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EC VETERINARY SCIENCE
Review Article

Challenges Associated with Utilization of Palm Kernel Cake (PKC) in Poultry Nutrition and Feed Additive Applications for their Mitigation

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Received: May 10, 2019; **Published:** June 20, 2019

Abstract

Challenges which are associated with the use of palm kernel cake (PKC) in poultry nutrition and the use of feed additives to reduce their negative impacts were reviewed. Palm kernel cake is a byproduct of palm kernel oil production. It is used principally to reduce cost of feed and increase gross margin in Nigeria. Its inclusion in feeds reduces levels of maize and soybean meal in poultry diets. Though the nutritive value of PKC has been adjudged to be adequate at certain levels when added to diets of different classes of poultry, there are certain challenges that could occur. Its proximate composition depending on processing method shows 18.0% crude protein, 18.0% crude fibre, 8.0% ether extract and 2500 Kcal/kg metabolizable energy. Its lysine and methionine content is less than 1.0% making them critical in PKC based diets. High level of cellulose and lignin, presence of non-starch polysaccharides (NSPs), grittiness, poor quality protein, rancidity and mold contamination pose a challenge. Effects of fibre and NSPs could be reduced by addition of appropriate enzymes to PKC based diets. Inclusion of synthetic lysine and methionine could mitigate the negative impact of poor protein quality, while anti-oxidants and mold inhibitors could be applied in feeds to improve feed utilization and reduce physiological dysfunctions. During storage, organic acids could also be used to prevent mold contamination. Application of spices and essential oils should be explored. Whereas addition of feed additives have proven to improve productivity of poultry, they should be used to reduce the negative impact associated with the use of PKC in poultry feeds.

Keywords: *Feed Additives; Negative Impact; Palm Kernel Cake; Poultry Nutrition*

Introduction

Animal agriculture otherwise known as livestock production plays important role in social-economic life of nations, providing employment, personal income and thereby contributing to gross domestic products GDP of nations. Poultry production as a subset of animal agriculture apart from the above, provide quality protein inform of meat and egg to citizens of nations hence improving their health status and invariably the productivity of the people. According to Oladokun., *et al.* [1] feeds and feeding account for about 60 to 70 or even 80% of total farm overhead cost depending on the nature of livestock enterprise and in this case poultry production. This is caused by high cost of conventional grain feedstuffs especially maize and soya bean meal used to produce poultry feeds. Nevertheless, the prospect of livestock feeding based on grains diet is becoming a threat for simple stomach animals [1]. For years nutritional strategy to reduce cost was to introduce agro-industrial by-products in feed formula for poultry. These agro industrial byproducts include palm kernel cake, brewer's dried grains, rice bran, maize offal and wheat offal. Palm kernel cake seems to have advantage over some of these agro byproducts like wheat offal and brewer's dried grains because its 'parent' product which is palm kernel is produced locally in large quantity. FAO [2] reported annual increase of 15% in producing countries such as Nigeria with an increase of 300% over the last two decades.

Improvement of animal performance is necessary in increasing the profit farmers could make. The quality of a feed is determined by the quality of the feed ingredients used to produce it. Some feed ingredients have limitations when they are used to produce poultry feeds. Such challenge is the problem of anti-nutritional factors. These limitations are more pronounced in non-conventional feedstuffs such as PKC which limits the level at which it can be included in both broiler and layer diets. For instance Zanu., *et al.* [3] discovered that hen day was negatively affected at 15% inclusion of PKC in layer diet. Though for a long time, animal nutritionists have devised means of improving these limitations such as processing and fermentation, there is the need to investigate and adopt other methods. Use of feed additives could be another strategic method to boost PKC quality to adequately support poultry productivity.

Palm kernel cake is a byproduct (residue) of palm kernel oil production. The nutritional value is dependent on the method used to extract the oil. Two methods are used – the expeller and solvent extraction methods. More oil is removed with solvent extraction method leading to lower oil and energy content with higher level of crude protein of the PKC. Its inclusion in poultry diets has since been advocated not only because of its nutritional value, but its beneficial effect on health of birds as a source of manna-oligosaccharides (MOS) which leads to growth of beneficial micro-organisms in the intestine [4,5]. Despite these nutritional benefits, feed millers always have second thought about using palm kernel cake.

