Nutrient digestibility and egg production of laying hens fed graded levels of biodegraded palm kernel meal

A. Z. ADEROLU, E. A. IYAYI & A. A. ONILUDE
(A. Z. A.: Department of Marine Sciences, University of Lagos, Nigeria; E. A. I.: Department of Animal Science, University of Ibadan, Ibadan, Nigeria; A. A.O.: Department of Botany and Microbiology, University of Ibadan, Ibadan, Nigeria)

ABSTRACT

A 20-week feeding trial involving 72 Isa brown-laying birds, in a completely randomized design, evaluated the nutrient digestibility and egg production of layers fed diets containing biodegraded palm kernel meal (PKM) at dietary levels of 20 per cent undegraded and 20, 30 and 40 per cent biodegraded PKM, respectively. Biodegradation slightly improved proximate and detergent fibre components compared to the undegraded sample. Among the fibre fractions, hemicellulose was most degraded, whereas acid detergent lignin was least. Proximate component digestibility was similar among the diets except at 40 per cent levels. With the detergent fibre component, increasing the level of the biodegraded PKM caused a significant difference ($P<0.05$) in fibre component digestibility. Increase in the quantity of biodegraded PKM resulted in significant differences in the values determined for feed intake, hen-day production, and average egg weight; but for egg length, yolk index, egg/yolk ratio and egg shell thickness, there was no significant difference. Despite the significantly lower hen-day production of Diet 3, the feed cost per egg produced was similar to the value determined for birds on Diet 1. It could, therefore, be concluded that when prices for soybean meal and maize are high , up to 30 per cent PKM could be used in layers' diets.

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RÉSUMÉ

Aderolu, A. Z., Iyayi, E. A. & Onilude, A. A.: *Digestibilité de substance nutritive et la production d'œuf de poules pondeuses nourries des niveaux classés de la farine d'amande de palme (FAP) biodégradée.* Un essai d'alimentation de 20 semaines impliquant 72 volailles pondeuses de l'espèce Isa brown était entrepris dans un dessin complètement randomisé pour évaluer la digestibilité de substance nutritive et la production d'æuf de pondeuses nourries de régimes contenant la farine d'amande de palme biodégradée aux niveaux alimentaires de 20% nondégradée, 20, 30 et 40% biodégradée de FAP respectivement. Le processus de biodégradation résultait en une amélioration légère de composant approximatif et de composant de fibre détersive comparé aux échantillons nondégradés. Parmi les fractions de fibre, Hémicellous était la plus dégradée alors que la Lignine Détergente Acide était la moindre dégradée. La digestibilité de composant approximatif était semblable parmi les régimes sauf aux niveaux de 40% alors que pour le composant de fibre détersive, l'effet du niveau d'augmentation de FAP biodégradée causait de différence considérable ($P < 0.05$) dans la digestibilité de composant de fibre. Augmentation de la quantité de FAP biodégradée résultait en différences considérables dans les valeurs obtenues pour la consommation alimentaire, la ponte de poule par jour et le poids moyen d'æuf mais pour la longueur d'æuf, l'indice de vitellus, la proportion d'æuf/vitellus et l'épaisseur de coquille d'æuf, il n'y avait pas de différence considérable. Malgré la ponte de poule par jour considérablement plus basse du régime 3, le coût d'aliment par æuf pondu est semblable à la valeur obtenue pour les volailles nourries avec le régime 1. Donc la conclusion pourrait être tiré que lorsque le prix de la farine de soja et de maïs sont à la hausse, jusqu' à 30% de FAP pourrait être recommandé dans le régime des pondeuses.

Introduction

Incorporating agro-industrial by-products in animal feed holds tremendous potential in alleviating the high cost and insufficient supply of feed ingredients (Longe, 1985; Babatunde, 1989).

Palm kernel meal (PKM), a by-product of palm oil extraction, is abundant in the tropics but its use, especially in poultry diets, has not been favourable (Yeong, Mukherja & Hutagalung, 1981; Olutoye, 1986; Ogbonna, Longe & Legel, 1988). The gritty nature of PKM and its lignified shells, which contain xylans, have been implicated for this reason.

