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Comparative Utilization of High Inclusion Rates of Three By-product Feed Resources by Finishing Broilers in the Tropics

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Key words: By-products, comparative utilization, high inclusion rates, finishing broilers.

Abstract

The comparative utilization of palm kernel meal (PKM), brewers dried grains (BDG) and maize offal (MO) was investigated in a 3x3 factorial combination of PKM, BDG and MO each at 20%, 30%, and 40% in finishing broiler diets. The nine diets were fed to the finishing broilers between 35 to 70 days of age. The results showed that final body weight and daily weight gain were highest ($P<0.05$) on PKM, then BDG followed by MO based diet. Weight gain decreased significantly ($P<0.05$) with increasing dietary levels of the by-products, but with significant interactions ($P<0.05$). The highest feed intake ($P<0.05$) was on BDG diets followed by MO and PKM, and the consumption increased ($P<0.05$) linearly without significant ($P>0.05$) interaction. Feed conversion efficiency was better ($P<0.05$) on PKM than MO and BDG, and decreased ($P<0.05$) with increasing levels of the test ingredients. Dry matter and crude protein were apparently better ($P<0.05$) utilized with MO and PKM than BDG, whereas ether extract was apparently utilized better ($P<0.05$) on BDG than others. Crude fibre and detergent fibre components were least ($P<0.05$) utilized with MO based diets. Some significant ($P<0.05$) interactions in nutrient utilization were observed. The broilers' apparent retention of the eight dietary minerals assayed were similar ($P>0.05$). Packed cell volume, haemoglobin and erythrocytes in broilers fed PKM tended to be superior to others, but the haematological indices decreased significantly ($P<0.05$) only at 40% inclusion, especially on MO when compared with the others. Total protein, albumin and globulin were similar ($P>0.05$) for the treatments, but total protein decreased ($P<0.05$) at 40% inclusion of the test ingredients. In conclusion, finishing broilers in the tropics tolerated up to 30% of the three by-products without deleterious effects on performance, nutrient retention and haematology, however, the results indicated the order PKM> BDG> MO. Beyond 30% inclusion rate there were demonstrated nutritional and physiological constraints leading to inferior performance.

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1 Introduction

The existence of feed insecurity for intensely managed poultry in the sub-Saharan region is unequivocal. The situation derives principally from inadequate domestic cultivation of conventional feed ingredients and the exorbitant costs of imported components (ONIFADE, 1993). Therefore to achieve a sustainable feeding programme for poultry in the tropical regions, maximum harnessing of agro-industrial by-products as feed resources becomes imperative.

Such by-products include palm kernel meal, a by-product of oil extraction from the kernel of *Elais guinensis*; brewers dried grains from conventional breweries, and maize offal, a by-product of industrial milling of *Zea mays*, and a host of others identified by Longe and Fagbenro-Byron (1990). These by-products are available in the tropics, moderately nutritive, but generally fibrous (LONGE AND FAGBENRO-BYRON, 1990; ONIFADE, 1993). A review of literature and the current feed formulation practice revealed a maximum inclusion rate of 10% for most of these by-product feed resources. However, Onwudike (1986) and Panigrahi and Powell (1991) achieved higher inclusion rates employing methodological approaches that are not economically feasible in the tropics.

Therefore, the current study was initiated upon three premises. First, there is the need to expand the utilization of by-product feed resources beyond the current practice to overcome the spiralling costs of conventional feedstufs. Second, there are few comparative studies on the utilization of tropical by-products in finishing broiler nutrition. Furthermore, confirmatory studies need to be conducted on the emergent knowledge (DROR AND BEN-GHEDALIA, 1987; PANIGRAHI AND POWELL, 1991; ONIFADE, 1993; ONIFADE AND BABATUNDE, 1996; 1997A,B; 1998; ONIFADE AND ODUNSI, 1998) that broiler chickens could tolerate high fibre diets. Supporting the third objective, Varel and Pond (1985); Varel (1987); Varel *et al.* (1988) reported that adult pigs coped better on fibrous diets than the younger pigs because of their bigger intestinal capacity, reduced rate of passage, higher digesta retention time, and the possibility of higher population of fibrolytic microorganisms.

