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Review Article
Utilization of Palm Kernel Cake as a Ruminant Feed for Animal: A Review

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Abstract

Palm kernel cake is a feed by-product that is used by the livestock industries. Chemical composition of palm kernel cake varies depending on the type of the fruits palm, source of sample and method of processing oil extraction (screw pressing or solvent extraction). This review was carried out to examine the effect of palm kernel cake on digestibility coefficients, daily weight gain, milk production and composition of animal. Varies treatments such as physical, chemical and biological were used to improve the nutrients digestibility and nutritive value of palm kernel cake. Several studies found that the animals performed satisfactorily well when fed on diets containing different levels of palm kernel cake. Palm kernel cake was used as feed for fattening and dairy cattle where as it has a source of protein, energy, vitamins and minerals. Digestibility coefficients for palm kernel cake were affected by adding it to animal's diets at high levels.

Key words: Animal nutrition, palm kernel cake, nutrients digestibility, fruits palm, milk production, animal's diets

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Feed is one of the important production inputs that affect the size of livestock production. Palm kernel cake is one of un-conventional feed stuff obtained from palm oil extraction which can be used as a feed for various livestock production[1-3]. The chemical composition of palm kernel cake varies depending on the type of the fruits palm, source of sample and method of processing oil extraction (solvent or mechanical extraction)[4-7]. The average chemical composition of palm kernel cake was 89.00-95.00% for dry matter[8-11], 6-24.9%[12] for crude fibre, Also, acid detergent fibre being 43.7%, neutral detergent fibre being 66.7% and lignin being 21.1% of palm kernel cake[9,13], 0.5-3% for ether extract of solvent extracted palm kernel and 4.5-19.5% expeller pressed[7] and 3.06 and 5.6% for total ash[7,11,14].

Several researchers were used physical and chemical treatments to improve nutrient contents of palm kernel cake[15-18]. The chemical processes of palm kernel cake using alkaline (ammonium hydroxide) or acid (acetic and formic acids) solution has been suggest to enhance the palm kernel cake nutrients digestibility and nutritive values by increasing the crude protein and decreasing the crude fibre contents[19]. The biological treatment such as enzymes, fungi and bacteria have been used to increase the nutritional value of palm kernel cake[20-23].

Many studies suggested that the animals performed satisfactorily well when fed on diets containing different levels of palm kernel cake[24-26]. Palm kernel cake was used as feed for fattening and dairy cattle where as it has a source of protein, energy, vitamins and minerals[27-29]. Digestibility coefficients for palm kernel cake were affected by adding it to animal's diets at high levels[30,31]. The objective of this review was carried out to investigate the effect of using palm kernel cake as a feed for animal on digestibility coefficients, daily weight gain, milk production and composition.

IDENTIFICATION AND PRODUCTION PALM KERNEL CAKE

Palm kernel cake is a gro-industrial by product which obtained from palm oil extraction in cultivated tropicalrain countries laying between 12°N and 12°S, such as Indonesia, Malaysia and Nigeria[1]. Indonesia and Malaysia are the largest producer and exporter of palm oil and palm oil by-products while, Nigeria, Colombia and Thailand are recorded less than 10% of the world production[26].

When the palm fruits are processed. It is produced palm oil, palm kernel cake and meal according to the method of extraction. Palm kernel cake resulted from the mechanical expeller procedure contains 5-12% oil while, palm kernel meal obtained from solvent extraction technique contains 0.5-3% oil[32].

Palm kernel cake has been used as a feed for various livestock production[2,24-26,33]. Several studies reported that the animals performed satisfactorily well when fed on diets containing levels of palm kernel cake.

Chemical composition of palm kernel cake: The chemical composition of palm kernel cake varies (crude protein, crude fiber, ether extract, ash and nitrogen free- extract) depending on the sources of the samples[34,4], soil type, method of processing oil extraction (e.g., mechanical or solvent extraction), the amount of endocarp remaining[5-7] and the efficiency of oil extraction from the kernel[35,36].