Attempts at improving the use of PKM in poultry diets include the suggestion of Bogner (1961) on enzymatic depolymerization of the polysaccharides in PKM, while Onifade (1993) suggested adding molasses, sand and different antibiotics to increase the inclusion level of PKM in poultry diets.

Biodegradation resulted in recycling and consequent release of biological building blocks of nutrients locked up, and in reducing environmental pollution. The foregoing advantages were, therefore, targeted, having improved nutrient composition of PKM through the same process (Aderolu, Iyayi & Ogunbanwo, 2002).

Materials and methods

Biodegradation of PKM

The PKM used in this study was purchased from a commercial miller in Ibadan, Nigeria. The biodegradation, which lasted for 10 days, followed the method of Aderolu *et al.* (2002), using the fungus *Trichoderma viridii*. The PKM (50 kg) was autoclaved at 121^{0}C for 15 min, allowed to cool down, and then inoculated with five plates of the fungi culture (plate size 10 cm diameter) and moistened with distilled water at the rate of 300 ml kg^{-1} of PKM. After 10 days, the action of the fungus was stopped by oven-drying the substrate at 80 ^{0}C for 24 h. The dried material was then incorporated into the diets.

Diet formulation and management of birds

A total of four diets, with crude protein of 17 per cent and energy between 2500 and 2700 cal kg^{-1}, were formulated (Table 1).

A total of 72 28-week-old Isa brown-laying birds were randomly selected and assigned three per

TABLE 1

Gross Composition of Layers' Diets Based on Biodegraded and Undegraded Palm Kernel Meal

Ingredient (%)	P_1 20% T	P_2 20% T	P_3 30% T	P_4 40% T
Maize	38.70	45.50	41.70	30.70
Soybean meal	18.00	11.20	5.00	0.00
Cassava flour	10.00	10.00	10.00	16.00
Palm kernel meal	20.00	20.00	30.00	40.00
Fish meal	1.30	1.30	1.30	1.30
Salt	0.50	0.50	0.50	0.50
Bone meal	4.00	4.00	4.00	4.00
Oyster shell	7.00	7.00	7.00	7.00
Premix	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15
Lysine	0.10	0.10	0.10	0.10
Total	100	100	100	100

Diet 1, the control, had 20% level of undegraded PKM. The other diets had 20, 30 and 40% biodegraded PKM inclusion levels.

cage. The cage, with a dimension of 38 cm × 40 cm, was kept in an open-sided building within the University of Ibadan Teaching and Research Farm. The birds were exposed to 16 h of light and the experiment lasted for 20 weeks.

Apparent nutrient digestibility was determined in a 7-day trial using 12 laying birds of similar weight (three per replicate). The birds were housed in metabolic cages and feed was allocated at 150 g bird^{-1} day^{-1}. Total collection of excreta was undertaken daily between the 4th and 7th days of the trial. Apparent nutrient digestibility was computed and expressed as a percentage.

Performance and egg quality measurement

Performance and egg quality characteristics determined included feed intake and feed efficiency, hen-day production, egg weight, and egg shell quality. These were recorded weekly over the 20-week experimental period.

Chemical analysis

Diet and excreta samples were analysed for proximate composition (AOAC, 1990) and detergent fibre using the procedures described by Goering & Van Soest (1970).

Statistical analysis

The data collected in the study were analysed using the procedures outlined by Steel & Torrie (1980). Treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Results

Fig. 1 and 2 show the digestibility of nutrients and detergent fibre components. Digestibility of proximate component between the control diet and Diet 2 recorded no significant difference ($P>0.05$), except for the crude protein digestibility. Increasing the quantity of PKM resulted in nutrient digestibility of proximate components

