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Prospect of Maximising Palm Kernel Cake Utilization for Livestock and Poultry in Malaysia: A Review

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Abstract
The main activity carried out by researchers all over the world is to complement existing idea with a more newer approach, capable to foster a sustainable development without compromising the generation ahead. Palm oil with its scientific name known as *Eleis guineensis* is one of the oil plant of commercial importance in Malaysia and some other tropical environments. The oil from this precious plant has always conferred many purposes to human life among which are soap making, nutritional benefit, biodiesel, soil fertilization and charcoal. Palm kernel cake as one of the left over product after oil extraction is available abundantly in Malaysia and the co-countries thereby contributing as alternative feed source to lower the cost of energy in animal nutrition. However, the ability of poultry animals to digest PKC is very limited. This article is therefore mean to describe palm oil plant and reviews the importance of PKC as source of feed ingredients and some of the factors limiting its inclusion level into poultry ration. It equally addresses earlier studies carried out on PKC and suggests possible solutions to improve more on its inclusion rate in livestock and poultry diet.
Keywords: Palm kernel cake, Livestock, poultry, Malaysia

1.0 Introduction

In any nation, livestock sector has always remained significant in agricultural development and to the growing economy. Feeds and feeding account for about 60 to 70 or even 80% of total farm overhead cost depending on the nature of livestock enterprise. Various manipulations have been adopted to minimize feed cost base on utilization of non-competitive locally available feed materials (Adesehinwa, 2007; Zahari et al., 2009). It has been recorded that high cost of food and conventional feed stuffs is due to a rise effect of grain materials to produce biofuel. Therefore, the prospect of livestock feeding base on grains diet is becoming a treat to livestock most especially for simple stomach animals. An effort made by researchers several years back to overcome such challenge is to substitute agro-industrial by-products (AIBP) with feed ingredients that are directly or indirectly competing with human (Boateng et al., 2013).

Palm kernel cake (PKC) as a case sample of AIBP is an important end-product of palm kernel oil (PKO) from the fruits of palm oil (*Elaeis guineensis*) which is readily available in many tropical environments among which are Nigeria, Malaysia and Indonesia. And the first feeding trials of this by-product for poultry was reported in 1940 (Onwudike, 1986). The utilization of fibrous feed materials for monogastric animals has been known to be a waste due to the fact that, non-starch polysaccharides (NSPs) have the potency to confer some anti-nutritive activity. It was revealed that most fibrous feed components found in PKC are NSP and β-Mannan (Sundu et al., 2006; Esuga et al., 2008). In this way, poultry cannot easily make use of such feed components for proper digestibility. However, the anti-nutritional factor associated with NSPs result to poor growth performance due to poor nutrient utilization by the animal.

The two most important feed ingredients in poultry ration are soya bean meal and corn. Malaysia is a country which is highly dependent on their importation for livestock feed particularly for simple stomach animals. Available data estimated that RM 2.5 billion was spent per annum on importation of livestock feed, with more than 50% is for corn (Wan Zahari et al., 2009). To solve the problem of this bulk importation of conventional feed materials, the focus of incorporating industrial by-products into the animal diets is a priority in Malaysia.

Owing to the fact that, Malaysia is among the world leading producer of palm oil, a huge amount of PKC is available and there is a need to efficiently use it in livestock and poultry industries as source of protein and energy. Though many research have been carried out to improve its nutritional value for animals over the last three decades and poultry can only tolerate 30% PKC into their diets while for larger ruminant animals could be up to 80%. Studies from the recent trend to maximize PKC utilization for poultry still remain inconsistent with no new further approval from MARDI. The efforts made by researchers for more improvement were focused on solid state fermentation of PKC and addition of exogenous enzymes. Apart from PKC, two other names ascribed to this by-product are palm kernel meal (PKM) and palm kernel expeller (PKE) and is extracted basically by means of two processing methods known as solvent extraction method and the mechanical process also referred to as screw press or expeller extraction method (Mohamad et al., 2012). Therefore the chemical composition of PKC varies depending on the method of extraction, source and the amount of left over endocarp (Rhule, 1996).

