641-10649.

Rhule, S W A (1996). Growth rate and carcass characteristics of pigs fed on diets containing palm kernel cake. *Animal Feed Science Technology, 61*: 167-I72.

Rohaya, M H; Ridzuan, R; Che Rahmat, C M; Nu'man, A H; Nasrin, A B and Astimar, A A (2017). Highly digestible palm kernel cake (PKC) for animal feed. *MPOB Information Series, No.758*.

Saenphoom, P; Liang, J B; Ho, Y W; Loh, T C and Rosfarizan, M (2013). Effects of enzyme treated palm kernel expeller on metabolizable energy, growth performance, villus height and digesta viscosity in broiler chickens. *Asian-Australas J. Anim. Sci., 26(4)*: 537-544.

Sekoni, A A; Omage, J J; Bawa, G S and Esuga, P M (2008). Evaluation of enzyme (Maxigrain®) treatment of graded levels of palm kernel meal (PKM) on nutrient retention. *Pak. J. Nut., 7(4)*: 614-619.

Sundu, B; Kumar, A and Dingle, J (2005). Response of birds fed increasing levels palm kernel meal supplemented with enzymes. *Austr. Poult. Sci. Symp., 12*: 63-75.

Slominski, B A; Meng, X; Campbell, L D; Guenter, W and Jones, O (2006). The use of enzyme technology for improved energy utilization from full-fat oilseeds. Part II: Flaxseed. *Poultry Science, 85*: 1031-1037.

Tisch, D (2005). Animal feeds, feeding, nutrition and ration evaluation. Clifton Park, NY: Thomson Delmar Learning.

Umunna, N N; Yusuf, A A and Aganga, A A (1980). Evaluation of brewer's dried grains and palm kernel meal as major sources of nitrogen for growing cattle. *Tropical Animal Production, 5(3)*: 239-247.

Yaakub, H; Masnindah, M; Shanthi, G; Sukardi, S and Alimon, A (2009). The effects of palm kernel cake based diet on spermatogenesis in Malin x Santa-Ines rams. *Animal Reproduction Science, 115(1-4)*: 182-188.