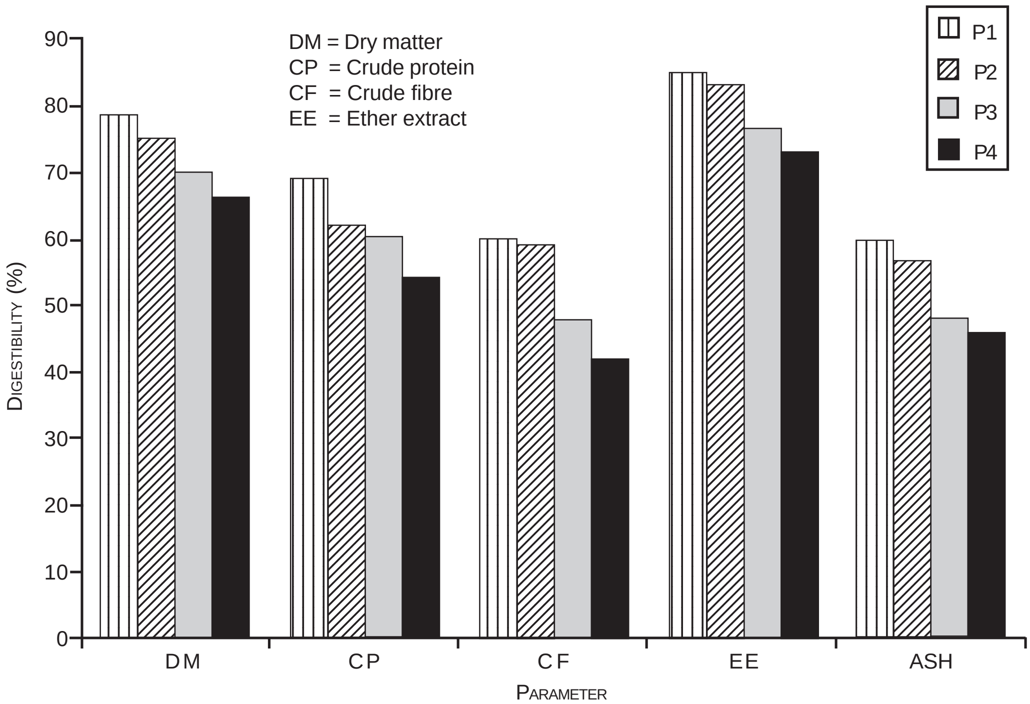

Fig. 1. Digestibility of proximate components of layers fed graded levels of palm kernel meal diets.

