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Growth performance and carcass quality of broilers fed with palm kernel meal-based rations

(Prestasi tumbesaran dan kualiti karkas ayam pedaging yang diberi makan rangsum berasaskan isirung sawit)

M. Mardhati*, H.K. Wong* and S. Noraini*

Keywords: broilers, palm kernel cake, growth performance

Abstract
A feeding trial was carried out to compare the effect of feeding broiler chicken with rations formulated with different types of palm kernel meal. A total of 96 one-day-old chicks (male, COBB) were reared in 2-tier battery cages in the open house system. Birds were assigned to 4 different treatments: T1, corn-soy ration as control, T2, ration formulated with 20% palm kernel expeller (PKE), T3, ration formulated with 20% commercial solvent extracted palm kernel cake (PKC) with about 4% shell and dirt and T4, laboratory produced solvent extracted palm kernel cake (PKC) with less than 3% shell and dirt content. The average weight of the birds, feed intake and feed conversion ratio were calculated for each ration. The feeding trial lasted 42 days and results showed that there were significant differences (p <0.05) among treatment rations in average body weight and feed conversion ratio for the starter and growth periods. Broilers fed with corn-soy-based ration gave the best result compared to PKE and PKC-based rations. Feed cost per kg bird live weight was lowest for T1 compared to other treatments.

Introduction

A major by-product of the oil palm industry is the palm kernel meal (PKM) with a total production of about 2,312,222 t (MPOB 2010), of which 95.6% was exported with export revenue of RM496 million. There are two types of PKM, the mechanically pressed palm kernel expeller (PKE) and the solvent extracted palm kernel cake (PKC).

PKE is obtained as a by-product from the extraction of palm kernel oil via the mechanical process. The production of PKE involves the grinding of palm kernels followed by screw pressing with or without an intermediary flaking and cooking stage. During the screw pressing stage, the raw palm kernel oil is diverted for clarification and the residual PKE is cooled and stored in a warehouse.

Palm kernel cake (PKC) on the other hand, is a by-product from the extraction of palm kernel oil via solvent (hexane) extraction of the ground palm kernels. As the cost of the solvent extraction process is much higher, most of the PKM production in the country uses the mechanical process. PKE and PKC are quite similar but have small differences in crude fat and fibre contents.

*Strategic Livestock Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Mardhati Muhammad, Wong Hee Kum and Noraini Samat
E-mail: mardhati@mardi.gov.my

The main difference between PKC and PKE is in the ether extract or oil content which is around 0.5–3% and 8–12%, respectively. A major drawback of PKE is the poor nutritive value (low metabolisable energy, highly variable amino acid content and high shell content). The screw pressing process used in producing PKE results in denaturation of the protein, peroxidation of the oil and the high shell content can damage the intestinal tract of monogastric livestock.

Nevertheless, use of PKE for poultry production has been widely reported by several researchers (Yeong and Mukherjee 1983; Osei and Amo 1987; Panigrahi and Powell 1991; Perez et al. 2000; Sundu et al. 2006; Chong et al. 2008). In broilers, Osei and Amo (1987) found no significant differences in body weight and feed consumption, but reported that feed conversion efficiency significantly declined as PKE levels reached 12.5% or higher. Perez et al. (2000) reported that PKE meal can be used up to 40% in layer diets with little effect on egg production. These authors also noted that use of PKE need to be balanced with high-energy fat sources and more information is needed on amino acid availability.

The metabolisable energy of palm kernel meal varies widely from 5.6 MJ/kg (Anon. 1993), 8.35–9.74 MJ/kg (Panigrahi and Powell 1991), 9.43 MJ/kg (Perez et al. 2000) and 9.46 MJ/kg (Sundu et al. 2006). The authors attributed the variations to the differences in oil content in the feedstuff and age of the birds consuming the feed (Sundu et al. 2006), where older birds have better ability to digest fat, protein and fibre.