2.0 Brief description of palm oil plant

The scientific reports obtained from FAO (2009), stated that palm oil production is restricted to the tropical region and is mostly cultivated in Nigeria in Africa, Malaysia, Thailand and Indonesia in Southeast Asia, Colombia and Ecuador in South America together with Papua New Guinea in Oceania. However, the palm oil is known to be an ancient tropical plant from the rainforest area of West African. It is still being cultivated there as well as across the tropics (Corley & Tinker, 2007). Palm oil could first described as a perennial plant belonging to the genus *Elaeis*, family *Arecaceae*, order *Palmale*s, and *monocotyledonous* class. The plant has a life span of approximately 25 years and economic importance. Basically, there are two viable species (*E. guineensis Jacq*, and *E. oleifera Cortés*) of economic importance. The first derived its source from African while the later characterized by constant production all over the year round. The African type palm oil origin is commercially planted, by means of varieties of the *Tenera* kind and the American types has been used to an improve varieties so as to give rise to interspecific hybrids (*E. oleifera* × *E. guineensis*) particularly for plantations area exposed to a grave yellowing disorder.

Gunstone (2011), revealed that, the main fruit of palm is oval in shape and its weight could be up to 30 g. More so it develops into bunches bearing approximately 1500 fruits with the whole bunch weighing in an average of 20 to 30 kg and the ripped fruits can be harvested in an interval of 10 to 14 days. The two most important products obtained from this fruit of palm oil are cake and oil. The palm kernel oil is extracted from the endosperm (seed) while the palm oil is obtained from the mesocarp (pulp of the fruit), and the relative amount between the quantities obtained is averagely 1:9 ratios (palm kernel oil: palm oil). As a result, the cake is given out by oil processing from the seed with varying amount of 17–19% protein and reasonable level of bromatological values, mainly for ruminant feed as a result of high fiber content and is rich in glutamic acid and arginine (Henderson and Osborne, 2000).

The most conducive climatic environmental conditions for palm oil farming can be described as follow: a 5 to 7 hours daily insolation period, a least temperature ranging from 22 and 24°C, a daily radiation of 15 MJ/m2, a yearly rainfall above 2000 mm which is accurately distributed, with no significant dry season, plus at least 100 mm on monthly basis and finally a normal highest temperature ranging from 29 and 33 °C (Corley and Tinker, 2003).

3.0 Nutritional values of palm kernel cake

By the year 2050, the palm oil production has the tendency to provide adequate vegetable oil to meet the high global demand for food, and there is enough mass land for it plantation with no necessity for deforestation (Corley, 2009). Apart from producing oil from the palm and kernel, PKC is a major product derived from the palm oil and used for livestock feed. Palm kernel cake has been included as experimental trial into the diet of poultry and ruminant animals as indicated by various researchers: in poultry (Fadil et al., 2014; Onwudike, 1986, 1988; Yeong et al., 1981).

3.1 Palm kernel cake in poultry feeding

Quite a number of scientific reports discussed about the incorporation of PKC into poultry diet and few are mentioned in this review. Poultry is the common term applied to every tamed fowl and this includes turkeys, ducks, chicken etc. The essence of providing normal diet for poultry is to serve mainly for two purposes: firstly is derive energy for their body maintenance and secondly is to renew worn-out tissues. Poultry feed is made up made up of carbohydrates, water, fats, proteins, minerals and vitamins and every nutrient functions for a different requirement (Vest & Dale, 1999). Garcia et al. (2012) in their research paper investigated the effect of PKC in broiler's diet from day old chicks to 42 days at various inclusion rate (0. 10, 20 and 30%). It was observed that the carcass and feed conversion ration tends to reduce at higher inclusion level and higher mortality percentage was also recorded at 20 and 30% levels. The authors therefore suggested that 10% PKC could be incorporated to replace corn-soybean meal base diet without having major effect on carcass yield and the performance of broiler chicken.