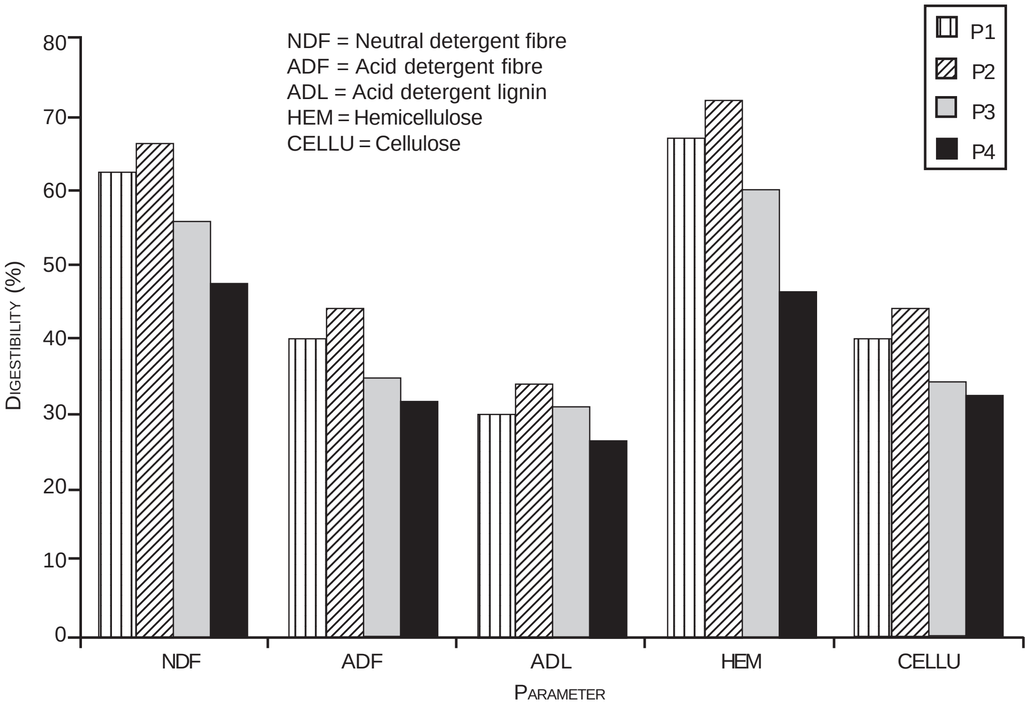

Fig. 2. Digestibility of detergent fibre components of birds fed graded levels of palm kernel meal diets.

being reduced. Ether extract was best digested and crude fibre least (Fig. 1).

Digestibility of detergent component between the biodegraded and undegraded feed favoured Diet 2. As the quantity of PKM increased, the digestibility of fibre components reduced, following the same trend as observed in proximate composition.

The trend observed in the digestibility of fibre fraction was HEM>NDF>CF>ADF>CELLU> ADL. Diet 4 was least digested compared to the other diets (Fig. 2).

There was significant difference ($P<0.05$) in the performance characteristics between 20 per cent biodegraded and 20 per cent undegraded PKM, considering the feed intake and average weight of egg (Table 2). The graded levels of PKM tested in this experiment had no significant difference ($P>0.05$) in yolk height, width, colour, yolk to egg ratio, egg length, and egg shell thickness. Inclusion of biodegraded PKM up to 30 per cent had comparable results in most characteristics studied when compared to the other diets with lower quantity of PKM. Feeding PKM to laying birds significantly affected ($P<0.05$) the feed intake, feed efficiency, hen-day production, total number of eggs, and egg weight when the PKM was included at 40 per cent of the total ingredients.

The economy of egg production based on using biodegraded PKM supported the use of up to 30 per cent PKM. Table 3 shows the comparative value of feed cost per egg produced and the net profit value.

Discussion

The inclusion of higher fibre fraction in diets of poultry greatly influenced the different nutrient digestibilities. This observation was documented earlier by Schoenher, Stably & Cromwell (1989) and Onifade (1993). This can be explained by the

TABLE 2

Performance and Egg Qualities of Birds Fed Graded Levels of Palm Kernel Meal

Parameter	P_1	P_2	P_3	P_4	*SEM*
Feed intake (g/bird/day)	147.22[a]	120.49b[c]	125.31[b]	108.40[c]	12.00
Feed efficiency	0.27[b]	0.23[b]	0.31[b]	0.48[a]	0.12
Hen-day production (%)	73.63[a]	71.64[a]	62.79[b]	38.20[c]	0.12
Average egg weight (g)	57.51[a]	53.34[b]	52.77[b]	48.64[c]	2.61
Yolk weight (g)	12.97[a]	12.41[ab]	12.70[a]	11.71[b]	0.77
Yolk height (cm)	1.50	1.50	1.46	1.47	0.10
Yolk width (cm)	3.28	3.16	3.59	3.08	1.17
Yolk colour score	1.92	1.88	1.94	1.77	0.41
Yolk/egg ratio	0.23	0.23	0.24	0.24	0.01
Yolk index	0.33	0.33	0.34	0.33	0.12
Egg length (cm)	5.28	5.25	5.29	5.17	0.14
Egg width (cm)	4.12[a]	3.99[ab]	3.92[b]	3.77[c]	0.43
Egg shell thickness (cm)	0.25	0.24	0.24	0.25	0.05
Egg shell index	0.79[a]	0.77[ab]	0.75[b]	0.73[b]	0.04
Egg shell surface area	68.08[a]	65.98[ab]	64.75[bc]	65.51[c]	3.03
Shell weight (g)	6.19[a]	5.83[a]	6.11[a]	4.49[b]	1.02

abc; means without common superscript on the same row are significantly different at $P<0.05$