Wide variation in metabolisable energy, lack of information on digestible amino acids and the need to balance the feed with more expensive high-energy fat sources are major factors hindering precise feed formulation and extensive use of this product by the commercial feed milling industry in Malaysia. Thus, the objective of this study was to evaluate the growth performance, feed efficiency and carcass quality of broilers fed on diets with similar levels of PKE and PKC.

Materials and methods

Material sources

The palm kernel used in this study was purchased from a palm kernel crusher factory in Klang. For this study, the laboratory PKC was extracted from the palm kernel using the solvent hexane extraction method (Hishamudin 2001) in the MARDI Feed Chemistry Laboratory while the commercially produced PKC and PKE were purchased from factories in Pasir Gudang, Johor and Klang, Selangor, respectively.

True metabolisable energy determination

The method of Sibbald (1976) was used to determine the true metabolisable energy (TME) of PKE and PKC using adult cockerels. It involved the measurements of total feed intake and total excreta output and subsequent measurements of gross energy (GE) and crude protein values of the feed and excreta. A total of 50 (6-week-old) adult cockerels with mean body weight of 2.7 kg were used. They were fasted for 48 h to empty the alimentary canals of feed residues. A further 48 h fasting was done to collect excreta for endogenous energy assay. After resting for 5 days, the birds were fasted once again and then precision-fed on a known quantity (30 g) of the test material to be assayed. Water was provided *ad libitum* throughout the experiment.

Individual bird excreta, cleared of obvious contaminants were collected in weighed cups and oven dried at 60 °C until constant weight was obtained. The weight was recorded and excreta within treatments were pooled. The samples of pooled excreta and test materials were assayed for dry matter, gross energy and crude protein. The TME values of feed ingredients were then corrected for N retention (TMEn) using a factor of 8.22.

Feeding trial
A total of 96 day-old chicks (male, COBB 500) were reared in 2-tier battery cages in an open house system with six birds per cage. Birds were assigned to four different treatments: T1 = corn-soy-based ration as control; T2 = ration formulated with 20% PKE; T3 = ration formulated with 20% commercial solvent extracted PKC, and T4 = ration formulated with laboratory extracted PKC. The starter and grower diets were formulated according to the nutrient recommendations of the Cobb breeder company (Anon. 2008). The compositions of the diets are shown in *Table 1*. There were four replicates per treatment, with six birds per replicate.

Rations were formulated to be isocaloric and isonitrogenous. Starter rations (1–20 days) and grower rations (21–42 days) were provided in mash form. Starter and grower commercial rations were provided as crumbles and whole pellets, respectively. The use of antibiotic and coccidiostat followed the recommendations of the manufacturer with a withdrawal period before slaughter. The calculated nutrient compositions of the experimental rations are shown in *Table 2*.

Chemical analyses
The experimental ration samples were analysed for proximate composition using the Association of Official Analytical Chemist (AOAC 1990) recommended procedures for dry matter (DM), crude protein (CP), ether extract (EE), ash and gross energy (GE). The European Commission Directive 98/64/EC method (Anon. 1998) for the analyses of amino acids from food and feedstuffs was used for analysis of amino acid composition of PKE and PKC using a Biochrom 30 amino acid analyser (Biochrom Ltd., Cambridge, England). The amino acid and TMEn data of PKE and PKC were used to formulate least cost rations (T1-T4) for the feeding trial.

Growth performance
Feed intake and total weight gain of the broilers were measured on day 21 and 42 to assess weight gain and feed conversion efficiency. The average broiler weight, total feed consumption and feed conversion ratio (kg of rations consumed per kg of weight gain) were calculated for each ration. Mortality was recorded daily and used to correct ration consumption. Growth performance was evaluated on day 1–20 for the starter period and day 21–42 for the grower period.

Carcass quality
After the final live weights were taken, two broilers from each replicate were randomly selected and killed by severing the jugular vein and exsanguinated. The birds were scalded, defeathered, and eviscerated with abdominal fat removed to determine carcass weight as a percentage of live weight. The abdominal fat, breast, drumstick and wings were also expressed as a percentage of live weight.