Dry matter refers to proportion of moisture in the palm kernel cake. The dry matter content is important to determination bulk purchasing and storage of palm kernel cake. Increasing moisture content than 14% could not be stored in bulk and it is the best culture for the molds growing on it Hartley[37]. Dry matter of palm kernel cake was recorded a range of 89.00-95.00% by several studies[8-11]. Palm kernel cake is low in crude protein content compared with soybean meal and groundnut cake. Various literature have indicated that the crude protein content of palm kernel cake ranges[6,38,11] between 14-20%. Protein content of palm kernel cake had poor amino acid balance, lysine followed by methionine, tryptophan, threonine and histidine contents[39,34,6,40,41] being the major limiting amino acids. The crude fibre is consists mainly of cellulose, hemicellulose and lignin. Crude fibre is an index that can used to be predict the feeding value and nutrients digestibility of the feeds. There was reversed relationship between crude fibre and nutrients digestibility to the animals[42,5]. The composition of crude fibre content of mechanically extracted was lower compared to solvent extracted of palm kernel cake[43]. The crude fibre content of palm kernel cake was about[12] 6-24.9%. Also, acid detergent fibre being 43.7%, neutral detergent fibre being 66.7% and lignin being 21.1% of palm kernel cake[9,13]. The sugar content in the cell wall of palm kernel cake fibre was mainly contributed by 56.4% mannose, followed by 11.6% glucose, 3.7% xylose and 1.4% galactose[44]. Ether extract of solvent extracted palm kernel cake was low 0.5-3% while the expeller pressed contained between[7] 4.5-19.5%. The total ash content of palm kernel cake as recorded by various studies ranges[7,14,11] between 3.06 and 5.6%. Palm kernel cake is relatively high in

minerals content were calcium 0.276%, phosphore 0.645%, magnesium 0.158%, zinc 0.214%, sodium 0.187%, potassium 0.365%, copper 0.25%, manganese 1.3 ppm and iron, 0.75 ppm[11]. It was observed that the Ca:P ratio is low and most diets based on palm kernel cake need to be supplemented with calcium to cover the requirement of animals and the carotene and vitamin E (about 0.3 IU kg^{-1}).

Enhancing nutritive value of palm kernel cake: Various treatments of agro-industrial and agriculture by-products could improve their NDF, ADF and hemicellulose content[15,17,18,45]. Until now there is no study has been investigated on the effect of physical treatments of palm kernel cake on its nutrient contents[46]. But, combination of physical and chemical processes could be enhanced nutrient contents of palm kernel cake[16].

The chemical treatments of palm kernel cake using alkaline (ammonium hydroxide) or acid (acetic and formic acids) solution has been suggest to enhance the palm kernel cake nutrients digestibility and nutritive values by increasing the crude protein and decreasing the crude fibre contents[19]. Also, chemical treatment processes using alkaline and/or acid solution acids can be used as delignification agents to decrease lignin content of palm kernel cake. The degradation of lignin could be affected by the concentration of the acid solution. There are relationship between using higher concentration of the acid used and more lignin could be removed[16]. While, using alkaline solution to treat palm kernel cake can be absorbed into the cell wall and thus hydrolysis the ester chemical bonds between cellulose, hemicellulose and lignin which finally make the structural fibre to swell[47].

The biological treatment has been used to increase the nutritional value of palm kernel cake. High level of non-starch polysaccharides contents of the cell wall of palm kernel cake contributes to reduce digestibility of its nutrients[48]. However, fibre in palm kernel cake is degraded to the smaller units of sugar, mostly mannose it has been suggested that the absorption of mannose is much lower than glucose, particularly when glucose is present in the system[23].

The addition of enzymes to palm kernel cake and its effect on nutrient content analysis[49,50], nutrient digestibility trial[51,22]. However, using fibrolytic enzymes as a biological treatment for palm kernel cake diets was reduced the fibre content and the increase of the total sugar released and there was an improvement in the metabolic energy value[23,49,50,52]. The effect of productive performance of different classes of livestock such as pig[22], layers[49], fish[53] and broiler chickens[52] have been evaluated. While, the studies of using enzymes to palm kernel cake for ruminants was poor. The composition of NDF, ADF, cellulose and hemicellulose contents of enzyme treated palm kernel cake was significantly decreased[50].

Various studies have been reported to enhance nutrients digestibility and nutritive values of palm kernel cake through solid-state fermentation either by using fungi such as *Sclerotium rolfsii*, *Trichoderma harzianum*[21], *Aspergillus niger*[20,21,54], *Trichoderma longibrachiatum* and *Trichoderma koningii*[20], *Trichoderma varidae* and *Mucor mucedo*[54], *Rhizopus* spp.[55,54,21] and bacteria such as *Bacillus 7DY7*[56].

