ORIGINAL PAPER

EVALUATION OF FERMENTED PALM KERNEL MEAL AND FERMENTED COPRA MEAL PROTEINS AS SUBSTITUTE FOR SOYBEAN MEAL PROTEIN IN LAYING HENS DIETS

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ABSTRACT

Two hundred and ten (210) laying hens of Black Harco breed at 37 weeks in lay were fed experimental layer diets, in which fermented palm kernel meal (PKM) and copra meal (CM) were used independently to substitute for soybean meal (SBM) on protein content basis at 0%, 25%, 50% and 75%, to give seven treatments in a completely randomized design feeding trial that lasted 12 weeks. Performance characteristics and some haematological indices were evaluated in this study. Fermentation for seven days increased the crude protein of PKM (from 20.04% to 23.42%) and that of CM (from 19.63% to 23.11%). The crude fibre of the fermented PKM and CM decreased (from 15.47% to 12.44 % and 16.00% to 11.63% respectively). The feed intake (FI) was significantly highest ($P<0.05$) for laying hens fed 75% PKM substitution for SBM (126.06g) but lowest for those on 25% CM (115.02g). Birds fed 75% PKM had the highest ($P<0.05$) body weight gain (1.73g) while those on 25% CM recorded the lowest (1.50g). Hen-day production was significantly highest ($P<0.05$) in the control group (72.42%) but similar with the values of 69.37%, 70.35% and 69.53% recorded by laying hens fed diets containing 50% PKM, 25% CM and 75% CM respectively. Hens fed 50% CM had the highest egg shape index (0.68) while those on 75% PKM recorded the lowest value of 0.65. The control diet had the highest feed cost per kilogramme (kg) (₦57.99) while 75% CM had the lowest (₦46.51). Feed cost per number of egg produced was highest ($P<0.05$) in the control (₦1.78) and similar with the values obtained for laying hens fed CM at 25%, 50% and 75% which are ₦1.80, ₦1.79 and ₦1.74 respectively. The compared values of PKM and CM at corresponding levels of substitution using t-test indicated significant increase ($P<0.05$) in FI for PKM at all levels of substitution for SBM (121.74g at 25%, 126.56g at 50% and 126.06g at 75%) over the values of 115.02g, 121.18g and 124.96g for the respective dietary substitution levels of CM at 25%, 50% and 75%. Body weight gain was higher ($P<0.05$) for hens on 25% PKM (1.60g) and 75% PKM (1.73g) inclusion over those on CM (1.50g and 1.58g respectively). Hen day production was consistently higher ($P<0.05$) in laying hens fed CM at 25%, 50% and 75% replacement for SBM than those on PKM with corresponding values of 70.35%, 69.53% and 69.09%. The highest ($P<0.05$) serum total protein (6.60g/dl) and serum albumin (4.60g/dl) were obtained from hens fed 75% PKM and 50% PKM respectively while the control had the lowest (4.85g/dl and 4.60g/dl). Serum globulin of 1.65g/dl was highest ($P<0.05$) for birds on 50% PKM and lowest (1.05g/dl) for those on 50% CM. Urea was significantly ($P<0.05$) highest for laying hens fed 75% PKM (36.80 mg/dl) and lowest for those on 25% CM (21.50 mg/dl). However, egg weight, egg yolk colouration and the feed efficiency (feed/kg egg) were not affected ($P>0.05$) by the substitution of PKM and CM for SBM. The study showed that SBM protein could be substituted optimally at 50% by either PKM or CM protein.

Key words: Soybean meal, Palm kernel meal, copra meal, layers, egg production, substitution.

INTRODUCTION

Copra meal (CM) and palm kernel meal (PKM) are both by-products of oil extractions from fruits/seeds of two different trees i.e. oil palm – Elaies guineensis and coconut palm – Cocos nucifera of the same family Palmae. The uses of CM and PKM in the feed of farm animals have been extensively studied [1, 7, 18 - 20]. Palm kernel meal inclusion in chicks diets up to 45% of basal ration and also in laying birds have been investigated [2, 17 - 20]. Similarly, it has been recommended that an inclusion level of 15.9% of PKM in layers diet will improve egg production and efficiency of feed conversion [16]. However, the feed efficiency was found to decrease with a depressed growth in pullet chicks when PKM was fed at 45% inclusion rate [2]. The observed depressed effect on growth and other production parameters when poultry and other monogastric animals are fed PKM is as a result of its fibre and gritty nature. The amino acid constituents of PKM and its availability that ranged from 63.3% in glycine to 93.2% in arginine make the use of this feed raw material not too promising [18].