Feed cost for broiler production
The price for feed ingredients used in the study was obtained from the feed industry. Feed costs for the starter and grower phases, feed intake and broiler live weight data were used to calculate the mean cost of feed for the starter and grower periods as well as the feed cost per bird and feed cost per kg live weight.

Statistical analysis
Data obtained on each parameter were subjected to analysis of variance using SAS Statistical Package 9.1 (SAS Inst. 2003). Significant differences among means were based on a 0.05 probability level using Duncan Multiple Range Test (DMRT).

Table 1. Starter-grower diet formulations (as-fed basis)

Ingredient	Amount (%)			
	T1	T2	T3	T4
Starter rations				
Corn	50.33	34.59	37.85	36.47
Soybean meal	33.06	29.46	25.29	24.15
Palm kernel expeller	–	20.00	–	–
Palm kernel solvent	–		20.00	20.00
CPO	4.00	8.50	6.00	6.00
Fishmeal	1.90	2.86	5.00	5.00
Wheat pollard	7.00	1.00	2.85	5.27
DCP	1.24	1.22	0.86	0.94
Limestone	1.23	1.07	0.96	0.95
Methionine	0.21	0.22	0.20	0.21
Salt	0.40	0.39	0.33	0.33
Choline chloride (60%)	0.10	0.10	0.10	0.10
Lysine	0.20	0.26	0.23	0.25
CTC	0.15	0.15	0.15	0.15
Mineral*	0.10	0.10	0.10	0.10
Salinomycin	0.05	0.05	0.05	0.05
Vitamin**	0.03	0.03	0.03	0.03
Grower rations				
Corn	57.95	43.36	46.09	44.77
Soybean meal	26.81	18.90	17.17	19.21
Palm kernel expeller	–	20.00	–	–
Palm kernel solvent	–	–	20.00	20.00
CPO	4.00	8.00	5.81	6.00
Fishmeal	2.35	5.95	6.68	4.81
Wheat pollard	5.48	1.00	1.63	2.19
DCP	1.12	1.00	1.00	1.00
Limestone	1.19	0.74	0.61	0.90
Methionine	0.22	0.21	0.21	0.22
Salt	0.31	0.24	0.21	0.27
Choline chloride (60%)	0.10	0.10	0.10	0.10
Lysine	0.23	0.25	0.24	0.28
CTC	0.15	0.15	0.15	0.15
Mineral*	0.10	0.10	0.10	0.10
Salinomycin	0.05	0.05	0.05	0.05
Vitamin**	0.03	0.03	0.03	0.03

*Gladron mineral providing per kg of ration at 1 kg/t inclusion: 80 g iron, 100 g manganese, 15 g copper, 80 g zinc, 1 g iodine, 0.2 g selenium, 0.25 g cobalt, 4 g potassium, 0.6 g magnesium and 1.5 g sodium

**Lutamix vitamin providing per kg of ration at 300 g/t inclusion: 50 MIU vit A, 10 MIU vit D3, 75 g vit E, 20 g vit K3, 10 g vit B1, 30 g vit B2, 20 g vit B6, 0.1 g vit B12, 60 g calcium D-pantothenate, 200 g niacin, 5 g folic acid and 235 mg biotin

Table 2. Nutrient compositions of starter and grower rations (as-fed basis)