Forming palm kernel cake under sold state fermentation conditions have been reported to be more proper for low purpose and there is no any waste disposal at the end because the whole product may be used directly in animal feeds. Also, solid state fermentation of palm kernel cake produces a product that contains low hemicellulose and cellulose contents and high protein concentration. The levels of saturated fatty acids decrease while unsaturated fatty acids increase as a result of solid state fermentation of palm kernel cake using fungi as culturing agents[20,57].

Feed intake and digestibility: There is a linear decrease in dry matter intake was observed due to the lower palatability and higher fiber content of the palm kernel cake[58,27]. Neutral detergent fiber (NDF) intake by the animals showed a negative effect on nutritive value and digestibilities[28]. Moreover, there was increase ($p<0.05$) for the efficiencies of rumination of dry matter and total digestible nutrients with the inclusion palm kernel cake in diets at level 15% on dry matter but the dry matter intake was not affected[29]. While, replacement of soybean meal with palm kernel cake at level 16% on dry matter was influenced on feeding behavior of steers and decreased dry matter intake[59]. Maciel *et al.*[60] observed that the use of palm kernel cake in the diet of dairy heifers at the highest level was 54.5% lead to decrease the intake of dry matter and neutral detergent fibre. The inclusion of by-products such as palm kernel cake and cocoa meal in diets for lactating goats, significantly increased fibre content but the feeding behavior had not changed[61]. Palm kernel cake expeller, rather than solvent extracted palm kernel cake is used as a source of protein, energy and fibre for dairy cattle at levels 300-500 g kg^{-1} of total diet[62]. However, using palm kernel cake at level 400 g kg^{-1} DM has been associated with reduced concentrate feed intake due to palatability problems[63]. While, increasing levels of solvent extracted palm kernel cake (50, 100 and 150 g kg^{-1} DM) in a total mixed ration have been found not affect cow dry matter intake[64].

Dry matter, crude protein and NDF digestibilities were lower ($p<0.05$) in buffalo calves fed diet contain 30% palm kernel cake than those fed other diets contain low level of

palm kernel cake. The reason behind low digestibility diet 30% palm kernel cake was due to increased amount of NDF in feed[65,66,28]. The other reason to low digestibility for diet contain palm kernel cake may also undergo Maillard reaction (the reaction of mannose with amino groups leading to the formation of a brown complex) due to heat applied in the process before and during oil extraction and this may adversely affect the digestibility[13,28]. Digestibility coefficients for expeller pressed palm kernel cake were 70% for dry matter, 63% for crude protein, 53% for neutral detergent fibre (NDF), 52% for acid-detergent fibre (ADF) and 88% for gross energy were obtained using sheep[30]. While, the digestibility coefficients of solvent extracted palm kernel cake was determined by using cattle at 65.1% for dry matter, 72.7% for organic matter, 69.7% for crude protein and 86.7% for the nitrogen free extract component[67]. The digestibility of dry matter, organic matter, crude protein, total carbohydrates and non-structure carbohydrate were significantly increased with an increased percentage of palm kernel cake in a dietary supplement for dairy cows of the Holstein x Gir crossbreed at pasture[31].

Effect of feeding palm kernel cake on dairy cattle: Feeds is important factors affecting on milk production and animal performance which, constitutes about 70 % of the total cost of enterprises. Therefore, using a gro-industrial by-products are very important to minimize the cost of feeds by including cheaper source of energy and protein without any adverse effect on animal productivity. Palm kernel cake plays a significant role in utilization has effectively reduced the cost of milk production as a result of replace expensive conventional feedstuffs, such as maize, cotton seed cake and soybean meal with a more economical and locally available one that also meets the nutrient requirements of livestock.