Copra meal was also included in the diet of the growing chicken up to 40% dietary level [5]. However, its use in broiler ration showed lower growth rate, declined feed intake and reduction in body weight gain [21]. It was also reported that inclusion level of 17.9% of CM in layers diet gave satisfactory performance in terms of egg production and feed cost per kilogramme egg [6]. The characteristics of CM and PKM make nutritionists to investigate means of improving their utilization through the use of enzymes and different processing methods such as fermentation and oven drying [1, 7, 13].

Copra meal and PKM production have been found to increase by 15-20% annually in the recent decades [10]. Against the backdrop of high cost of the conventional vegetable sources of high quality protein, more interest have been developed in these ingredients which consequently make for intensified efforts in various techniques to improve their feeding values for use in animal feed, especially in the developing countries. These two feed ingredients (CM and PKM) have been reported to be free of any harmful anti-nutritional factors as obtained in grain legumes; however their use in the feeding of monogastric animals is limited as a result of high fibre, gritty appearance and coarse texture conferred on them by their branched polysaccharides constituents [14]. Lysine and methionine have been reported to be deficient in PKM and CM which also limits their use in poultry feed [6, 18, 24]. The present study therefore investigated and compared the use of ensiled PKM and fermented CM in the diet of laying hens.

MATERIALS AND METHODS

Copra meal used in this study was collected wet from the cottage industries for coconut oil extraction in Ajido village in Badagry, Lagos State of Nigeria. The residue was pressed with a hydraulic press to remove water and covered with polythene to stimulate fermentation. After seven days, the fermented product was subsequently sun dried to about 10% moisture content. The residue was then milled, bagged and stored until inclusion in the experimental rations (Table 2).

The PKM was obtained from Highland Oils Limited, Ikorodu in Lagos State of Nigeria. It was ground into smaller particle sizes using a locally fabricated hammer mill, sprinkled with water until wet to touch but not dripping. It was later and ensiled for a period of seven days. The product was also sun dried, milled (now in a plate mill to break the lumps formed as a result of fermentation), bagged and stored until inclusion in the layer's diet. Palm kernel meal and copra meal proteins were used to substitute for soybean meal (SBM) protein independently at 0, 25, 50 and 75% in a pre-formulated diet to give seven different experimental diets including a control. The diets were adjusted to be isocaloric and iso-nitrogenous (Table 2). The caloric-protein ratio was adjusted to be 0.64 - 0.65.

Management of Experimental Animal and Data Collection

Sixty weeks old laying hens that were 210 in number and of Black Harco breed were used for the feeding trial that lasted for 12 weeks. The hens were 37 weeks in lay which was the time they reached about 70% hen day production. The experimental diets were fed at this time to ascertain their influence on the laying performance. The birds were divided into seven groups of three replicates per group in a completely randomized design experiment. Each replicate contained 10 birds making a total of 30 birds per treatment. The birds were housed in a two tier cage with cell dimension 38 cm x 40cm at two birds per cell in an open-sided house in the Teaching and Research Farm of the Lagos State Polytechnic, Ikorodu, Nigeria. The birds were dewormed and fortified with vitamins prior to one week adjustment period on the experimental feeds. The birds had an average initial weight of 1.49 ± 0.13 kg. They were fed experimental feed and water ad libitum at 07:00 hr. and 13:00 hr through out the experimental period. The eggs were collected at 11:00hr and 14:00 hr for the period that the experiment lasted.