Thus, we fed 35-day-old broiler chickens graded high inclusion rates of three by-product feed resources, namely, palm kernel meal, brewers dried grains and maize offal up to 70 days of age. Growth performance, apparent nutrient and mineral retention and haematological values were determined as response criteria.

2 Materials and Methods

Palm kernel meal (PKM), brewers dried grains (BDG) and maize offal (MO) were obtained from Vegetable Oils Nigeria Limited, Lagos; Nigerian Breweries, Ibadan, and Eagle Flour Mills, Ibadan, Nigeria respectively. The proximate composition of the test ingredients is shown in Table 1. Further minor processing of the test ingredients, experimental protocol, and minimum diversity of diet composition based on the suggestions of Kennelly and Aherne (1980); Gous *et al.* (1990) are fully reported elsewhere (ONIFADE AND BABATUNDE, 1998).

Table 1: Proximate composition of the test ingredients

Proximate component	Palm Kernel Meal	Maize Offal	Brewers Dried Grains
Dry matter	90.64	91.30	92.50
Crude protein	18.25	12.40	21.60
Crude fibre	16.27	8.86	19.70
Ether extract	7.98	2.11	3.45
Ash	4.47	3.42	3.62

Each of PKM, BDG, and MO was incorporated into finishing diets at three levels viz. 20%, 30%, and 40% in a 3x3 factorial experimental design. The nine isonitrogenous diets are shown in Table 2. Thirty-five day-old finishing broilers of Hubbard strain previously maintained on a common starter diet (21% crude protein, 3000 kcal/kg) were fed on the experimental diets up to 70 days of age. Each dietary treatment was fed to three replicates of ten 35-day old broilers each in a fully randomized manner. The broilers were reared on floor pens throughout the experimental period. Feed and water were provided *ad libitum*. Between 63 and 70 days of age six broilers of similar weights were selected per treatment, housed individually in metabolic cages for determination of apparent retention of dietary organic and mineral components using the balance method. Feed allocation to the broilers on metabolic studies was 10% less than the *ad libitum* intake and it was served at 07.00 hr. daily. Total excreta collection was carried out during the last three days of the metabolic trial.

Blood specimens for haematological analysis were collected terminally from six broilers which had been fasted overnight per treatment using sterile needles and syringes. Haematological specimens were collected in anticoagulant (EDTA)-treated bottles, and samples for serum protein determination were collected without anticoagulant. Parked cell volume (PCV), haemoglobin and serum total protein and its fractions were determined using Wintrobe's microhaematocrit, cyanomethaemoglobin methods, and Sigma assay kits respectively.

Proximate analysis of the test ingredients was carried out according to the methods of Aoac (1990), and detergent fibre analysis by the methods of Goering and Van Soest (1970) as modified by Van Soest *et al.* (1991). Mineral analysis was carried out using wet digestion method followed by determination in an Atomic Absorption Spectrophotometer (PYE UNICAM MODEL 9100). Phosphorus was determined using the phosphovanadomolybdate method.

The data were subjected to analysis of variance of factorial experiments of completely randomized design followed by Duncan's multiple range test for the separation of the means as outlined by Daniel (1995). Linear equations were computed using SPSS (1988).

Table 2: Composition of experimental diets for finishing broilers

By-products	Palm Kernel Meal			Maize Offal			Brewers Dried Grains		
Dietary levels:	20%	30%	40%	20%	30%	40%	20%	30%	40%
Maize	50.00	43.00	36.00	46.00	37.00	28.00	51.50	45.00	38.50
Soybean meal	18.50	15.50	12.50	22.50	21.50	20.50	17.00	13.50	10.00
Palm kernel meal	20.00	30.00	40.00	-		-	-	-	-
Maize offal	-		-	20.00	30.00	40.00	-	-	-
Brewers dried grains	-		-	-	-	-	20.00	30.00	40.00
Fish meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Palm oil	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Oyster Shell	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated analysis									
Crude protein %	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Metabolizable Energy MJ/kg	12.46	11.91	11.33	12.29	11.70	11.04	12.62	12.12	11.62

[1] For composition see Onifade and Babatunde (1997A)

3 Results

The performance characteristics of the finishing broilers are shown in Table 3, and the factorial effects of the by-products and their levels of inclusion are summarized in Table 4.