Nutrient name	Requirement	Supplied			
		T1	T2	T3	T4
Starter rations					
Crude protein (%)	21.00	21.00	21.00	21.00	21.00
ME (MJ/kg)	12.50	12.50	12.50	12.55	12.50
Calcium (%)	1.00	1.00	1.00	1.00	1.00
Available phosphorus (%)	0.40	0.40	0.40	0.40	0.40
Lysine (%)	1.20	1.27	1.28	1.28	1.28
Methionine (%)	0.49	0.57	0.57	0.57	0.57
Met + cys (%)	0.89	0.89	0.86	0.89	0.89
Threonine (%)	0.79	0.84	0.84	0.81	0.83
Tryptophan (%)	0.19	0.27	0.26	0.25	0.24
Arginine (%)	1.26	1.31	1.58	1.55	1.66
Grower rations					
Crude protein (%)	19.00	19.00	19.00	19.00	19.00
ME (MJ/kg)	12.90	12.90	12.90	12.90	12.90
Calcium (%)	0.96	0.96	0.96	0.96	0.96
Available phosphorus (%)	0.38	0.38	0.43	0.46	0.39
Lysine (%)	0.99	1.15	1.16	1.17	1.17
Methionine (%)	0.44	0.55	0.56	0.56	0.56
Met + cys (%)	0.84	0.84	0.82	0.85	0.85
Threonine (%)	0.74	0.76	0.76	0.74	0.76
Tryptophan (%)	0.19	0.24	0.23	0.21	0.21
Arginine (%)	1.17	1.17	1.41	1.41	1.54

Table 3. Proximate composition of experimental starter and grower rations for broilers

	T1	T2	T3	T4
Starter ration				
Dry matter (%)	89.45	86.77	88.29	87.65
Crude protein (%)	22.20	21.09	21.42	21.91
Crude fibre (%)	1.35	3.59	3.55	2.58
Ether extract (%)	4.88	9.05	6.24	6.01
Ash (%)	6.86	5.51	6.06	5.71
Gross energy (MJ/kg)	16.78	17.87	17.22	17.04
Grower ration				
Dry matter (%)	85.99	85.21	86.64	86.83
Crude protein (%)	22.91	19.79	20.69	19.41
Ether extract (%)	4.00	9.19	5.24	8.44
Ash (%)	4.18	4.72	4.64	4.77
Gross energy (MJ/kg)	16.85	17.70	16.53	16.15

Results and discussion

Chemical composition and metabolisable energy

The chemical composition of the experimental broiler rations used in this study is shown in *Table 3*. All the values are quite comparable to each other except for the ether extract content. The variation in the ether extract values was due to more oil being needed in PKM based rations especially for T2 to meet the metabolisable energy requirement of broiler chickens.

The TMEn values as determined by the Sibbald (1976) method were 6.00, 9.00 and

9.43 MJ/kg for PKE, PKC (commercial) and PKC (laboratory produced) respectively. The higher TMEn values for the PKC can be attributed to the lower shell and dirt content which was 4% and 3% respectively for the commercial and laboratory produced PKC. By comparison, the shell and dirt content in the PKE exceeded 8% and is one factor for the lower TMEn value.

Growth performance

Starter period Data on the growth performance of broilers during the starter period are shown in *Table 4*. Replacement of maize and soybean meal in the diets with palm kernel cake or expeller did not significantly ($p > 0.05$) affect the total feed consumption (TFC) of the starter broilers. The birds fed on the PKC diets (T3 and T4) had significantly lower ($p < 0.05$) average body weight (ABW) compared to birds in the corn-soy meal diet. This could be due to the presence of higher fibre content in PKC/PKE as shown in *Table 3*.

The gritty nature of the diets was also reported to reduce digestibility and possibly the availability of nutrients especially amino acids (Yeong 1983). The fibre in PKC/PKE, as reported by Ojewola and Ozuo (2006), may be structural in nature and might therefore reduce digestive enzyme action on PKC/PKE protein and availability of the protein.

The feed conversion ratio (FCR) of T3 and T4 were significantly higher ($p < 0.05$) compared to the corn-soy based ration and palm kernel expeller (PKE) based ration. The lowest body weight was in the T4 group and this group also had the lowest feed consumption. Generally, the increase in feed intake translated to higher weight gain for the starter period. The corn-soy-based ration (T1) gave the best FCR compared to the PKC/PKE-based rations.

Grower period For the grower period (*Table 4*), T3 showed the highest TFC (3.99 kg per bird) compared to the other treatments. However, the values for TFC were not significantly different ($p > 0.05$) between treatments. The ABW for T1 was significantly higher ($p < 0.05$) than the other treatments. The FCR were significantly better ($p < 0.05$) for T1 compared to T2, T3 and T4. Solvent extracted palm kernel-based ration (T4) had the lowest ABW and highest FCR. The better growth performance and FCR for T1 can be attributed to better digestible nutrients in the corn-soy-based ration.

