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Original Article

Effects of palm kernel meal level on live performance and gut morphology of broilers

Nisarat Yaophakdee, Yuwares Ruangpanit,* Seksom Attamangkune

Department of Animal Science, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen, Nakhon Pathom, 73140, Thailand

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ABSTRACT

A study was conducted to determine the effects of feeding different levels of palm kernel meal (PKM) on the live performance and gut morphology of broilers. In total, 600 one-day-old broilers (Ross 308) were divided into two groups. Each group consisted of six replications with 50 birds (25 males and 25 females) each. The diets were: 1) corn-soybean meal basal diet with low PKM levels (5% and 7.5% in starter and grower diets, respectively) and 2) corn-soybean basal diet with high PKM levels (10% and 15% in starter and grower diets, respectively). The experiment was conducted from 1 to 35 days of age (DOA). All birds were raised in an evaporative cooling house with pellet feed and water provided *ad libitum*. During 1–17 DOA, feeding diets with different levels of PKM had no effect on broiler performance ($p > 0.05$). During 18–35 DOA, feeding high levels of PKM had no significant effect on body weight gain, feed intake and mortality of broilers. However, birds fed high PKM diets had a significantly higher feed conversion ratio (FCR) than the low PKM group ($P = 0.0495$). Throughout the experimental period (1–35 DOA), feeding high levels of PKM had no effect on body weight gain but feed intake tended to increase with high PKM levels ($P = 0.0873$). This led to a significant lower feed conversion ratio of broilers ($P = 0.0505$). No significant effect of PKM level was observed on the ileum morphology and litter quality of broilers. It was concluded that feeding high levels of PKM had a negative effect on the feed efficiency but not on the gut health and litter quality of broilers.

Introduction

As the demand for animal products increases with an increase in population and improvement in living standards, conventional feedstuffs are likely to be insufficient to maintain poultry production. Commercial feed production for poultry currently places more reliance on the use of agro-industrial by-products (AIBs). High inclusion levels of some AIBs or high fiber-containing feed ingredients in a poultry diet have been limited due to their effect on reducing bird performance (Iyayi and Bina, 2005). Palm kernel meal (PKM) is a by-product of palm kernel oil extraction from the nut of the palm tree, *Elaeis guineensis*. Due to its high fiber content, PKM is widely used in ruminant diets (Nakkaew et al., 2008).

According to Sundu et al. (2006), PKM is aflatoxin free, palatable and has considerable potential as carbohydrate and protein source. The inclusion of PKM in the diet has been less practiced in monogastric animals particularly in poultry due to its high fiber content. However, PKM can be incorporated at 20% in the broiler diet without any negative effects on the performance of the broilers (Yeong, 1980; Hutagalung, 1980). Onwudike (1986) indicated that PKM can be used in starter and finisher diets of broilers at 28% and 35%, respectively, without any effect on performance and health. Ng and Chong (2002) reported that PKM contained high amounts of non-starch polysaccharide (NSP) with 78% linear mannan, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans (Dusterhoft et al., 1992). The galactomannan in palm kernel meal is possibly a part of the soluble NSP (Sundu et al., 2006). A number of researchers have indicated that soluble-NSP has an antinutritional effect. These NSPs can bind great amounts of water, which leads to an increased digesta viscosity and reduced digesta movement. High gut viscosity causes a reduction of nutrient availability especially, fat (Annison, 1993) resulting in higher amounts of sticky droppings (Choct, 1998). The consumption of a high fiber diet is known to increase fecal moisture content and wet litter (Atteh, 2001). Wet litter leads to increase incidences of bacterial and protozoa diseases, one of the main issues in modern poultry industry (Esuga et al., 2008). In addition, the high level of NSP found in the plant cell wall contributes to lower nutrient digestibility. These NSPs impair nutrient digestibility in the plant feedstuff either by direct encapsulation of the nutrients, which reduces the rate of hydrolysis and absorption of nutrients in the diet (Choct and Annison, 1992). Therefore, the

* Corresponding author.
E-mail address: agryos@ku.ac.th (Y. Ruangpanit).

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purpose of the present study was to observe the effects of palm kernel meal levels on the live performance, gut histology and litter quality of broilers.