Generally, final body weight and daily weight gain were highest ($P<0.05$) on PKM than BDG followed by MO based diet. There was significant ($P<0.05$) interaction caused by the similarity in body weights of broilers fed 20 and 30% of PKM unlike with BDG and MO. Final body weight and daily weight gain decreased significantly ($P<0.05$) with increasing dietary levels of the by-products, except the significant interaction ($P<0.05$) on PKM in which case significant reduction in weight only occurred at 40% inclusion.

Average daily feed intake of finishing broilers was highest ($P<0.05$) on BDG diets followed by MO and PKM respectively. No significant ($P>0.05$) interaction was observed because of the comparable trends in all the dietary treatments. Also feed intake increased (P<0.05) correspondingly with levels of inclusion of the by-products.

Table 3: Performance characteristics of finishing broilers fed high inclusion rates of three by-product feed resources in the tropics

By-products	Palm Kernel Meal			Maize Offal			Brewers Dried Grains			
Dietary levels:	20%	30%	40%	20%	30%	40%	20%	30%	40%	SEM
Final Body Weight	1887^{a}	1883^{b}	1630^{d}	1867^{a}	1731^{c}	1520^{e}	1888^{a}	1734^{c}	1611^{d}	30.2
Daily weight gain	28.4^{a}	$27.2^{a,b}$	21.6^{d}	$27.1^{a,b}$	24.6^{c}	20.2^{e}	27.9^{a}	24.2^{c}	21.0^{d}	1.8
Daily Feed intake	91.5^{e}	98.9^{c}	104.1^{b}	95.1^{d}	105.1^{b}	111.1^{a}	100.3^{c}	106.2^{b}	115.1^{a}	3.7
Feed:gain	3.22^{d}	3.64^{c}	4.83^{b}	3.51^{c}	4.25^{b}	5.51^{a}	3.60^{c}	4.40^{b}	5.48^{a}	0.2

Linear regression equations[1] of performance characteristics of finishing broilers on the levels of the test ingredients

	Palm Kernel Meal	Maize Offal	Brewers Dried Grains
Final Body weight	$Y = 2161.6 - 12.84X$ $r^2 = 0.943$	$Y = 2227 - 17.37X$ $r^2 = 0.985$	$Y = 2159 - 13.85X$ $r^2 = 0.996$
Daily Weight Gain	$Y = 36.01 - 0.34X$ $r^2 = 0.884$	$Y = 34.30 - 0.35X$ $r^2 = 0.997$	$Y = 34.60 - 0.34X$ $r^2 = 0.998$
Feed intake	$Y = 79.34 + 0.63$ $r^2 = 0.991$	$Y = 79.41 + 0.82X$ $r^2 = 0.992$	$Y = 85.01 + 0.74X$ $r^2 = 0.987$
Feed: gain	$Y = 1.48 + 0.08X$ $r^2 = 0.929$	$Y = 1.42 + 0.1X$ $r^2 = 0.978$	$Y = 1.67 + 0.09X$ $r^2 = 0.993$

a,b,c,d,e: Means in the same row without a common superscript are significantly different (P<0.05)

[1] Linear regression equations with positive or negative coefficients of the gradient indicates direct or inverse relationship with increasing levels of the test ingredients

Feed conversion efficiency was better (P<0.05) on PKM than MO and BDG based diets without significant (P>0.05) interaction. Feed conversion efficiency decreased (P<0.05) with increasing dietary concentrations of the test ingredients. Considering the linear equations computed (Table 3) for the effects of the graded inclusion on the performance indices, it was observed that all equations have high coefficients of determination (r^2), and are therefore useful to interpret the results. First, final body weight and daily weight gain decreased (as shown by negative values), feed intake increased (shown by positive values) while feed conversion worsened though indicated by positive values as the dietary levels of the by-products increased. Second, using the numerical coefficients of the independent variable (X), it was observed that the rate of decrease in final body weights and daily gain was in the order MO > BDG > PKM. This trend was similar to the factorial effects discussed earlier.