Objective of the Study

The objective of this work was to review the role feed additives could play in mitigating the negative impact associated with the inclusion of PKC in poultry feeds.

What are feed additives

Feed additives are substances or mixture of substances which are added to animal feeds to improve their quality and or performance of farm animals and the quality of animal products. According to the report of European Union Council on regulation of feed additives EUC-RFA [6] feed additives are products used in animal nutrition for purposes of improving the quality of feeds and quality of food from animal origin or to improve the animal's performance and health, for example providing better digestibility. Feed additives are not nutrients but are added to feeds to maximize nutrient utilization. They may occur in both organic and inorganic forms. They are added during or after feed production. Another method of administration of feed additives such as organic acids is via the drinking water [7]. Good feed additive must not have negative effect on the animal that consumes it, the consumer of the animal or the product of the animal such as meat, egg and milk.

Feed additives can be grouped into natural and synthetic types. Examples of synthetic feed additives are pharmaceutical antibiotics and butylated-hydroxyl- toluene, while natural feed additives basically are the phytogenics such as spices and essential oils. In their own way these feed additives act as anti-mycotoxins, antioxidants, preservatives, anti-caking agents and growth promoters. Enzymes, probiotics, prebiotics, organic acids, essential oils, spices and bioactive herbs are some examples of individual feed additives [8,9]. While enzymes liberate energy, protein and minerals that are locked up in feeds; probiotics, prebiotics, organic acids, herbs and essential oils stimulate and modulate the gut leading to functional gut ecosystem.

Challenges and practices adopted to metigate them

Poor Digestibility

Digestibility is the quantity of feed or nutrient in percentage consumed by an animal that is retained in the body that did not appear in faeces. Feeds need to be broken down into its micro constituents called nutrients (starch, protein, oil, vitamin and mineral). Report emanated from Research and Development Department of Framelco [10] showed that more nutrients must be made available from feed but the nutrients can only be valuable if they are properly digested and absorbed. The report maintained that non-digested nutrient is a potential source for pathogenic bacteria to develop and to colonize the small intestine of the host animal. Unlocking these constituents

in the feed depends on the feed ingredients used to produce the feed. Some feed ingredients such as maize and soya bean meal are more digestible than others like the high fibre ingredients (palm kernel cake, wheat offal, brewer's dried grains etc.). Digestibility of palm kernel cake has been reported to be low especially in young chickens compared to other feedstuffs such as maize and soya bean meal. This is due to high level of fibre (18%) in PKC. The acid detergent fibre component (cellulose) of PKC was reported to be high. Cellulose is poorly digested by birds. It also contains indigestible fraction called lignin. The lignin component is said to emanate from the shell fraction of the nut. Other compounds that PKC contains which hinder its utilization is non-starch polysaccharides namely β-glucan, mannan, and xylan. These indigestible compounds cause high digesta viscosity, fermentation and consequently resulting to poor nutrient absorption, utilization and watery faeces. In layers, watery faeces is more pronounced in deep litter system of management. Watery faeces leads to production of dirty eggs and wet litter.

How can problem of poor digestibility be reduced. This can be managed by inclusion of feed grade enzymes in the feed. The effectiveness of enzymes in improving PKC utilization in poultry has been reported [11]. Multi-enzymes should be used to take care of all the components in PKC that are resistant to digestion. In this case, protease, cellulase, glucanase, xylanase, mannanase, pectinase, amylase and galactosidase are important enzymes which can be used to unlock the nutrients. Degradation of β-mannan and xylan in PKC by an appropriate enzyme to mannose and xylose respectively will release also the sugar and other digestible units that can be absorbed and metabolized by poultry. Bedford [12] reported that addition of enzymes to the diets of chicks up to 42 days reduced the viscosity of the digesta with a resultant improvement in the feed conversion ratio and fat digestibility of the birds. To further boost digestibility other specific enzymes such as protease and phytase are suggested to be added to target protein and phytic acid complexes to release free protein and phosphorus respectively.