The feed intake of the birds was obtained on weekly basis and later converted to daily intake by dividing by seven. The remnant in the feeding trough were weighed out at the end of the seven day period and added to the left-over in the bag. The figure obtained was divided by seven

Table 1. PROXIMATE COMPOSITION OF COPRA MEAL, PALM KERNEL MEAL AND THEIR FERMENTED PRODUCTS (%)

PARAMETER	COPRA MEAL	FERMENTED COPRA MEAL	PALM KERNEL MEAL	FERMENTED PALM KERNEL MEAL
Crude Protein	19.63	23.11	20.04	23.42
Crude fibre	16.00	11.63	15.47	12.44
Ether Free Extract	14.18	2.10	8.63	3.89
Ash	7.01	8.54	7.56	8.33
Dry matter	87.85	90.82	91.80	91.83
Metabolizable Engergy ($MJ\ kg^{-1}$) (Calculated)	12.55	10.77	11.69	11.12

Table 2. COMPOSITION OF EXPERIMENTAL DIET (%)

Ingredients	%Replacement of SBM PKM				% Replacement of SBM CM		
	0	25	50	75	25	50	75
Maize	47.00	42.74	38.50	34.22	42.85	38.70	34.55
Soybean meal	18.00	13.50	9.00	4.50	13.50	9.00	4.50
Palm kernel meal	_	8.76	17.52	26.28	_	_	_
Copra meal	_	_	_	_	8.65	17.30	25.95
Fixed ingredients	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Determined Analysis (%)							
Crude Protein	16.92	16.87	16.55	16.48	16.91	16.68	16.62
Crude Fibre	5.76	5.93	6.01	6.30	5.98	6.41	6.64
M.E. (Calc.) MJ/kg	10.92	10.89	10.72	10.68	10.94	10.88	10.79
Ca^{2+}	2.95	2.99	3.01	3.20	2.84	3.12	3.47

Fixed ingredients supplied the following: Maize offal, 16%; wheat offal, 10%; fish meal, 1.5%; oyster shell, 5.0%; bone meal, 2.0%; salt, 0.25% and *premix, 0.25%.

*The Premix Supplied The Following Per Kg Diet: Vit. A $1x10^4$ I.U; Vit. D3 300 I.U; Vit. K, 2.0 mg; B_1 2.mg B_6, 0.12mg; Niacin, 1.0mg; Zn, 50mg; Co, 0.45mg; Iodine, 2.0mg and Se, 0.1mg.

to obtain the daily feed intake. The birds were weighed at the end of the experimental period to obtain the body weight gain during the experiment. This procedure was adopted to prevent stress. The feed efficiency was calculated as the feed intake to the kilogramme egg produced. The egg shell thickness was measured using the micrometer screw gauge while the egg length and breadth were obtained using the vernier calliper. The egg shape index was calculated a ratio of the egg breadth to egg length. The egg yolk colour index was obtained by using the Roche egg yolk colour fan. The feed cost per egg produced was also calculated as the cost of the quantity of feed consumed to produce the total number of eggs during the experimental period.

Collection of Blood Samples, Chemical and Biochemical Analysis

Blood samples were taken at the end of the experimental period using a 5ml syringe, into well labelled bottles which were immediately put in an ice packed vacuum flask and later transferred to the laboratory. The serum was separated using the table Gallenkamp centrifuge at 2500 rpm. The total serum protein and the serum urea were determined colorimetrically using the SIGMA assay kits. Albumin was analyzed using the bromocresol green method and globulin was obtained by subtracting the values of albumin from that of total protein [15].

The proximate composition of the CM, PKM and the experimental feed and samples were determined [3]. The metabolizable energy (M.E.) of copra meal and PKM were calculated using Pauzenga equation: M.E. = 35 x CP % + 81.8 x EE %+ 35.5 x NFE % [23]. The amino acid analysis was carried out on the milled samples of PKM and CM and their fermented products after hydrolysis at 150°C for 1.5 hr using the modified techniques of Gardner et. al., and Bidlingmeyer et. al., [12, 4].

Statistical Tool

Table 3. PERFORMANCE CHARACTERISTICS AND SOME HAEMATOLOGY OF LAYING HENS FED DIETS IN WHICH FERMENTED PKM AND CM REPLACED SOYBEAN MEAL