The results of apparent nutrient utilization of proximate and detergent fibre components in the diets of the finishing broilers are shown in Table 5. Dry matter was better (P<0.05) utilized on MO and PKM than BDG while crude protein followed the same pattern but for its greater (P<0.05) utilization on BDG than PKM. Ether extract was apparently utilized better (P<0.05) on BDG than others. Crude fibre and detergent fibre components were least (P<0.05) utilized MO based diets. Some significant (P<0.05) interactions were observed as follows. Dietary dry matter, crude protein and crude fibre tended to be unaffected in broilers fed 20 and 30% inclusion rates of PKM, MO and BDG respectively. The above trends were unlike the observations for the respective nutrients on all the treatments. Also acid detergent lignin in MO seems to be extraordinarily resistant to digestion unlike other by-products tested as shown by the lowest (P<0.05) apparent utilization. There was visible appearance of undigested MO in the excreta of the broilers.

Table 4: Factorial effects of the by-product feed resources and their high inclusion rates on the performance characteristics of the finishing broilers.

	Final Body weight	Daily weight gain	Daily Feed intake	Feed:gain
Factors (F)				
PKM	1777^{a}	25.73^{a}	98.17^{b}	3.90^{b}
MO	1706^{c}	23.97^{c}	104.78^{a}	4.42^{a}
BDG	1744^{b}	24.37^{b}	107.20^{a}	4.49^{a}
Levels (L)				
20%	1881^{a}	27.8^{a}	95.63^{c}	3.44^{c}
30%	1759^{b}	25.7^{b}	103.4^{b}	4.10^{b}
40%	1587^{c}	20.9^{c}	110.1^{a}	5.27^{a}
Significance				
F	*	*	*	**
L	**	**	**	**
F x L	*	NS	NS	*

*: P<0.05; **: P<0.01; NS: Not Significant

The apparent retention of the minerals by the finishing broilers is summarized in Table 6. In all cases there were no significant (P>0.05) differences in the apparent retention of the eight minerals by broilers fed on the nine diets except the lower (P<0.05) retention of phosphorus and potassium on MO based diets than others. However, the apparent retention of minerals was significantly (P<0.05) reduced with increasing levels of the test ingredients.

Table 5: Apparent nutrient utilization by finishing broilers fed high inclusion rates of three by-product feed resources in the tropics[1]

By-products	Palm Kernel Meal			Maize Offal			Brewer Dried Grains			
Dietary levels:	20%	30%	40%	20%	30%	40%	20%	30%	40%	SEM
Dry matter[2]	60.73b	59.89b	55.74c	66.12a	61.65b	54.08c	58.55b	52.58cd	50.98c	2.1
Crude protein[2]	66.58b	59.27c	50.42d	76.00a	73.96a	61.61c	71.13a	65.08b	50.95d	6.4
Ether extract	75.16b	83.04a	81.63a	75.12b	81.78a	83.53a	83.25a	82.29a	82.29a	1.4
Crude fibre[2]	49.66a	40.16b	36.82bc	45.56ab	39.28b	34.19c	50.29a	46.36ab	32.22c	3.5
Neutral detergent fibre	57.35ab	52.86b	46.65b	58.92ab	50.02c	44.36cd	62.96a	55.25b	47.12c	2.4
Acid detergentfibre	44.07ab	38.16b	32.05c	46.04a	38.91b	30.40c	47.78a	34.83c	32.22c	2.6
Acid detergent[2] lignin	26.22a	20.30b	18.75c	21.30b	20.47b	15.60c	26.15a	19.59b	17.42c	0.5
Hemicellulose	62.48a	59.40ab	50.76c	60.90ab	55.35b	48.89c	63.98a	59.62ab	54.59b	3.1
Cellulose	53.36a	50.46a	42.42bc	46.13b	40.68c	32.80d	51.66a	47.08b	38.74cd	2.9

a,b,c,d: Means in the same row without a common superscript are significantly different (P<0.05)

[1] The significance of the differences amongst the by-products are explained in the text