Materials and methods

Birds and housing

In total, 600 Ross 38 broiler chicks (1 day old) were obtained from a commercial hatchery and used in this study. All the chicks were randomly divided into two groups, each group consisting of six replications, with 50 birds each (25 males and 25 females). All birds were housed in a 12 m × 30 m curtain-sided, evaporative cooling system house with rice husk as litter material. Light was provided for 23 h daily throughout the experiment. The trial was run between 1 and 35 days of age (DOA).

Experimental diets

The experimental diets (Table 1) consisted of a corn-soybean meal-based diet with two levels of PKM—low PKM (5% and 7.5% PKM in the starter and grower phases) and high PKM (10% and 15% PKM in the starter and grower phases). Salinomycin at 66 ppm was used as coccidiostat and was removed during the last 7 d of the study. Diets were formulated according to the recommendation of the Ross Nutritional Guild. Feed in pelleted form and water were provided *ad-libitum* throughout the experimental period.

Performance, ilium morphology and litter score

During the experimental period, the body weight and feed intake of the birds in each pen were recorded at 1 DOA, 17 DOA and 35 DOA for body weight gain, feed intake and feed conversion ratio calculation. Mortality, temperature and humidity were recorded daily. At 34 DOA, two birds (one male and one female) from each pen were randomly selected, weighed and killed by cervical dislocation. A sample (2 cm segment) was taken from midway between Meckel's diverticulum and the ileocecal junction (ileum) of each broiler. Tissue samples were prepared for histological analysis, and were fixed using immersion in 10% neutral buffered solution in vials at room temperature for hematoxylin and eosin staining. The slides were further used to determine the villus height (measured from the brush-border membrane to the basolateral membrane) and the crypt depth (area encircled by the basement membrane and the crypt mouth) as described by Brunsgaard (1998). All measurements were taken using a 20′ objective on a light microscope and the villus surface area was calculated using the length and width of the villus.

Representative samples of litter were collected from each replication at 21 DOA from two areas in each pen (the feeder and away from the feeder). The condition of the litter was monitored using a 5-point score system: score 1: very dry litter, can see all the particles; score 2: litter dry, can see litter particles; score 3: can see the litter particles very well, but beginning to make a wet mass; score 4: litter is fat and has a homogeneous mass/crust; score 5: wet and cake litter (Nalle et al., 2010).

Statistical analysis

All data from each pen were considered as an experimental unit. Data from both treatments were analyzed using Student's *t*-test according to Steel and Torrie (1980). Significant differences were accepted if $p \leq 0.05$.

Table 1
Ingredients and calculated analysis of experimental diets containing palm kernel meal (PKM).

Ingredient (%)	Starter diet		Grower diet	
	Low PKM	High PKM	Low PKM	High PKM
Corn	48.72	45.78	47.99	42.11
PKM	5.00	7.50	10.00	15.00
Rice bran oil	0.97	1.66	3.42	4.81
SBM 46%	21.27	21.01	19.86	19.34
Full fat soybean	20.00	20.00	15.00	15.00
L-lysine	0.20	0.20	0.09	0.09
DL-methionine	0.24	0.24	0.22	0.23
Choline chloride (50%)	0.005	0.006	0.004	0.005
Monodicalcium phosphate	1.65	1.66	1.54	1.54
Calcium carbonate	1.29	1.28	1.22	1.19
Sodium chloride	0.41	0.41	0.42	0.42
Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated analysis (%)				
ME (kcal/kg)	2975	2975	3050	3050
Crude protein	22.00	22.00	20.00	20.00
Ash	2.09	2.13	2.19	2.29
Fat	6.81	7.54	8.60	10.06
Fiber	4.30	4.59	4.69	5.27
Calcium	0.90	0.90	0.85	0.85
Total P	0.77	0.77	0.73	0.74
Available P	0.45	0.45	0.42	0.42
Salt	0.52	0.53	0.53	0.55
Lysine	1.31	1.31	1.10	1.10
Methionine	0.58	0.58	0.54	0.55
Met + Cys	0.92	0.92	0.85	0.85
Choline (mg/kg)	1500.00	1500.00	1300.00	1300.00
Na	0.18	0.18	0.18	0.18

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).

Results and discussion

Nutrient composition

The compositions of the nutrient experimental diets are shown in Table 2. Crude protein in the diets agreed with the calculated values. The amounts of crude fat, crude fiber, calcium and phosphorus in the experimental diets were also in good agreement with the calculated values.