Parameters	% Replacement of SBM PKM				% Replacement of SBM CM			SEM
	0	25	50	75	25	50	75	
Feed Intake (g)	120.64^{ab}	121.74^{a}	126.56^{a}	126.06^{a}	115.02^{b}	121.18^{b}	124.96^{a}	11.06
Body Gain (g)	1.58^{c}	1.60^{bc}	1.66^{ab}	1.73^{a}	1.50^{d}	1.60^{bc}	1.58^{c}	0.001
Hen-day Production (%)	72.42^{a}	68.13^{b}	69.37^{ab}	66.52^{bc}	70.35^{ab}	69.53^{ab}	68.09^{bc}	3.31
Egg Wt. (g)	58.19	58.28	57.63	56.20	58.58	58.37	57.42	2.04
Egg Shell Thickness (mm)	0.32	0.33	0.33	0.32	0.33	0.34	0.33	3.3*10-4
Egg Shape Index	0.67^{ab}	0.67^{ab}	0.67^{ab}	0.65^{b}	0.67^{ab}	0.68^{a}	0.66^{ab}	0.027
Egg Yolk Colour score	1.93	1.94	1.94	1.94	1.92	1.93	1.93	6.0*10-4
Feed Cost/kg. ([1]₦)	57.99^{a}	53.77^{b}	49.56^{c}	45.33^{d}	54.16^{b}	50.33^{c}	46.51^{d}	3.01
Feed cost/ no of egg produced (₦/kg)	1.78^{a}	1.96^{c}	1.89^{c}	1.81^{b}	1.80^{a}	1.79^{a}	1.74^{a}	0.065
Feed efficiency (Feed/kg egg)	2.07	2.06	2.19	2.21	1.95	2.08	2.18	0.43
Total Protein (g/dl)	4.85^{g}	5.75^{c}	6.25^{b}	6.60^{a}	5.55^{d}	5.45^{e}	5.25^{f}	0.064
Albumin (g/dl)	3.60^{g}	4.55^{b}	4.60^{a}	4.40^{c}	4.25^{e}	4.34^{d}	4.15^{f}	0.046
Globulin (g/dl)	1.25^{d}	1.20^{e}	1.65^{a}	1.55^{b}	1.30^{c}	1.05^{g}	1.15^{f}	0.037
Urea (mg/dl)	26.60^{d}	33.80^{c}	35.30^{b}	36.80^{a}	21.50^{f}	23.50^{e}	24.75^{d}	0.527

a,b,c Means with different superscript within the same row differ significantly (P<0.05)
[1]₦128 = US$ 1:00 (March, 2005)

All the data were subjected to statistical analysis using SAS [24] computer package for ANOVA, means separation, t- test and correlation coefficients among the parameters were evaluated.

RESULTS AND DISCUSSION

The proximate composition of PKM and CM is presented in Table 1 which also shows some similarities after fermentation. Palm kernel meal had a crude protein content of 20.04% while the value for the fermented PKM is 23.42%. Copra meal was analyzed and it contained 19.63% crude protein while the fermented sample had 23.11%. This increased the crude protein of fermented PKM and CM by 16.87% and 17.72% respectively which must have been contributed by the microbes responsible for the fermentation process. The crude fibre of PKM (15.47%) also decreased in the fermented sample (12.44%). Copra meal followed the same trend for the crude fibre in both the unfermented (16.00%) and fermented (11.63%) samples. The fat or ether extract and the M.E. values also follow the same trend. Metabolisable energy for fermented CM had 10.77 MJ/kg while it was 12.55 MJ/kg for unfermented sample. Similarly, M.E. for unfermented PKM was 11.69 MJ/kg M.E. while the fermented had 11.12 MJ/kg (Table 1).

The performance characteristic of laying hens fed the experimental diets is shown in Table 3. The feed intake of laying hens fed diets in which PKM replaced SBM were similar at 25%, 50% and 75% which are 121.74g, 126.56g and 126.06g respectively. They also have similar values as hens on the control diet (120.64g). Laying hens fed CM as replacement for SBM at 75% had similar values (124.96g) with those fed PKM and the control diets. However, hens on 25% and 50% CM substitution for SBM had significantly (P<0.05) lower feed intake (115.02% and 121.18% respectively) than the others. The body weight gain was highest (P<0.05) for laying hens fed PKM at 75% replacement for SBM (1.73g) but similar values were recorded by those on PKM at 25%

Table 4. CORRELATION VALUES OF SOME PARAMETERS OF LAYING HENS FED DIETS IN WHICH PKM AND CM REPLACED SBM

	Feed Intake	Body Gain	Hen-day Production	Egg Wt.	Egg Shell Thickness	Egg Length	Egg Yolk Colouration
Feed Intake	_	0.7	-0.46	-0.35	0.21	-0.10	0.26
Body Gain		_	-0.36	-0.32	0.25	-0.29	-0.06
Hen-day Production			_	0.25	-0.11	-0.22	0.15
Egg Wt.				_	-0.004	0.12	0.30
Egg Shell Thickness					_	-0.23	-0.29
Egg Length						_	0.17
Egg Yolk Colouration							_