[2] There were significant (P<0.05) interactions between the by-products and their levels of inclusion

Table 6: Apparent retention of dietary minerals by finishing broilers fed high inclusion rates of three by-product feed resources in the tropics1

By-products	Palm Kernel Meal			Maize Offal			Brewer Dried Grains			
Dietary levels:	20%	30%	40%	20%	30%	40%	20%	30%	40%	SEM
Calcium1	58.34a	56.68b	50.14c	60.11a	52.90b	50.03c	60.39a	55.39b	49.20c	2.1
Phosphorus2	72.29a	67.77b	53.50d	71.18a	60.36c	52.60d	70.94a	65.14b	55.47cd	4.2
Magnessium1	60.41a	52.42b	50.63b	58.42a	53.66b	50.18b	61.11a	58.26a	51.04b	1.8
Potassium2	80.29a	75.38b	67.89bc	80.36a	73.68b	64.96c	82.33a	79.64a	71.10b	2.2
Sodium1	80.43a	73.82b	65.11c	79.36a	73.44b	69.20c	81.16a	76.38b	69.82c	2.3
Iron1	78.33a	66.42b	59.16c	76.29a	68.13b	60.92c	76.98a	70.04b	61.33c	3.0
Zinc1	81.01a	73.39b	64.55c	80.11a	71.29b	60.36c	78.11a	76.24b	63.43c	3.2
Manganese1	54.96a	50.23b	49.89b	54.83a	53.12a	48.42b	54.44a	52.17b	50.07b	0.6

a,b,c,d: Means in the same row without a common superscript are significantly different (P<0.05)

[1] There was no significant (P>0.05) interactions between the by-products and their levels of inclusion.

[2] The significant (P<0.05) differences amongst the by-products are explained in the text.

Haematological indices of the broilers on the treatments appeared in Table 7. Packed cell volume in broilers fed PKM were superior (P<0.05) to others, and it decreased (P<0.05) with levels of the test ingredients except on 20 and 30% levels in PKM and MO thereby causing an interaction (P<0.05). Haemoglobin, however, was only numerically superior on PKM, and decreased significantly (P<0.05) only at 40% inclusion on MO. Erythrocytes in broilers were similar on PKM and BDG but higher (P<0.05) than MO based diets, and there was significant (P<0.05) depression at 40% of all the test ingredients. There was significant interaction (P<0.05) because of the similarities at 20 and 30% of PKM, on all MO and 30 and 40% of BDG based diets. Total protein, albumin and globulin were similar (P>0.05) on the treatments, and total protein decreased (P<0.05) at 40% inclusion of the test ingredients. However, albumin and globulin were not significantly different (P>0.05), though there were slight numerical decreases on increasing levels of the test ingredients.

Table 7: Haematology, serum protein, albumin and globulin concentrations in finishing broilers fed high inclusion rates of three by-product feed resources in the tropics[1]

By-products	Palm Kernel Meal			Maize Offal			Brewer Dried Grains			
Dietary levels:	20%	30%	40%	20%	30%	40%	20%	30%	40%	SEM
Parked Cell volume2 %	36.00a	35.50a	32.0b	32.5b	32.00b	29.00c	34.5a	31.28b	30.00b	1.0
Haemoglobin3 %	11.80a	11.70a	10.80a	10.60ab	10.40ab	9.70b	11.30a	9.89b	10.00ab	0.3
Erythrocytes2 106/L	2.80a	2.75a	2.63b	2.65b	2.60b	2.50b	2.70a	2.65b	2.60b	0.15
Total Protein3 g/dL	4.02a	3.89b	3.85b	4.10a	3.95ab	3.89b	4.05a	4.01a	3.89b	0.1
Albumin3 g/dL	1.70a	1.64b	1.63b	1.73a	1.65ab	1.65ab	1.71a	1.72a	1.68ab	0.04
Globulin3 g/dL	2.32a	2.25a	2.22b	2.37a	2.30a	2.24b	2.34a	2.29a	2.21b	0.03

a,b: Means in the same row without a common superscript are significantly different (P<0.05)
[1] The significant (P<0.05) differences amongst the by-products are explained in the text
[2] There was significant (P<0.05) interaction between the by-products and their levels of inclusion
[3] There was no significant (P>0.05) interactions between the by-products and their levels of inclusion.