Also a study was recently conducted in Malaysia by Fadil et al. (2014), to evaluate the feeding effects of PKC at three inclusion rate (0%, 15% and 35%), on the growth performance of Muscovy duck. The findings indicated no significant difference between 15% addition level and the control diet. Therefore the authors suggested that PKC could be added to Muscovy diet at a level of 15% to replace corn-soybean mean with no adverse effect on nutrients digestibility and growth performance.

Obviously it is clear that many studies have been conducted over the years to evaluate the effect of PKC in poultry ration and there is agreement that PKC can be used to replace corn-soybean meal base diet (Anaeto et al., 2009; Armas & Chicco, 1977; Bello et al., 2011; Ezieshi & Olomu, 2004 ; Loh et al., 2002; Ojewole & Uzuo, 2006; Okeudo et al., 2005; Onifade & Babatunde, 1998; Onwudike, 1986; Osei & Amo, 1987; Oyawoye & Bogoro 2011;Yeong et al., 1981; Yeong, 1983). It should however be noted that there is limitation about PKC inclusion level into the diet of monogastric animals due to its high fiber content. Yeong et al. (1981), revealed that when PKC is included higher than normal will, this impede egg quality and production. However, the optimum inclusion level of PKC into poultry diet is not constant and it is restricted at higher inclusion level due to its high shell content, higher fiber content and the NSP content.

3.2 Palm kernel cake in ruminants feeding

Scientific data revealed that, small ruminant like sheep could be fed with 30% PKC as the highest inclusion level into their diet with optimum performance. However, when sheep are fed higher than that, it will lead to Cu toxicity, due to the fact that sheep have been identified to be more prone to Cu intoxication (Hair Bejo et al., 1995; Al-Kirshi, 2004).To solve Cu poisoning that may lead to liver damages. Hair Bejo et al. (1995) indicated that adding 440 mg kg^{-1} sodium sulphate 5.2 mg kg^{-1} ammonium molybdate or 100 ppm of zinc sulphate into their diets can get rid of the toxicity.

In buffaloes, cattle, goats together with some other animals, Cu toxicity is not usually identified. But the persistent use of high PKC level in such animals may consequently lead Cu to accumulate in the liver. A case sample for goat diet formulation is given as follow: 30% grass/hay +50%PKC+ 9%soybean meal + 10%rice bran and1% mineral premix (Wan Zahari and Alimon, 2003). More so, PKC is known to be included into the diet of dairy cattle at a level of 30-50% as a source of protein and energy. In Malaysia, pelleted based PKC diets including grass plus other concentrates are generally given to feed dairy cattle (Abu Bakar et al., 2000). The ratio of concentrate to grass is approximately 30–50% : 50–70% (Chin, 2007). It was also reported that Malaysian dairy cattle have the potential to yield higher quality milk which close to 11 L head of cow^{-1} (Wan Zahari et al., 2000). Therefore, grass and other high quality protein forages are fed *ad libitum* in some areas to achieve such performance.

Alimon (2004) on his study illustrated a sample of a dairy cattle basal diet as 5%molasses + 50%PKC + 42% grass/hay +1.5% lime-stone +0.5% common salt +1%mineral premix . It should be noted that dairy cattle benefit more on larger amount of PKC brought to European countries, but15% is known to be the maximum inclusion in their diet.

4.0 Factors inhibiting the nutritional value of PKC

Polysaccharides can simply be defined as polymeric carbohydrate structures that are linked together by covalent bond known as glycosidic bonds. And cellulose is a name used to describe linear concentration polymer buildup of glucose units that are linked to each other with β-1,4-glycosidic bonds. The connection of this glycosidic structure normally behaves as a functional group, and this is next to the hydroxyl groups that essentially represent the properties of cellulotic compound. However, PKC was observed to have possessed 12% amount of cellulose and it should be noted that cellulose digestibility is very poor and at times remains indigestible in monogastric animals (Sundu & Dingle, 2003).