Table 5. COMPARED VALUES OF SOME PERFORMANCE INDICES USING T-TEST FOR LAYING HENS FED DIETS IN WHICH PKM AND CM REPLACED SBM

Parameters	% Replacement of SBM by PKM and copra meal								
	25			50			75		
	PKM	Copra meal	|t| value	PKM	Copra Meal	|t| value	PKM	Copra meal	|t| value
Feed Intake (g)	121.74[a]	115.02[b]	0.03[S]	126.56[a]	121.18[b]	0.07[S]	126.06[a]	124.96[b]	0.68[S]
Body Gain (g)	1.60[a]	1.50[b]	0.04[S]	1.66	1.60	0.08	1.73[a]	1.58[b]	0.01[S]
Hen-day Production (%)	68.13[b]	70.35[a]	0.02[S]	69.37[b]	69.53[a]	0.01[S]	66.50[b]	69.09[a]	0.04[S]
Egg Wt. (g)	58.28	58.58	0.49	57.63	58.37	0.16	56.20	57.42	0.50
Egg Shell Thickness (mm)	0.33	0.33	1.00	0.33	0.34	0.26	0.32	0.33	0.67
Egg Length (cm)	5.52	5.49	0.84	5.41	5.53	0.35	5.32[b]	5.69[a]	0.04[S]
Egg Yolk Colour score	1.94	1.94	0.93	1.94	1.92	0.25	1.92	1.93	0.88

S= Significant (P<0.05)
a,b, Means with different superscripts within parameter and of same replacement level in diet differ significantly (P<0.05)

(1.60g), 50% (1.66g) and CM at 50% (1.60g) while the lowest gain of 1.50g was observed in birds on 25% CM. The hen day production was highest (P<0.05) for hens fed control diet (72.42%) and similar to those on diets where CM replaced SBM at 25% and 50% (70.35% and 69.53% respectively). Birds fed 50% PKM replacement of SBM also showed similarity in egg production (69.37%) as those on the control.

The egg shape index (ESI) was higher (P<0.05) and similar for birds fed the control diet, 25% PKM, 50% PKM, 25% CM and 50% CM replacement for SBM with values 0.67 each and hens on 50% CM having 0.68. The lowest ESI of 0.65 was obtained for those on 75% PKM. The feed cost significantly decreased (P<0.05) as the level of replacement of PKM and CM increased for SBM. The control diet had the highest (P<0.05) kilogramme feed cost (₦57.99) but this decreased as the dietary levels of either PKM or CM increased in the diets (Table 3). Feed cost per no of egg decreased significantly (P<0.05) as the PKM and CM substitution increased in the diet. At 25% PKM (₦1.96) to 75% PKM (₦1.81) whereas it is ₦1.80 for 25% CM and ₦1.74 for 75% CM. Copra meal inclusion at 75% protein replacement value of SBM had the best feed cost per no of egg produced (₦1.74) and also the lowest cost of feed per kilogramme (₦46.51). The egg weight, shell thickness, yolk colouration and feed efficiency were not affected by the substitution of PKM or CM for SBM in laying hen's diet.

The student t-test showed significant difference (P<0.05) for feed intake and the body weight gain. Feed intake for hens fed 25% PKM was 121.74g while their counterpart on 25% CM had 115.02g (Table 5). The body weight gain of birds on 25% PKM was 1.60g whereas those fed 25% CM recorded 1.50g. Laying hens fed 75% PKM had 1.73g body weight gain while that of their counterpart on 75% CM was 1.58g. The feed intake correlated positively with the body weight gain (0.7) but negatively (-0.46) with the hen day egg production (Table 4).