4 Discussion

Generally, the significant performance of finishing broilers fed high inclusion rates of by-product feed resources in this experiment substantiated the hypothesis (VAREL AND POND, 1985; VAREL, 1987; VAREL *et al.*, 1988) that older non-ruminants may tolerate more fibrous diets than the growing animals. Moreover, the results support the emergent findings of Panigrahi and Powell (1991); Sobamiwa and Longe (1994); Olorede *et al.* (1996); Onifade (1993; 1997); Onifade and Babatunde (1996; 1997A,B; 1998) that broiler chickens could subsist on high inclusion rates of tropical by-products feedstuffs. In the current study, finishing broilers demonstrated significant capacity to expand their feed intakes on the three by-products and at increasing levels of inclusion. This was contrary to our observation in broiler chicks fed high inclusion rates of the same test ingredients (ONIFADE AND BABATUNDE, 1998) especially on MO based diets. Nonetheless, the observed increase in feed consumption on the fibrous experimental diets is consistent with previous reports in broiler chickens and other poultry species (SAVORY AND GENTLE, 1976A,B; SUMMERS AND LEESON, 1986; SHIM *et al.*, 1989; PANIGHRAHI AND POWELL, 1991; SAVORY, 1992; SOBAMIWA AND LONGE, 1994; ODUNSI AND LONGE, 1995; OLOREDE *et al.*, 1996; ONIFADE AND ODUNSI, 1998). Recently, Onifade and Babatunde (1998) explained the augmented feed intake as a probable attempt to consume adequate nutrients for maintenance and growth consequent upon the diminishing nutrient density and increasing feed volume at higher inclusion rates of the test ingredients. A Similar explanation had been previously offered by Savory and Gentle (1976A,B), Summers and Leeson (1986) and Gous *et al.* (1990).

It seems obvious that the enhanced feed intake was most likely supported by the supposedly larger intestinal capacity of finishing broilers. This agrees with the explanation by Varel and Pond (1985); Varel (1987) and Varel *et al.* (1988) for older pigs. However, our previous finding and others showed that starting chicks have a somewhat limited intestinal capacity for expansion to accommodate large feed consumption (NEWCOMBE AND SUMMER, 1984; SUMMERS AND LEESON, 1986; NIR *et al*, 1978; 1993; ONIFADE, 1993; ONIFADE AND BABTUNDE, 1998).

In spite of the augmented feed intakes at higher inclusion rates of the test ingredients, broilers were unable to achieve comparable growth except for the interaction observed on 20 and 30% of PKM. It is evident from the data on body weights that the nutrient density decreased considerably with higher inclusion rates of the test ingredients thereby causing the significant decrease observed. The exception on PKM indicated that finishing broilers consumed commensurate nutrients to achieve comparable body weight, but they were ostensibly constrained beyond 30% dietary concentration of PKM. Broilers fed BDG and MO were unable to achieve similar ability most probably because of the characteristic fluffiness, high bulk density and excessive feed volume on MO, and the extreme fibrousness of BDG. In the same vein, the decreasing weight gain of the broilers in spite of the linear increase in feed intake obviously implied that the birds were not deriving adequate nutrients for comparable growth. Kennelly and Aherne (1980) and Onifade (1993) indicated that there is quantitative and qualitative changes in diets containing high rates of fibrous ingredients. Perhaps, the presumed low nutrients per gram or volume of intake on MO at 40% explain the lowest body weight observed on this treatment. The reasons adduced for the pattern of body weight are sufficient to explain the trends of the feed conversion efficiency of the finishing broilers.

It was difficult to reconcile trends in apparent nutrient utilization to the performance of broilers on the treatments, but for the inferior digestibility of fibre fractions in MO based diets which also indicate a possible resistance and interference of the fibre with nutrient utilization in the intestinal milieu. On other hand, significant ($P<0.05$) depression in apparent utilization of all dietary components except ether extract understandably caused the reduction in final live weight despite the significant increase in feed intake.