Hemicellulose is the arrangement of polysaccharides found in the cell wall of a given plant, in which lignin and cellulose are closely related. More so, hemicellulose is a combination of polymer consisting of sugars but generally sugar from a not glucose derivative. Furthermore, the monomers in hemicellulose comprise of 3 hexoses known as mannose, galactose and glucose and 2 pentoses known to arabinose and xylose. It should be noted that, the majority of main-chain sugars found in hemicellulose structure are connected to one another with β-1, 4-glycosidic bonds (Moreira & Filho, 2008). However, mannose is the largest component of hexoses found in PKC (Cerveróa et al., 2010 & Düsterhöft et al., 1992).

The classification of Hemicellulose is not the same base on the bedrock of main residual sugar, and examples are as follow: galactomannans, mannans, xylans, glucoronoxylans, glucans, arabinoxylans, glucomannans, galactoglucomannans, xyloglucans and β-glucans. PKC averagely consist of 78% mannans among all NSPs and 32.5% β-mannans base on dry matter. It was also observed that, mannans in palm kernel very well look like crystalline cellulose, solid and water insoluble. Again, mannans are generally located within the plant cell wall thereby impede nutrients utilization for better digestibility. This is normally achieved through the rise viscosity of the intestinal contents or by directly encapsulates nutrients. Therefore, this resultant effect leads to poor hydrolysis rate and nutrients intake (Sundu & Dingle 2003).

Cerveróa et al. (2010) stated that, the percentage PKC lignin content is averagely 15.1% and it is referred to as, a compounded fragrant heteropolymer consisting of phenylpropanoid aryl-C3 units, connected one another with a range of ether and C–C bonds that are generally sourced from wood, and an essential fraction of the secondary plant cell walls. The most important type of connection is the β-aryl ether connection, having an ether connection to a different aryl unit at C-2 of the C3 chain; the biphenyl connection, having an aryl C–C bond; the diarylpropane connection having a C–C bond on C-2 of the C3 chain to a subsequent aryl ring; the diarylether connection having an ether connection among 2 aryl rings; the phenylcoumarane connection having a dihydrofuran ring merged to an aryl unit; the pinoresinol connection having connected to form via 2 combined tetrahydrofuran rings (Bugg et al., 2011). It could however be seen that there is more lignin compare to both cellulose and hemicelluloses.

5.0 Chemical composition of palm kernel cake

Sundu et al. (2006) reported that dietary PKC possess the potential to provide energy and protein for poultry and livestock and its chemical constituent suggests that it can be categorized as an energy feed ingredient. Though the method of extracting oil from the kernel varies thereby reflecting on the nutritional quality of PKC. It was however noted that, the solvent-extracted PKC contains less oil compared to the mechanically-extracted PKC. O'Mara et al. (1999) revealed a range values of 0.5 – 3 % for PKC that was chemically extracted and 5 to 12 % for expeller pressed. The chemical composition of PKC is not constant (table 1) and this usually depends on the processing mode. Therefore other nutrients, like CP and minerals tends to become poor in expeller-pressed PKC.

6.0 Palm kernel cake and recent trend of research activities

The incorporation of PKC into the ration of livestock and poultry has been accepted all over the world, and the past three decades recorded more than hundred publications. The main limiting factor for PKC utilization is still the high NSPs content associated with it. It should be noted that various attempts have been made to maximize PKC utilization for livestock and poultry and these include PKC chemical treatment (A'dilah & Alimon, 2011; Chenost & Kayouli, 1997) and biological treatment (Chong et al., 2008; Dairo and Fasuyi, 2007; Dusterhoft & Voragen, 1991; Lawal et al., 2010 and Saenphoom et al., 2011). However, the recent trend of research activities on PKC is the addition of exogenous enzymes capable to breakdown fibrous feed materials and this approach attracted many audiences in relation with monogastric animals like poultry.

