

Value of palm kernel co-products in swine diets

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Abstract

Recently, swine production costs have increased due to increased feed cost, especially the price of corn and soybean meals. Soybean meal is traditionally an expensive ingredient, but the price of corn has dramatically increased because of increased biofuel production. This change has resulted in the swine industry looking for alternatives in order to reduce feed cost, resulting in decreased production costs. Thus, various alternatives have been used as feed ingredients to replace corn, soybean meal, or other expensive ingredients. One other candidate may be palm kernel co-products that are a by-product of oil extraction from palm fruits. Palm kernel co-products have not been used in swine diets due to high fiber content and imbalanced amino acids compared with corn and soybean meal. However, recent studies showed that palm kernel co-products did not have any negative effects on growth performance of pigs when they replaced some proportions of corn and soybean meal. In addition, palm kernel co-products may provide some physiological properties to pigs by modifying gut microbiota and/or immunity of pigs, resulting in improvement of growth and health of pigs. Therefore, the value of palm kernel co-products were reviewed as one of the alternatives for corn, soybean meal, or other major ingredients in swine diets.

Keywords: alternatives, growth, health, palm kernel expellers, pig

Introduction

Turning a profit between the selling price of pigs and the cost of production for swine is variable and not easy. Production cost is based on price for feed, livestock, labor, and other input costs (KAPE report, 2014). Above all, the price of feed ingredients, over sixty percent of the production cost, have strikingly increased in recent years, because of the intensified competition and demand for traditional ingredients between food (human consumption), feed, and biofuel production industries (Kim et al., 2001; Oluwafemi, 2008; Hoffman and Baker, 2011). To reduce the cost of feed, many attempts to find alternative feed ingredients as other protein and energy sources for swine nutrition have been made (Rhule, 1996; Kim et al., 2001; Son, 2013). Thus, various co-products or by-products have been used as feed ingredients to replace corn and/or soybean meals



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(Wachenheim et al., 2006; Hoffman and baker, 2011; Kim, 2015). Several candidates for oilseed meal have been identified, such as palm kernel, copra, and cassava co-products. They have the advantage of cost efficiency and are a good source of nutrients (Agunbiade et al., 1999; Kim, et al., 2001; Son et al., 2014; Kim, 2015).

Palm kernel co-products and their utilization in swine diets

Palm kernel co-products

Among the above-mentioned candidates, palm kernel co-products are abundant in tropical areas of the world, such as Nigeria, Ghana, and Malaysia (Rhule, 1996; Agunbiade et al., 1999; Teoh, 2002; Kim et al., 2013; Sharmila et al., 2014). With their increasing global production, from approximately 5 million metric tons in 2005 to almost 7 million metric tons in 2012, the potential of palm kernel co-products as a source of both dietary protein and energy would seem to justify its increased use in animal feeding (Agunbiade et al., 1999). Palm kernel expeller is a co-product produced after the oil extraction from the kernels of oil palmfruits (*Elaeis guineensis*). The nutrient concentration of palm kernel expellers depends on the species of the palm fruits and the process of oil extraction (Stein and Sulabo, 2014). Palm kernel expeller is removed by mechanical pressing extraction; therefore, it usually contains more residual oil than a by-product produced with solvent extraction, but concentrations of other components are almost similar (Boateng et al., 2008; Mohamed and Alimon, 2012; Sulabo et al., 2013; Almaguer et al., 2014; Jaworski, 2014; Sharmila et al., 2014). The nutrient composition and physical characteristics of palm kernel co-products from different methods of oil extraction are shown in Table 1. Palm kernel co-products supply both protein and energy, and contain a high amount of crude fiber (Sharmila et al., 2014).

Table 1. Comparison of nutrient composition and physical characteristics of palm kernel co-products compared with corn and soybean meals (Data from NRC, 2012; Jaworski et al., 2014).

Item	Soybean meal	Corn	Palm kernel expellers	Palm kernel meal
DM (%)	90.0	88.3	91.9	91.9
GE (kcal/kg)	4,256	3,933	4,482	4,250
DE (kcal/kg)	3,619	3,451	2,892	2,669
ME (kcal/kg)	3,294	3,395	2,786	2,542
CP (%)	47.7	8.2	14.3	13.6
AEE (%)	1.5	3.5	6.9	1.3
NDF (%)	8.2	9.1	70.6	77.9
ADF (%)	5.3	2.9	43.0	49.4
Total dietary fiber (%)	16.71	13.73	63.5	70.9
Insoluble dietary fiber (%)		-	60.9	68.7
Soluble dietary fiber (%)		-	2.6	2.2
Bulk density (g/L)	-	-	634.1	401.0
Water binding capacity (g/gv)	-	-	1.83	2.17