Although TMEn values were determined for PKE and PKC, the effect of a ration is also due to the digestible nutrients in the ration. However, in this study, the digestibility of the amino acids in PKC and PKE were unknown and feed formulation

Table 4. Total feed consumption, average body weight and feed conversion ratio of male COBB 308 broiler fed on T1, T2, T3 and T4 rations (starter and grower periods)

	T1	T2	T3	T4
Starter period				
TFC (kg)	1.16a ± 0.03	1.15a ± 0.04	1.17a ± 0.02	1.13a ± 0.07
ABW (kg)	0.84a ± 0.03	0.82ab ± 0.02	0.79bc ± 0.02	0.75c ± 0.03
FCR	1.46b ± 0.06	1.49b ± 0.04	1.58a ± 0.07	1.61a ± 0.03
Grower period				
TFC (kg)	3.81a ± 0.13	3.94a ± 0.17	3.99a ± 0.35	3.88a ± 0.20
ABW (kg)	2.28a ± 0.03	2.09b ± 0.10	2.08b ± 0.15	2.04b ± 0.11
FCR	1.67b ± 0.05	1.88a ± 0.02	1.92a ± 0.08	1.91a ± 0.05

Means in the same row with different letters are significantly different ($p < 0.05$)
TFC = Total feed consumption; ABW = Average body weight; FCR = Feed conversion ratio

was based on the amino acid content and not on the digestibility of the amino acids. Yeong (1983) reported that the mean amino acid digestibility for PKC was 64.4% and this figure is considerably lower than the mean amino acid digestibility values published by National Research Council (NRC 1994) for soybean meal (90.1%) and corn (88.4%). In addition, the mechanical process of PKE production gives rise to heat damaged protein due to high temperatures during the screw pressing stage.

Another reason for the poorer performance of birds in the PKE and PKC treatments was probably due to the TMEn values used for the feed formulation. These values may not be suitable since TMEn values were determined from adult cockerels (56 weeks old) while the experimental birds in this study were from day-old to 6 weeks.

Sundu et al. (2006) reported that the metabolisable energy (ME) of PKE fed on to broilers at 3 and 6 weeks of age increased from 7.87 MJ/kg to 9.46 MJ/kg and suggested that older birds have better ability to digest fat, protein and fibre. Although the method of Sibbald (1976) assumed that the TMEn values of conventional feed ingredients were not affected by bird age, this adage may not be suitable for PKE and PKC ingredients.

Results obtained from this study were not in line with Sundu et al. (2006) who stated that the feed intake of birds fed on a palm kernel meal-based diet was usually higher than that of a maize-based diet. In this study, the lower feed intake in the PKE and PKC diets may be due to the PKE and PKC being more unpalatable compared to the soybean meal and corn rations. Results from this study also showed that the inclusion of PKC negatively affected the growth of broiler chickens.

Although several researchers (Panigrahi and Powell 1991; Perez et al. 2000; Sundu et al. 2006) had reported that PKM can be used up to 40% in poultry diets, the results from this study did not support their conclusions. The growth performance was lower and FCR was higher for broilers fed on the PKE/PKC-based diets compared to the corn-soy diet (T1) indicating that PKE and PKC, although cheaper, were poorer quality feeds and required further improvement in their nutritive quality.

Yeong and Mukherjee (1983) also reported that weight gain and feed efficiency of broilers were poorer in 20% PKC-based diets as well as PKC diets supplemented with 3% and 6% palm oil. However, they reported comparable weight gain and feed efficiency in 20% PKC-based diets supplemented with 9% and 12% palm oil but concluded that this level of supplementation was too expensive and impractical for commercial use.