Previous effort made by scientists in Malaysia postulated that, broilers can tolerate 30% PKC inclusion level with no harmful effect when it undergoes a fermentation process. It was also observed that, when PKC is fermented with *Aspergillus niger*, the true metabolizable energy increased by 2.6 ME/kg from (5.5 MJ ME/kg to 8.1 MJ ME/kg) (Abdul Rahman et al., 2010). Again, the inorganic PKC treatments by means of formaldehyde and sodium hydroxide have been as well studied, but there is need for more investigations due to inconstancy in results (Wong et al., 2009).

A study conducted by Dairo and Fasuyi (2007), to partially replace the solid state fermentation of PKC with soybean meal at various inclusion level (25, 50 and 75%). When the experimental diets were fed to laying hen, the results indicated a significant improvement on growth performance. And the authors found out that, the fiber content in PKC reduced from 15.47 to 12.44% while the protein level increased from 20.04 to 23.42%.

More so, Sundu and Dingle (2003) basically incorporated three enzymes in trying to improve the overall nutritive value of PKC with their main aim was to reduce the high fiber content and to increase the protein level. These enzymes include α galactosidase, mannanase and celullase to digest the galactosidic, mannan and cellulose. Laboratory analysis of this nature of research have been conducted earlier by Balasubramaniam et al. (1976), as at then PKC and enzymes supplementation and the effects on animals have been studied extensively. Therefore the recent update was recorded that up to 25% PKC inclusion rate can be used in layers diet without affecting egg quality and production, and 20% PKC inclusion level can be tolerated for broiler chicken with no effect on their Feed Conversion Ratio FCR and growth performance (Yeong, 1987; Radim et al., 2000; Abu Hassan and Yeong, 1999).

7.0 Conclusion

In tropical livestock enterprises, feeds and feeding cost play a crucial role in determining the farmer's income. Malaysia as a country depends largely on the importation of corn for livestock feeding. In an effort to reduce the high cost related feed ingredients, PKC has been partially used to replace corn and soybean meal. Apparently PKC is made available abundantly in Malaysia plus other oil producing oil countries and its utilization in animal farming have drawn more attention.

Many efforts have been undertaken in trying to increase the CP content of PKC, minimize the fiber content and to improve its overall nutritive value. The most recent trend of such efforts is the incorporation of microbial enzymes to enhance nutrient utilization and for the past three decades there is no improvement on how to increase PKC supplementation particularly in poultry ration. Previous and recent studies have focused more on chemical and solid state fermentation of PKC with no regard to its particle size treatment. Since there is cogent publication about PKC particle size treatment, there is need for new direction as particle size may influence nutritional components of a feed ingredient. In the view of this, there is need for a new line of research interest in determining the chemical component of PKC physically treated into different particle sizes.

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Table1. Chemical composition of palm kernel cake source from different studies

Ingredients (%)	Alimon (2004)	Dairo & Farsuyi (2007)	Sundu et al. (2005)	Wan et al. (2000)
CP	14.5 – 19.6	20.0	14 - 23	17.2
CF	13.0 – 20.0	-	21 - 23	17.1
ADF	-	-	-	52.9
NDF	-	-	-	74.3
Ash	3.0 – 12.0	8.6	3 - 6	4.3
Dry matter	88.0 – 94.5	91.8	94	
Ether extract	5.0 -8.0	15.47	8 - 17	1.5
Phosphorus	0.48 – 0.7	-	-	-
Calcium	0.2 – 0.3	-	-	-
ME (MJ/Kg)				
Ruminant	10.5 -11.5		-	
Chicken	6.50 – 7.50	-	-	11.3
AA (g/16gN)				
Lysine	2.68	-	-	-
Methionine	1.75	-	-	-

Note: AA: amino acid; CP: Crude protein; CF: crude fiber; ME: metabolizable energy; NDF: Neutral detergent fiber; ADF: Acid detergent fiber