Performance

The effect of PKM on body weight gain, feed intake, feed conversion ratio and mortality during the starter (1–17 DOA), grower (18–35 DOA) and overall (1–35 DOA) periods are shown in Tables 3–5, respectively. During the starter period, feeding the diets containing PKM had no significant effect on body weight gain, feed intake, feed conversion ratio and mortality of broilers (Table 3). Commonly, it has been accepted that an increase in dietary fiber reduces feed intake in poultry (Mateos et al., 2012). However, the experimental diet containing the high PKM level contained 4.59% crude fiber (Table 3) which was an acceptable level recommended for broiler diet. Walugembe et al (2015) indicated that using high fiber ingredients at levels of 60–120 g/kg in broiler diets had no effect on growth performance. Therefore, it was not surprising that the high PKM level did not show any adverse effect on the feed intake of broilers. During this period, higher wet droppings were observed in birds fed the high PKM level (data not shown), possibly due to the epithelium of the small intestine not being completely mature from a cellular and an enzymological viewpoint during the first 14 DOA. Therefore, the chicks could not utilize any problematic material such as non-starch polysaccharide (McNab and Smithard, 1992). In addition, a very short transition time of digesta through

Table 2
Nutrient composition of experimental diets containing palm kernel meal (PKM).

Nutrient composition	Starter diet		Grower diet		Grower diet (withdrawal period)[a]	
	Low PKM	High PKM	Low PKM	High PKM	Low PKM	High PKM
Moisture	10.66	10.32	9.73	9.16	10.43	9.13
Fat	7.89	8.39	9.65	10.23	9.16	10.65
Ash	5.63	5.93	5.62	5.73	5.7	5.7
Calcium	1.04	1.06	1.05	1.1	1.09	1.11
Fiber	3.31	3.59	3.61	4.04	3.7	3.88
Total P	0.67	0.71	0.68	0.7	0.62	0.69
Crude protein	21.35	21.25	19.56	19.15	19.11	19.49
Gross energy (GE) (kcal/kg)	4640.83	4633.68	4712.07	4779.17	4770.6	4803.02

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).
[a] withdrawal of coccidiostate

Table 3
Effect of palm kernel meal (PKM) level on growth performance of broiler during 1–17 days of age.

Treatment	Weight gain (g)	Feed intake (g)	FCR	Mortality (%)
Low PKM	476.33	645.00	1.354	0
High PKM	467.50	637.75	1.365	0
p-value	0.3448	0.3883	0.4761	–
Pooled SE	13.6305	12.3123	0.0216	–

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).

the gut could limit the efficacy of NSP digestion by the gut microflora of chicks (Choct and Annison, 1990).

During the grower period, no significant effect of PKM level was observed on the feed intake and body weight gain. However, the feed conversion ratio was higher ($p < 0.05$) in birds fed the high PKM diet (Table 4). Problems created by the use of PKM may not be related only to the physical properties of PKM but also to its contribution to the overall nutrients in the diet, in particular amino acids utilization, as PKM contains low levels of key essential amino acids such as lysine and methionine. Methionine and lysine are the most important amino acids to consider when using this ingredient because PKM only meets about 30% and 50%, respectively, of the requirements of young chicks (Sundu et al., 2006). Similar findings were reported by Armas and Chicco (1977) that a broiler-fed diet with a high PKM the level (15%, 30%, 45%) resulted in better growth performance with the supplementation of lysine and DL-methionine. In the present study, the experimental diets were formulated based on the total amino acid and not the digestible amino acid requirement; therefore, the addition of high PKM in the diet led to lower amino acid availability and ultimately, lower growth performance.

Throughout the experimental period, the birds fed the diets containing high PKM tended to have higher feed intake ($p = 0.0873$), which led to a higher feed conversion ratio ($P = 0.0505$) compared to that of the group fed the low PKM, while there was no significant difference in the body weight gain (Table 5). Ariff Omer et al. (1998) and McDonald et al. (1995) indicated that the lower weights of birds fed PKM diets was caused by the high fiber content that increased with increased inclusion of PKM in the diet. The high fiber content resulted in dilution of the energy concentration in the diets and reduced the nutrient availability for the birds. In addition, PKM contains a high level of β-mannan which could cause high gut viscosity, growth depression and reduce feed efficiency (Dienick, 1989).