TABLE 3

Economy of Egg Production Based on Graded Levels of PKM

Economic parameter	P_1	P_2	P_3	P_4
Total feed consumed (kg)	16.49	13.50	14.04	12.12
Feed cost/kg (₦)	24.78	24.24	21.55	18.52
Cost of total feed consumed (₦)	408.62	327.24	302.56	224.83
Total number of eggs produced	82.00	80.00	70.00	43.00
Trays of egg produced	2.75	2.68	2.30	1.44
Gross revenue from egg (₦280/tray)	770.00	750.40	655.20	400.10
Feed cost/egg produced (₦)	0.53	0.44	0.46	0.56
Net profit (₦)	361.38	423.16	352.64	175.57

Costs were calculated from prices of ingredients at the time of purchase
The data were not analysed statistically because they were computed as single observation

fact that when the fibrous feed ingredient was fed to the birds, it increased viscosity of the intestinal content, reduced transit time, and increased excreta weight. The possibility of wear and tear of the mucus membrane of the gastro-intestinal tract, and the shorter period of contact between the digesta and the absorption membrane cannot be overemphasized. These are responsible for the poor nutrient digestibilities at higher fibre levels. Other reasons may include the sparing action of easily digestible nutrients like carbohydrates and proteins for high fibre fractions which are not easily digestible (Laplace *et al*., 1989; Salyer *et al*., 1991).

The better crude protein digestibility recorded in Diet 1 could be due to the quality of protein in the diet. Soybean meal was substituted for microbial protein. Soybean meal is the standard for plant protein, the amino acid composition; hence, digestibility will be better compared to the non-protein nitrogen from the microbial source.

The better digestibility of ether extract compared to the other nutrients was probably due to preferential digestion of fat (compared to carbohydrate) because of the lower heat increment associated with fat digestion (Freeman, 1983).

The trend observed in digesting the different fibre fractions is similar to the findings of Kass *et al*. (1980) and Milton & Dennment (1988), but slightly different from that of Onifade (1993). Variation in the rate of digesting each fibre component has to do with the chemistry of the fibre fractions and the extent to which the microbial enzyme from biodegradation acts on each component of the fibre.

For performance and egg quality characteristics, dietary fibre exerted anti-nutritional or depressing influence or both with the use of dietary components, all of which may have had an effect on the animal. Because dietary fibre depresses intake of essential nutrients, the deficiency would in turn affect biological characteristics as well as performance (Delorme & Wojcik, 1982). The above reasons could, therefore, account for the decline in production parameters observed with higher level of PKM inclusion.

This study showed that when PKM was biodegraded, the density reduced; and as discussed by Cherry (1982), the density of a feed affects the intake of birds. Birds' feed intake has been found to be restricted by physical capacity of the gastro-intestinal tract. This, together with reduced nutritional quality of the feed, brought about by the substitution of microbial protein for soybean and the high fibre content, might be responsible for the reduced feed intake, feed efficiency, hen-day production, and egg weight.

When biodegraded PKM was fed to the birds, the inclusion level could be as high as 30 per cent without deleterious effect on major production characteristics. But beyond this, the significant reduction in egg quantity and quality observed was probably because of poor nutrient digestibility and poor nutrient availability for production.

The non-significant differences observed in egg shell and yolk qualities may probably point to the fact that ingredients, other than biodegraded PKM, substituted for maize and soybean meal are able to supply them in adequate quantities.

Despite the lower hen-day production of Diet 3, the feed cost per egg produced was comparable to that for Diet 1. This has to do with lower cost associated with using PKM when compared with the cost of maize and soybean meal. The use of biodegraded PKM is, therefore, inevitable when the cost of conventional feed ingredients is high.
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Conclusion

Biodegradation of PKM spares the quantity of maize and soybean in layer diets and affords the opportunity to use this produce up to 30 per cent inclusion level, but with significant difference in hen-day production when compared to Diet 2. Improved digestibility was observed with some nutrients when compared to the undegraded PKM diet, and nutrient contribution from the microbial source seems possible. Of the fibre fractions in PKM, the least digestible component is the acid detergent lignin. Biodegradation of PKM affords the opportunity of reducing cost of egg production from using more agro-industrial by-products, and of reducing competition between man and animal for cereal products.

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