The carbohydrate characteristics of PKM and CM had been found to be mainly in the form of insoluble non-cellulose polysaccharides which appear in form of non starch polysaccharide (NSP) in PKM and CM [14, 25]. The β-(1 - 4) - D mannan, branched galactomannans, glucoronoxylans and arabinoxylans constitute the antinutritional factors in PKM and CM called NSP [8, 9]. The feed intake increased in diets containing PKM and

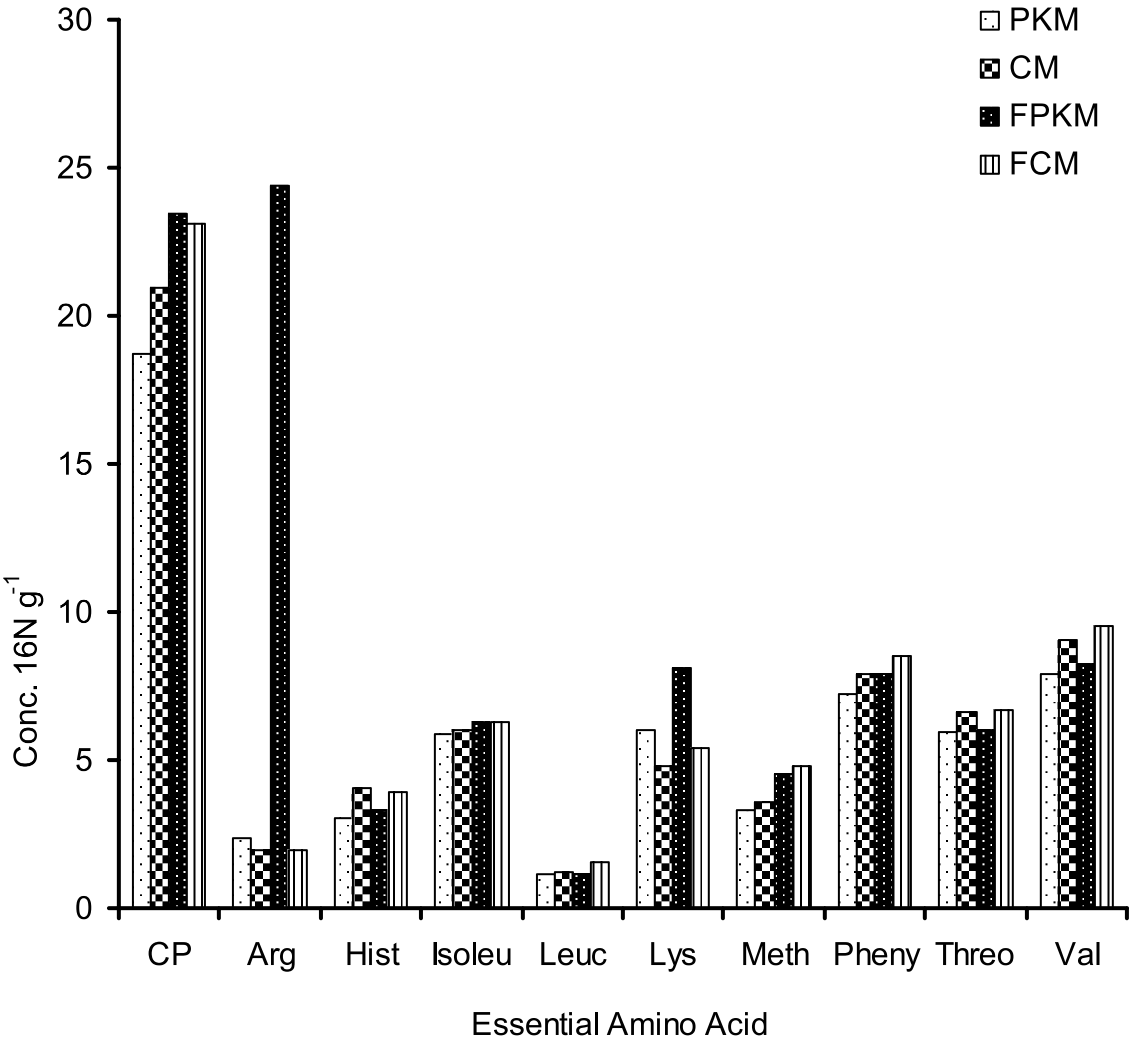

Fig. 1. Amino acid profile of fermented and unfermented Palm kernel meal (PKM) and copra meal (CM)

Table 6. AMINO ACID COMPOSITION OF FERMENTED AND UNFERMENTED PKM AND CM (16 N/G)