Ilium morphology

There was no significant effect of PKM level on the villi height, villi width, crypt depth and surface area of ileum section of broiler measured at 34 DOA (Table 6). Based on investigation (data not shown) during the starter period, it was clear that broilers fed the high PKM diets had lower litter quality when compared to those of the low PKM group. However, this negative effect disappeared during the grower period. The gut morphology of broilers in the present study was measured during the grower period when the digestive system had fully developed. Adult chicks have good development of the gastrointestinal tract (GIT), enzymology, and NSP-degrading microflora; therefore, grower and finisher chicks can utilize high fiber diets more efficiently compared to young chicks (Patrapan, 2013). The birds could cope very well with the negative effect of the high fiber diet. Therefore, no negative effect was observed on gut morphology from feeding the high PKM diets. A similar effect was reported by Baurhoo et al. (2011) from the use of a pearl millet-based diet containing arabinoses and xylans which had no effect on the villus height, villus width and villus surface area of the jejunum of broilers at 28 DOA and 42 DOA.

Litter score

Because of the presence of NSP in PKM, it was anticipated that there would be a wet litter problem when these feed ingredients were introduced into broiler diets. However, in the present study, the litter score of the birds observed at 21 DOA was not affected by the PKM level (Table 7). Normally, soluble NSP is present in high proportions in poultry diets and can cause familiar problems such

Table 4
Effect of palm kernel meal (PKM) level on growth performance of broiler during 18–35 days of age.

Treatment	Weight gain (g)	Feed intake (g)	FCR	Mortality (%)
Low PKM	1529.33	2747.00	1.798	0.7667
High PKM	1504.00	2820.25	1.875	0.5675
p-value	0.3710	0.1256	0.0495	0.8018
Pooled SE	41.4116	66.3615	0.0519	0.2639

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).

Table 5
Effect of palm kernel meal (PKM) level on growth performance of broiler during 1–35 days of age.

Treatment	Weight gain (g)	Feed intake (g)	FCR	Mortality (%)
Low PKM	2001.33	3662.17	1.831	0.6667
High PKM	1971.00	3753.25	1.904	0.5000
p-value	0.2685	0.0873	0.0505	0.8067
Pooled SE	39.5179	72.4393	0.0494	0.2435

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).

Table 6
Effect of palm kernel meal (PKM) level on ilial morphology of broiler at 34 days of age.

Treatment	Villus height (μm)	Crypt depth (μm)	Villus width (μm)	Villus surface area (μm^2)
Low PKM	450.92	123.90	139.64	6453.6
High PKM	475.90	111.04	142.66	6942.7
p-value	0.4267	0.1576	0.6601	0.4161
Pooled SE	44.1438	12.1161	9.8084	843.6264

Low PKM = (5% and 7.5% PKM in the starter and grower diets).
High PKM = (10% and 15% PKM in the starter and grower diets).

Table 7
Effect of palm kernel meal (PKM) level on litter score of broiler at 21 days of age.

Treatment	Litter score[a]	
	Near feeder	Far from feeder
Low PKM	2.167	1.833
High PKM	2.333	2.000
p-value	0.6643	0.5995
Pooled SE	0.6455	0.5322

[a] score 1: very dry litter, can see all the particles; score 2: litter dry, can see litter particles; score 3: can see the litter particles very well, but beginning to make a wet mass; score 4: litter is fat and has a homogeneous mass/crust; score 5: wet and cake litter (Nalle et al., 2010).

as moist, sticky droppings and wet litter (Pottgüter, 2008). In the current experiment, this was observed in broilers fed the high PKM diet during the starter period but reduced during the grower period. It was possible that the broilers during the latter period had a fully developed digestive system (McNab and Smithard, 1992; Patrapan, 2013).

Under the conditions of the present study, the use of PKM at 7.5% had no effect on the growth performance and gut health of broilers. Although feeding PKM at 15% in broiler diet had no effect on the ileum morphology and litter quality, it did result in a negative effect on the feed intake and feed efficiency. This detrimental effect of a high PKM level should be alleviated when formulating the diet by using the digestible amino acid level of PKM.

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