The concentration of crude protein in palm kernel co-products ranges between 12 and 23%. The most of the amino acids have lower digestibility and availability than soybean meal but are close to those in corn (Sulabo et al., 2013; Son et al., 2014; Stein and Sulabo, 2014). The crude fiber concentration is between 7 and 20% (Babatunde et al., 1975),

which is less than that of soybean meal but higher than that of corn (NRC, 2012). The total carbohydrates in palm kernel co-products are mostly in the form of non-starch polysaccharides (NSP) (Dusterhoft and Voragen, 1991), primarily as β -mannans (Dusterhoft and Voragen, 1991). However, water binding capacity of palm kernel co-products is less than that of other co-products such as copra meal (Jaworski et al., 2014). Because of the high concentration of insoluble dietary fiber, which increases the passage rate of feedstuff through the gastrointestinal tract (GIT), the energy in palm kernel co-products is inadequately digested by pigs and its digestible energy (DE) and metabolizable energy (ME) concentrations are less than 75% of those in soybean meal and corn (NRC, 2012; Sulabo et al., 2013; Stein and Sulabo, 2014). The fiber concentration of palm kernel co-products was about 13 - 20%, which is responsible for grittiness, low palatability, and low availability of amino acids and energy for non-ruminants (Agunbiade et al., 1999; McDonald et al., 2011; NRC, 2012; Sharmila, 2014; Stein and Sulabo, 2014). Because pigs have difficulty in digesting high fiber diets using their own endogenous enzymes, palm kernel expellers have mainly been used in ruminant diets (Dias, 2008; Kim, 2015) and poultry diets (Oluwafemi, 2008; Saenphoom et al., 2013; Sharmila, 2014) but rarely used in swine diets (Kim, 2015).

Benefits of fiber in palm kernel co-products

These days, the importance of fiber is emphasized due to these physiological and nutritional advantages to both human and animals. Dietary fiber may have a positive effect on satiety, behavior, gut health, overall animal wellbeing improvement, and reproductive and growth performance of pigs (Farmer et al., 1995; Johnston et al., 2003; Lindberg, 2014).

A previous study described the impact of high-fiber diets on the feeling of satiety by expanding of the stomach and leading to a gastric signal (Wenk, 2001). Satiety is important in gestating sows because it reduces the stress that comes from restricted feeding and consequently influences physical activity and behaviors (Rijnen et al., 1999; Wenk, 2001; De Leeuw et al., 2008). Also, fiber has an important role in gut health by way of complex interactions with microflora and mucosa (Johnston et al., 2003; Lindberg, 2014).

Fiber is rarely digested and absorbed in non-ruminant animals. On the other hand, fiber is fermented by microbes, functions as a prebiotic, and selectively prompts the population and/or the activity of the colonic microbes within the GIT (Gibson et al., 2004; Lindberg, 2014). For instance, microbial activity in the large intestine generally increases when feeding a fibrous diet, helping the host better utilize feed nutrients and excrete microbial substances (Wenk, 2001). The fermentation of soluble fiber and insoluble fiber mainly occurs in the proximal colon and distal colon, respectively (Urriola et al., 2013).

The major products of fermentation are short chain fatty acids (SCFA), for example, lactate, acetate, propionate, and butyrate, predominantly. Those create an acidic environment, inhibit the growth of pathogens, and provide energy (Lunn and Buttriss, 2007; Lindberg, 2014; Song et al., 2015b). The absorption of SCFA is a very efficient process due to rapid production and absorption (Bergman, 1990; Montagne et al., 2003; Urriola, 2010). Most of the SCFA is absorbed before reaching the rectum in non-ruminant species (Montagne et al., 2003), and less than 1% is excreted in the feces (Urriola, 2010).

The absorption of SCFA can contribute to the energy status of pigs because SCFA is used to generate energy. Thus, the hindgut fermentation can generate 17% and 25% of the total digestible energy derived from the diet in growing pigs and sows, respectively (Johnston et al., 2003). In addition, the SCFA can possibly supply 24 to 30% of the energy needs for growing pigs (Rerat et al., 1987; Johnston et al., 2003).

The effect of fiber on develops intestinal morphology and the epithelium. For instance, cell growth, cell proliferation, blood flow, and secretory/absorptive functions of the large intestine resulted from the physical stimulus and energy supply from the product of fiber fermentation (Bergman, 1990).

The effect of SCFA which comes from fiber fermentation is not restricted to the hindgut, but it also stimulates cell proliferation and growth of the small intestine, which ultimately can affect nutrient digestion, absorption, and metabolism (Wenk, 2001; Montagne et al., 2003). This effect on distant mucosa seems to depend on a systemic mediatory mechanism. Montagne et al. (2003) described that insoluble fiber enhances the secretion of mucins by the epithelial cells of the GIT as a response to physical stimulus and to protect the gut against bacterial infection. Consequently, those are associated with reduced incidences of diarrhea.