The use of cheaper feed can reduce broiler performance and does not maximize margin for the producer (Waller 2007). Thus, commercial use of PKE in poultry diets needs to be cost competitive. In the present scenario, very little PKE is used by the poultry industry in Malaysia although it is much cheaper (RM200/t) compared to imported corn (RM970/t). It is estimated that Malaysia produces 3.4 million t of poultry feed yearly and using 5% PKE in poultry diets would require 170,000 t of PKE. However, in 2008, Malaysia (MPOB 2010) produced 2,358,000 t, exported 2,261,000 t and used only 97,000 t of PKE, mostly for the ruminant industry. There is no significant use of PKE in the domestic poultry industry. Further R&D is needed to improve the quality and cost competitiveness of the product for large scale use by the feed milling industry.

At 42 days, the male COBB bird was expected to achieve a live weight of 2.84 kg with FCR of 1.7 and total feed consumption of 4.83 kg (Anon. 2008). In this study, broiler growth performances were much lower than the expected body weight for the COBB breed. This was attributed to the lower feed intake due to high daily temperatures although the FCR of 1.67 for the corn-soy (T1) diet was considered good.

Mortality During the 6 weeks feeding trial, bird mortality was 0% for T1, T2 and T4 while T3 registered mortality of 12.5%. The temperatures during the study ranged from 25–34 °C and the high day temperatures may be a stress factor causing bird mortality especially in T3 where feed intake were higher than the other treatments. Several authors reported that reducing feed intake in the early stage of the broiler growth period have proven to reduce mortality (Shlosberg et al. 1991; Tottori et al. 1997; Urdaneta-Rincon and Leeson 2002; Whitehead 2006).

Carcass quality The broiler eviscerated weight was significantly higher (p <0.05) in T1 compared to the other treatments and this was due to the higher final live weight (*Table 5*). However, the dressing percentage was not significantly different among the treatments. Breast percentage, although highest in T1, was not significantly different among the treatments. Abdominal fat percentage was highest in T2 but the differences were not significant among treatments. This may be due to the higher fat content in the T2 diet with values of 9.05 and 9.19% (*Table 3*) for starter and grower ration respectively.

There were also no significant differences for drumstick and wing percentage (*Table 5*) among treatments. Generally birds in all groups showed better carcass quality with higher eviscerated and breast portion as percentage of live weight than those reported by the COBB breeder company (Anon. 2005) with values of 72.1% (eviscerated carcass) and 22.4% (breast). The carcass values in this study were also higher than those values reported for commercial broilers (Lucas et al. 2007; McNaughton et al. 2008). The drumstick portion as percentage of live weight was similar to those reported by the COBB breeder company (Anon. 2005). However, the abdominal fat content in the birds (1.70–2.26%) was higher than those (1.43–1.52%) reported by McNaughton et al. (2008). The differences may be due to the different types of ration, nutrient content, bird breed, environment, processing and management conditions.

Table 5. The effect of PKM based rations on broiler carcass quality

Treatment	Live wt. (g)	Eviscerated wt. (g)	Dressing (%)	Breast (%)	Drumstick (%)	Abdominal fat (%)	Wing (%)
T1	2302.88a	1721.37a	74.73a	26.49a	10.84a	2.17a	8.65a
T2	2176.88ab	1604.47b	73.72a	25.53a	10.85a	2.26a	8.58a
T3	2037.25b	1518.13b	74.54a	25.55a	11.08a	1.70a	8.78a
T4	2099.25b	1546.88b	73.67a	25.87a	11.35a	1.84a	8.62a

Means in the same column with different letters are significantly different (p <0.05)
Eviscerated wt. = Carcass weight with internal organs and abdominal fat removed
Breast (%) = Breast meat as % live weight
Drumstick/Wing = Whole drumstick/wing with skin and bone as % live weight
Abdominal fat = Fat as % live weight