Palm kernel expeller is a low cost by-product and high fibre, it has been used extensively as a feed by the dairy cattle[68] at 56%. Using palm solvent extracted kernel cake at levels (50, 100 and 150 g kg^{-1} DM) in a concentrate feed mixture have been found not to affect cow milk yield and composition[64]. Moreover, milk yield and composition except milk lactose were not affected in a study in which cows grazed high quality pasture in spring season, added with two levels of palm kernel cake (200 and 400 g kg^{-1} DM) in total mixed ration[63]. While, supplementation of palm kernel cake may induce a positive milk yield and composition response when the nutrient supply of a pasture based system is at sub-optimum levels[69]. The high neutral detergent fibre content of palm kernel cake may induce a positive milk fat content response[70]. Comparative between the use of expeller pressed palm kernel cake and solvent extracted palm kernel cake for fed cows on milk production, it was found out that pressed palm kernel cake gave significantly lower (4.8 kg milk/day) milk production than the solvent extracted palm kernel cake (7.9 kg milk/day). In the same trial, when Sahiwal-Friesian cow were fed on expeller pressed palm kernel cake and solvent extracted palm kernel cake lead to a low fat content[71] of 7%. Other study found, there are no significant difference on daily milk yield between cow Sahiwal-Friesian cows fed on conventional concentrate feed mixture without palm kernel cake (8.4 kg milk/day) and those fed on identical amounts of solvent extracted palm kernel cake (7.7 kg milk/day)[72]. The milk of dairy cattle fed palm kernel cake tends to produce a firm butter and the ration containing on 2-3 kg of palm kernel cake daily is more satisfactory for adult dairy cattle[73]. Increased fat yield and fat corrected milk yield of dairy Jersey cows fed on 200 g palm kernel expeller/kg DM can partially replace maize in a dairy concentrate feed mixture[74]. Milk composition such as milk lactose and milk protein content were not affected by palm kernel expeller supplementation[63,64,74,75]. No change in behavior activities for dairy cows with the inclusion of palm kernel cake in diets at level 15% on dry matter[29]. Also, no significant difference in milk yield and fat corrected milk yield for lactating Saanen goats when, replacing maize and soybean meal with palm kernel cake in the concentrate feed mixture at level 30% on dry matter[76].

Effect of feeding palm kernel cake on fattening cattle: Palm kernel cake was used as the sole feed for commercial feed lotting where it has included on more vitamins and minerals[8]. Also, palm kernel cake is used in mixture with other oil palm by-products (such as palm pressed fiber) for feeding growing dairy bull calves[77]. Various studies suggested that average daily weight gain ranged from a lower 0.39 kg/day achieved by the indigenous Kedah-Kelantan cattle fed a 100% expeller pressed palm kernel cake diet to 0.83 kg/day obtained by drought master cattle fed a mixed ration comprising 60% solvent extracted palm kernel cake and 40% palm oil sludge[78,79,8]. No significant difference in daily gains was found between Sahiwal-Friesian animals when fed the expeller pressed palm kernel cake/dried sago pith at 50/50 ratio group and the solvent extracted palm kernel cake/dried sago pith at 50/50 ratio group as compared to animals fed 100% Palm kernel cake without dried sago pith, this was due to the higher energy availability of diets with dried sago pith[71]. In the same trial, Sahiwal-Friesian cows were fed on expeller pressed palm kernel cake and solvent extracted palm kernel cake lead to a low fat content[71] of 7%. Moreover, there was no significant difference in the daily gain among Sahiwal-Friesian

dairy heifers fed on Napier grass plus tow kg of supplementary rations comprising palm kernel cake alone or with either cassava or molasses as a source of energy[80]. The growth performance of daily weight gain was not affected in buffalo calves fed palm kernel cake at level 30% against cotton seed cake in diets day[28]. Also, 30% palm kernel cake is a source of energy and protein in feedlot cattle and sheep[62]. Drough master animals were superior on Brahman bull calves in terms of a better carcass analysis and daily weight gain when, it was fed a ration of palm kernel cake with palm oil sludge in the ratio[81] of 60/40. Under intensive management, an adding of palm kernel cake to grass molasses diets has improved the performance daily weight gains of growing Zebu-Holstein dairy bulls compared to those receiving either grass or grass-molasses mixture[77]. Daily weight gain was highest in WAD goats fed on soybean meal compared with palm kernel cake[82].

CONCLUSION

In general, incorporation palm kernel cake with different levels in animal diets has positive effect on animal performance, weight gain, milk production and coefficients of digestibility. Also, it was contributed to solve some problems related to with increase in feeds prices.

SIGNIFICANCE STATEMENT

This study was carried out to investigate the effect of using palm kernel cake as a feed for animal on digestibility coefficients, daily weight gain, milk production and composition. Animal performance, weight gain, milk production and coefficients of digestibility were significantly improved by using palm kernel cake with different levels in animal diets. Incorporation palm kernel cake in animal diets had no negative effect on animal health status. Using palm kernel cake was contributed to solve some problems related to with increase in feeds prices.

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