Rancidity

Rancidity is oxidation of fats and oils by biochemical reactions. This leads to either poor nutritional value or change in physical conditions of fats and oils. The actions which cumulate to these could also be, hydrolytic or microbial. Fats and oils that contain unsaturated fatty acids undergo oxidative rancidity when exposed to oxygen, especially the polyunsaturated fatty acids such as linoleic, linolenic and arachidonic acids [13]. Their double bounds are susceptible to oxygen attack which produces free radicals such as peroxides, ketones and aldehydes. These free radicals are injurious to internal body organs like liver and heart which could lead to heart and neuro-diseases. In the presence of moisture and a catalyst, triglycerides of a fatty acid are hydrolyzed resulting to production of short chain fatty acids (C1 - C5 organic acids) and their salts like formic, acetic, propionic, butyric, isobutyric, valeric and isovaleric acids. Microbial rancidity occurs when the enzyme (lipase) produced by bacteria or mold breaks down the long chain fatty acids to short chain fatty acids. This occurs usually under poor storage. Because palm kernel cake contains about 8.0% ether extract which is a measure of its oil component it could be susceptible to rancidity. Rancidity occurs during storage of PKC and PKC based feeds. Physical characteristics of rancidity are odour and change in colour of PKC and PKC-based-feeds. Fat and oil oxidation causes poor palatability which causes low feed intake. Poor growth and low egg production occur in birds fed rancid feed.

Addition of antioxidants in the feed is a good practice to reduce fats and oils oxidation. Natural antioxidants such as vitamin E, vitamin C, flavonoids and carotenoids can be used to manage oxidation in feeds and feedstuffs [14]. Good source of vitamin C which farmers even at rural areas could use is lime juice. Lime juice is a good source of vitamin C. Lime juice has been reported to improve growth in broiler chickens recently [15]. Also, synthetic antioxidants like butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and ethoxyquin (1, 2-dihydro-6-ethoxy-2, 2, 4- trimethylquinoline) are also used to control fat oxidation. Some antioxidants prevent the generation of relative oxygen species (ROS) which are free radicals, while some scavenge and attack free radicals are generated.

Poor protein quality

The quality of protein is measured by its amino acid profile which depends on the source of the protein. We have animal and plant sources of protein. Animal sources of protein which include fish meal, blood meal and meat meal are richer in essential amino acids (especially lysine and methionine) than plant sources like, maize, sorghum, cassava meal, soya bean meal and groundnut cake. Judging by reports of Olomu [16] and Sundu., *et al*. [5] the amino acid profile of PKC does not favour poultry nutrition. It contains low level of lysine (0.60 - 0.70%) and methionine (0.4 - 0.5%). These two amino acids are essential and critical in poultry nutrition. This is because plant materials form greater proportion of poultry feeds. The two amino acids are more critical now that use of animal protein which is good source of the amino acids has been banned in poultry feeds. In animal nutrition especially monogastric animals, the ratio of essential to non-essential amino acids is important. This does not favour PKC based feeds.

Also, plant based protein is embedded in a matrix and therefore cannot be easily released during digestion. Another factor that could affect the quality of protein in PKC is maillard reaction or browning. This is a reaction which occurs during heat processing of protein feedstuffs. Heat processing affects quality of lysine in feeds and feedstuffs negatively. It is a reaction between lysine and carbohydrate which occurs during heat processing of protein feedstuffs that forms an indigestible complex. During heat processing of protein feedstuffs, the *epsilon* amino group (the amino group attached to the first carbon atom) in lysine structure is detached (set free) and it reacts with carboxyl moiety of carbohydrate in the feedstuff to form an indigestible complex [17]. The protein in this complex is difficult to release for utilization by poultry. According to Ndelekwute., *et al.* [18] proximate analysis of the feedstuff will give normal protein content but cannot be well utilized by birds resulting to poor productivity. Since heat application during PKC processing has not been known to be controlled to favour PKC quality, feed millers should always assume that every PKC was over heated to have negatively affected its protein quality. This will encourage them to take precautionary measures such as addition of feed grade enzymes. Vegetable oil producers are more interested in industrial practices that will increase the yield of oil in palm kernel which is the primary product than the quality of the PKC. Palm kernel cake primarily is regarded as waste, though of economic value to poultry feed millers [18]. Therefore, palm kernel oil producers are not primarily interested in quality of palm kernel cake. The best practice to reduce the negative effect of poor protein quality is by addition of synthetic lysine and methionine in the feed during production.