Table 6. Comparison of the mean cost of feed for broiler production

Ration	Feed cost (RM/bird) (starter period)	Feed cost (RM/bird) (grower period)	Feed cost (RM/bird) (whole period)	Live weight (kg/bird)	Feed cost (RM/kg live weight)
T1	1.57	3.49	5.06	2.28	2.22
T2	1.54	3.63	5.17	2.09	2.47
T3	1.52	3.59	5.11	2.08	2.46
T4	1.45	3.46	4.91	2.04	2.41

Feed cost for broiler production

Feed cost per bird (*Table 6*) was highest for T1 diet during the starter period, and for the grower period, feed cost was highest for the T2 diet. Feed cost per bird for the whole period was also highest for the T2 diet compared to the other treatments. However, the cost of feed per kg live weight was the lowest in T1 (RM 2.22) compared to the other treatments due to the higher final live weight.

Waller (2007) reported that the use of cheaper feed can reduce broiler performance and did not produce maximum margin. As nutrient level increased, feed cost per bird also increased. Improvement in bird performance from better feed also increased revenues from the birds. Thus, the most economic option is not always to reduce feed cost by using cheaper feed ingredients.

Conclusion

This study showed that the inclusion of 20% PKE or PKC in broiler starter and grower diets negatively affected the growth of chickens compared to the corn-soy-based diets.

The FCR for broilers fed on the PKE and PKC-based diets were also poorer than the FCR for the corn-soy diets. Feed cost per kg live weight of broiler was also higher for the PKE and PKC fed birds compared to the corn-soy diets. The wide variation in TMEn values in PKE and PKC, possible differences in digestibility between young and older birds and the lack of data on its amino acid digestibility restrict the use of PKE and PKC in the poultry industry. Therefore, there is a need to carry out more research to improve the quality of PKE and PKC in order to make them suitable and economical to be used in broiler diets without affecting their growth performance, feed efficiency and production costs.

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References

AOAC (1990). *Official method of analysis*, 15th Ed. Washington DC: Association of Analytical Chemists

Anon. (1993). *Rhodimet feed formulation guide*. Cedex, France: Rhone Poulenc Animal Nutrition

—— (1998). *Method for the analyses of amino acids from food and feedstuffs*. European Commission Directive 98/64/EC

—— (2005). *Cobb product profile*. Siloam Spring, Arkansas, USA: Cobb-Vantress Inc.

—— (2008). *Broiler performance & nutrition supplement*. Siloam Spring, Arkansas, USA: Cobb-Vantress Inc.

Chong, C.H., Zulkifli, I. and Blair, R. (2008). Effects of dietary inclusion of palm kernel cake and palm oil, and enzyme supplementation on performance of laying hens. *Asian-Australasian J. Anim. Sci*. 21(7): 1053–1058

Hishamudin, M.A. (2001). Malaysian palm kernel cake as animal feed. *Palm Oil Development* 34: 4–6

Lucas, D.M., Taylor, M.L., Hartnell, G.F., Nemeth, M.A., Glenn, K.C. and Davis, S.W. (2007). Broiler performance and carcass characteristics when fed diets containing lysine maize (LY038 or LY038 X MON 810), control, or conventional reference maize. *Poultry Sci*. 86: 2152–2161

McNaughton, J., Roberts, M., Smith, B., Rice, D., Hinds, M., Rood, T., Layton, R., Lamb, I. and Delaney, B. (2008). Comparison of broiler performance and carcass yields when fed diets containing transgenic maize grains from event DP-Ø9814Ø-6 (Optimum GAT), near-isogenic control maize grain, or commercial reference maize grains. *Poultry Sci*. 87: 2562–2572

MPOB (2010). *Overview of the Malaysian oil palm industry*. Kuala Lumpur: Malaysian Palm Oil Board

NRC (1994). *Nutrient requirements of poultry*, 9th Revised Ed., National Research Council. Washington DC: National Academy Press

Ojewola, G.S. and Ozuo, U.K. (2006). Evaluation of palm kernel meal as substitute for soyabean meal in the diet of growing cockerels. *International Journal of Poultry Science* 5(5): 401–403

Osei, S.A. and Amo, J. (1987). Palm kernel cake as a broiler feed ingredient. *Poultry Sci*. 66: 1870–1873

Panigrahi, S. and Powell, C.J. (1991). Effects of high rates of inclusion of palm kernel meal in broiler chick diets. *Anim. Feed Sci. and Tech.* 34: 37–47

Perez, J.F., Gernat, A.G. and Murillo, J.G. (2000). The effect of different levels of palm kernel meal in layer diets. *Poultry Sci*. 79: 77–79

SAS Inst. (2003). *SAS User's Guide: Statistics*. Version 6.04 Ed. Cary, North Carolina, USA: SAS Institute Inc.