A previous study describes how high fiber diets decrease back fat and improve carcass quality through the inclusion of different amounts of fibrous feeds in diets for growing-finishing pigs. Fetuga et al. (1977a, b) described that the major role of high fiber diets in carcass quality was the prevention of fat deposition through regulation of digestible energy intake; however, several studies also identified the role of high lysine concentration to encourage muscle development (Cooke et al., 1972; Fetuga et al., 1975a, b).

Therefore, palm kernel co-products with high fiber levels have mainly been used to grow and fatten ruminants and extend lactation (Chin, 2008; Singhanian et al, 2008; Dias, 2008). However, in recent years, there have been attempts to evaluate palm kernel co-products for swine diet .

Palm kernel co-products in swine diets

There is limited information about swine diets. In addition, the inclusion of palm kernel co-products in swine diets has not been widely assessed because of their negative effect on the growth performance and carcass characteristics in finishing pigs (Kim et al., 2001; Rhule, 1996), which was attributed to their high NSP content, poor palatability, and low availability of energy and amino acids (Ao et al., 2011). Rhule (1996, 1998) reported that the use of palm kernel co-products in the diet significantly decreased average daily gain (ADG) during a growth period.

Especially, it has been shown that high contents of insoluble dietary fiber increase the passage rate of digesta through the GIT and thus, the energy contained in palm kernel co-products is poorly digested by pigs and their DE and ME concentration (NRC, 2012; Sulabo et al., 2013, Stein and Sulabo, 2014). Likewise, Oluwafemi (2012) reported no negative effect on overall performance in finishing pigs at an inclusion level of 60% with or without enzyme supplementation.

Many previous studies reported that the use of a palm kernel co-product in growing-finishing swine diets did not influence dressing percentage, backfat thickness, and loin eye area (Babatunde et al., 1975; Fetuga et al., 1977a; Ao et al., 2011). Rhule (1996, 1998) showed that palm kernel co-products in growing-finishing pig diets did not influence dressing percentage, but up to 40 % palm kernel co-products in the diet significantly reduced dressing percentage. Fetuga et al. (1977a, b) reported that there was a tendency for carcasses of pigs on the high palm kernel co-products diets to be leaner.

Kim (2015) has shown adverse effects on performance, nutrient digestibility, and blood profiles of lactating sows and weaned pigs. A recommended level of palm kernel expellers in livestock is shown in Table 2.

Table 2. Recommended levels of palm kernel expellers in livestock feeds (Zahari and Alimon, 2004).

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

Enhancement of palm kernel co-products utilization

Many studies have been conducted to improve nutrient values of palm kernel co-products through solid-state fermentation (SSF), using an enzyme, and in combination with others.

Fetuga et al. (1977a) have shown that palm kernel co-products in combination with blood meal during the growing-finishing period could be efficiently utilized because of the co-operative effect on amino acid contents of palm kernel co-products and blood meal (Song et al., 2015a).

Fetuga et al. (1977b) have shown that the inclusion of cane molasses, between 10 and 20% of the total mix, in diets high in palm kernel co-products improved the efficiency of nutrient utilization for growth through the combined effects of improved digestion of the fiber. Furthermore, Marini et al. (2005) have shown that the SSF of palm kernel co-products seems to increase the protein value and bioavailability of nutrients. The protein and amino acid composition of palm kernel expellers and fermented palm kernel expellers with *A. niger*. So, many studies have been evaluating the effect on the nutrient value of palm kernel co-products through SSF either by using fungi (Iluyemi et al., 2005). Iluyemi et al (2005) have shown that unsaturated fatty acid concentrations increase according to SSF using fungi.

Soltan (2009) has shown that palm kernel co-products inclusion at 20% with enzyme resulted in similar growth performance to that in control diet. Thus, use of the enzymes with palm kernel co-products is recommended to elevate production and efficiency.

Feeding a palm kernel co-product supplement with carbohydrase increased the growth performance and nutrient digestibility of finishing pigs (Ao et al., 2011). Feeding palm kernel products using carbohydrase improved the energy and nutrient digestibility in finishing pigs (Ao et al., 2011; Oluwafemi, 2012; Kim et al, 2013; Mok, 2013). However, Kwon and Kim (2015) reported no effect on the DE and ME values of palm kernel co-products fed to pigs with or without enzyme. Similarly, no difference was found in loin muscle surface area and quality such as water holding capacity, pH, and drip loss (Ao et al., 2011).

Conclusion

The swine industry is looking for various alternatives to expensive ingredients such as corn, soybean meal, or other ingredients to reduce feed and production cost. Based on recent studies, palm kernel co-products may be one of the best candidates despite their high fiber content and imbalanced amino acids compared with more expensive ingredients of swine diets. However, more research is needed to verify the effects of palm kernel co-products in swine diets.

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