Amino acid	PKM (Unfermented)	Copra meal (Unfermented)	PKM (Fermented)	Copra meal (Fermented)
Crude Protein N x 6.25 (%)	18.71	20.93	23.04	23.11
Arginine	2.38	1.97	2.41	1.99
Cystinie	0.22	0.25	0.27	0.30
Histidine	0.30	0.40	0.33	0.39
Aspartate	1.63	1.62	1.63	1.63
Glutamate	3.43	3.58	3.54	3.69
Threonine	0.59	0.66	0.60	0.67
Tyrosine	0.45	0.46	0.46	0.44
Valine	0.79	0.90	0.82	0.84
Lysine	0.60	0.47	0.81	0.54
Isoleucine	0.59	0.60	0.63	0.63
Methionine	0.33	0.36	0.45	0.48
Phenylalanine	0.72	0.79	0.77	0.85
Proline	0.59	0.70	0.62	0.77
Serine	0.76	0.90	0.79	0.95
Glycine	0.84	0.89	0.88	0.91
Alanine	0.80	0.81	0.82	0.84

CM as substitute for SBM. These two test ingredients have fairly high fibre content (of 11.63% for CM and 12.44% for PKM); hence their inclusion increased the dietary fibre concentration. This therefore increased feed intake of the birds to meet energy needs. A decrease in feed intake would have been expected due to the fat composition of the test ingredients but this had been reduced as a result of the fermentation process. The improved feeding value of PKM and CM is responsible for the increased body weight gain of the laying hens. Fermentation process improved the amino acid profile (Fig.1) and perhaps their availability (this was not measured). The effect of this is observed as increased hen-day egg production up to 50% inclusion of PKM and CM and also improved body weight gain. The fermentation of PKM and CM at solid state must have served as a good medium for the proliferation of microbes which induce microbial enzymes for the hydrolysis or cleavage of the 1 – 4- β- structures of glycosidic bonds in the mannan derivatives of the cell wall component hence a decrease in the crude fibre content. This is consistent with some findings in literature [1, 13]. The increase in the ash content evidently supports the mentioned activities of the microbial enzymes. These enzymes cleaved the minerals in the fibrous components of the feed that could have formed complexes such as phytate and oxalate, there by making the minerals available for metabolic functions. This invariably also made available the locked-up nutrients in the cell wall components of the fibrous feed. Palm kernel meal and copra meal have fairly high fibre component and this is extensively reported to be a contributory factor to their low digestibility and utilization in monogastric diets [15, 16, 20, 24]. The amino acids profile of the fermented PKM and CM increased which support the idea that the nutrients in the cell component must have been released for utilization (Fig. 1).

The comparison of the corresponding substitution levels indicated similarities in the utilization of PKM and CM hence could be used interchangeably in animal feed especially in layer's ration where high quality vegetable protein such as soybeans or groundnut cake is very scarce or may be expensive as obtained in most developing countries of Africa. However, laying hens on CM had significantly increased ($P<0.05$) hen-day egg production than those fed PKM (Table 5).

The serum total protein and urea were significantly ($P<0.05$) highest for laying hens fed 75% PKM substitution for SBM (6.60 g/dl and 36.80mg/dl respectively) while albumin (4.60g/dl) and globulin (1.65g/dl) were highest for those on 50% PKM (Table 3) . The total protein increased in the blood of birds fed PKM while it decreased in those on CM. Serum albumin increased in birds fed PKM and CM but decreased at 75% replacement for PKM and CM. This trend was followed by globulin. The urea content increased as the PKM and CM increased; however laying hens fed 25% CM replacement of SBM had the lowest blood urea content of 21.50 mg/dl. The values obtained for layers fed CM as replacement for SBM were not as high as those recorded for PKM. The trend observed indicates inadequacy in the quality of protein as compared with the control. This is further confirmed by the trend exhibited by the values for the hen-day egg production. It is observed that globulin formation is increased in PKM at 50% and 75% substitution. This may be a peculiar attribute of PKM as a plant protein source which favours the formation of globulin that acts as prebiotic to enhance defense mechanism against pathogenic microbes and improve immunity of the birds as suggested [11, 26]. This perhaps may be contributory to zero mortality during the experimental period.

Conclusively, PKM and CM in this study exhibited similar feeding values when fermented and both can be used optimally at 50% protein replacement value of SBM in laying hen's ration. The serum indices also indicated that the proteins in these two feed raw materials are not extremely poor as the birds did not show any anaemic condition. This implies that PKM and CM when adequately fermented can be used to substitute for the expensive soybean meal in layers ration.

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