Shlosberg, A., Berman, E., Bendheim, U. and Plavnik, I. (1991). Controlled early feed restriction as a potential means of reducing the incidence of ascites in broilers. *Avian Dis*. 35: 681–684

Sibbald, I.R. (1976). A bioassay for true metabolizable energy in feeding stuffs. *Poultry Sci*. 55: 303–308

Sundu, B., Kumar, A. and Dingle, J. (2006). Palm kernel meal in broiler diets: Effect on chicken performance and health. *World's Poultry Science Journal* 62(2): 316–325

Tottori, J., Yamaguchi, R., Murakawa, Y., Sato, M., Uchida, K. and Tateyama, S. (1997). The use of feed restriction for mortality control of chickens in broiler farms. *Avian Diseases* 41(2): 433–437

Urdaneta-Rincon, M. and Leeson, S. (2002). Quantitative and qualitative feed restriction on growth characteristics of male broiler chickens. *Poultry Sci*. 81(5): 679–688

Waller, A. (2007). Take a fresh look at broiler nutrition. *Poultry International*, Sept.: 12–14

Whitehead, C.C. (2006). Broiler nutrition today. Early benefits in lower nutrient density. *Cobb Product Focus-Europe Special* (1): 2–3

Yeong, S.W. (1983). Amino acid availability of palm kernel cake, palm oil sludge and sludge fermented product (Prolima) in studies with chickens. *MARDI Res. Bull*. 11(1): 84–88

Yeong, S.W. and Mukherjee, T.K. (1983). The effect of palm oil supplementation in palm kernel cake-based diets on the performance of broiler chickens. *MARDI Res. Bull*. 11(3): 378–384

Abstrak

Satu kajian pemberian makanan ayam pedaging telah dijalankan untuk membandingkan kesan pemberian makanan yang diformulasi dengan pelbagai jenis rangsum isirung sawit (PKC). Sebanyak 96 ekor ayam jantan pedaging berumur sehari daripada baka COBB telah diternak di dalam sistem rumah terbuka yang mengandungi reban 2 tingkat. Sebanyak empat perlakuan digunakan dalam kajian ini iaitu T1, rangsum berasaskan jagung-soya, T2, rangsum yang diformulasi dengan 20% kek isirung sawit yang dihasilkan secara mekanikal (PKE), T3, rangsum yang diformulasi dengan 20% kek isirung sawit komersial (PKC) yang dihasilkan secara ekstraksi berpelarut mengandungi lebih 4% kandungan tempurung dan benda asing dan T4, rangsum yang diformulasi dengan 20% kek isirung sawit yang dihasilkan di makmal secara pengekstrakan berpelarut yang mengandungi kurang 3% kandungan tempurung dan benda asing. Purata berat ayam, pengambilan makanan dan nisbah tukaran makanan dikira bagi setiap perlakuan. Tempoh kajian ialah 42 hari dan keputusan menunjukkan terdapat perbezaan yang signifikan (p <0.05) bagi prestasi setiap parameter yang diukur (purata berat ayam dan nisbah penukaran makanan) bagi setiap rangsum semasa permulaan dan tumbesaran. Ayam pedaging yang diberi rangsum berasaskan jagung-soya menunjukkan prestasi yang terbaik berbanding dengan ayam yang diberi rangsum berasaskan PKE dan PKC. Kos makanan per kg berat hidup adalah terendah bagi T1 berbanding dengan perlakuan lain.

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