Mold growth

Further and poor storage of palm kernel cake could lead to mold growth under environmental factors such as high humidity and temperature which favour mold growth. Wallace., *et al*. [19] reported that under room temperature palm kernel cake should not be stored more than two weeks. Earlier, reports had indicated that one major setback affecting the poultry and livestock enterprise is the preservation and storage of feed ingredients. Improper storage of feeds and feedstuffs could result to growth of molds. Also, improper storage results to rancidity with its attendant unpleasant taste and odour [19,20]. Though reports had shown that PKC is not likely to be contaminated by mold but recent report indicated that different mycotoxins were observed in stored PKC using liquid chromatography-tandem mass spectrometry analysis [21]. Earlier Kolapo., *et al.* [22] had observed that after three months of storage, aflatoxin B1 (21.65 - 49.26 µg/kg) was detected on groundnut cake, soyabean meal and palm kernel cake. It is important to note that fungi are ubiquitous and therefore contamination of PKC by mycotoxins should not be ignored. Level as low as 20 ug/kg of Aflatoxin B1 on feedstuffs has reported by the European Union Regulatory Body as the minimum acceptable level on feeds and feedstuffs [23]. Furthermore, poor fermentation and storage of fermented PKC by local farmers could attract mold because of high moisture content and temperature generated by microbial activities. In addition, prolong storage of fermented PKC could attract mold growth. Fungi are not by themselves toxic but their secondary metabolites called mycotoxins which they release into their substrate are toxic. According to Murugesan., *et al.* [24] mycotoxins are secondary metabolites of low molecular weight produced by a wide range of fungi, principally molds. There are over 200 species of molds that produce mycotoxins. Aflatoxins, zearalenone, ochratoxin, fumonisins, trichothecenes (such as deoxynivalenol and T-2 toxin) are some of the mycotoxins that can negatively impact the health and productivity of poultry species [24]. Mycotoxins when

ingested could be hepatotoxic, nephrotoxic, and neuro-musculotoxic. Some of these mycotoxins are potentially carcinogenic, mutagenic and could cause vomiting. Ingested mycotoxins results to decreased weight gain, poor feed efficiency, reduced egg production and egg weight. Mycotoxin toxicity also leads to increased liver fat, changes in organ weights, reduction in serum protein levels, carcass bruising, poor pigmentation and liver damage. Other negative effects are decreased activities of several enzymes involved in the digestion of starch, protein, lipids, and nucleic acids, and immunosuppression [25]. Not only that mycotoxins can inflict pathological and physiological injury, they can cause erosion of the villi thereby limiting the absorptive capacity of the lumen [26]. Nutritionally, mycotoxins interfere with metabolic processes leading to accumulation of lactic acid during carbohydrate catabolism. During breakdown of glucose at the glycolytic level, thiamine which is a cofactor in the conversion of pyruvate to acetyl-COA is inhibited thus resulting to conversion of pyruvate to lactic acid in the muscle. This leads to muscle spasm, paralysis and other physiological disorders. Inclusion of this vitamin as additive in the feed could reduce this anomaly. The problem with mold is not in the production of toxins, but also mold contain an enzyme called lipase which breaks down fatty acids in PKC leading to poor quality product.

Generally, addition of anti-mycotoxins to feeds is good practice to reduce effect of mold. Arrays of anti-mycotoxins both organic and inorganic ones have been developed. Inorganic substances that could be used to mitigate the negative effect of mycotoxins are the clay minerals such as bentonites and aluminosilicate. Also, micro-organisms such as yeast (e.g. *Trichosporon mycotoxinivorans*) and bacteria (*Eubacterium*) have been reported to detoxify mycotoxins [27,28]. glucomanan, yeast cell wall and including plant extracts have been suggested to be used [29]. It is important to note that anti-mycotoxins do not destroy mycotoxins but bind them in the intestine so that they will not be absorbed into the blood stream to exert their toxicity. Rather they are passed out with the faeces.

Conclusion

Despite its nutritional challenges palm kernel cake has shown a great potential in production of poultry feeds in terms of its availability, nutrient content and cost. Application of feed additives could ameliorate these challenges. One big hiccup is the additional cost the use of feed additives could attract and their possible inaccessibility by local farmers. However, since addition of feed additives to feeds increases the cost and sometimes they are not readily available, there is the need to explore local options through sustained investigation of local raw materials and sharing of information, especially between researchers and farmers. This will help to curb the challenges in all ramifications.

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Volume 4 Issue 5 July 2019