The decreasing apparent retention of nutrients, detergent fibre components and mineral components of the diets may be the consequence of higher fibre intakes at high inclusion rates of the by-products. Dietary fibre reduces nutrient retention (NWOKOLO *et al.*, 1977; 1985; PANIGHRAHI AND POWELL, 1991; FAHEY *et al.*, 1992; ONIFADE, 1993; SOBAMIWA AND LONGE, 1994; ODUNSI AND LONGE, 1995; ONIFADE AND BABATUNDE, 1997A). Unlike other dietary nutrients, apparent retention of dietary fat by the finishing broilers was high perhaps as a metabolic response to compensate for the diminishing caloric densities at higher inclusion rates of the test ingredients or an attempt to exploit the metabolic advantages of supplemental fat such as extra-caloric effect, reduced rate of digesta passage and lower heat increment reported by Mateos and Sell (1982); Freeman (1983); Nrc (1994).

In comparison with our recent report (ONIFADE AND BABATUNDE, 1998), finishing broilers achieved superior utilization of the by-products to starting chicks as evinced by the higher digestion coefficients of the detergent fibre components. Supporting our finding with finishing broilers, adult cockerels have been reported to utilize non-starch polysaccharides (LONGSTAFF AND MCNAB, 1989). A plausible explanation for the higher utilization of fibrous diets could be the presence of a larger population of cellulolytic bacteria in the intestine of the finishing broilers as reported for pigs by Varel *et al.* (1988). In addition, Onifade (1993) detected *Bacteroides species* fibre degrading micro-organisms in the caecal and excreta samples of finishing broilers fed on the fibrous diets. It could as well be that greater intestinal capacity of finishing broilers facilitated greater mean retention time of digesta thus exposing the fibrous components to greater microbial digestion. This explanation is congruous with the suggestions by Varel and Pond (1985); Varel *et al.* (1988).

Observing a depressing consequence of increasing levels of by-products on apparent mineral retention is congruent with previous evidence (NWOKOLO *et al.*, 1977; MOORE *et al.*, 1986; MOORE AND KORNEGAY, 1987; ONIFADE, 1993) in non-ruminant animals. Indeed, Nwokolo *et al.* (1985) established a negative correlation between increasing levels of wheat or rice bran on the availability of dietary calcium, phosphorus, magnesium, copper and zinc to broiler chickens.

Since haematological and biochemical indices are a proximate measure of nutritional adequacy and/or status (ODUNSI AND LONGE, 1995; OLOREDE *et al.*, 1996; ONIFADE, 1997); the generally comparable values in the finishing broilers suggest adequate nutrition, save the birds fed 40% of the test ingredients whose values confirm the diminishing nutritive quality of the diets. The superior values in broilers fed PKM is consistent with direct relationship between performance and haematology (ONIFADE, 1997). However, there appears to be inferior erythropoiesis or mild erythropoietic depression of indeterminate etiology in broilers fed MO as indicated by their uniformly low erythrocytes concentration.

In conclusion, finishing broilers in the tropics tolerated up to 30% of any of the three by-products, and the performance was best on PKM followed by BDG and MO in this order. There were no deleterious effects on performance, nutrient retention, haematology and nutritional status by feeding the by-products up to 30%, however, beyond this level, there were demonstrated constraints leading to inferior productivity.

5 Der Einsatz von Futterbeiprodukten in vergleichenden Raten in der Endmast von Broilern in den Tropen

Zusammenfassung

Palmkernschrot (PKM), Biertreber (BGD) und Maiskleie (MO) in einer 3 mal 3 fabrikmäßig hergestellten Zusammensetzung, wurde zu 20%, 30% und 40% dem Broilerendfutter zugesetzt. Die neun Mischungen wurden an die Broiler zwischen dem 35. und 70. Lebenstag gefüttert. Die Ergebnisse zeigen, daß das höchste Endgewicht und die höchste Tageszunahme in der Mischung PKM >BDG>MO erreicht wurde, die höchste Futteraufnahme dagegen bei der Mischung BDG>MO>PKM. Zusammengefaßt, tolerieren Broiler in der Endmast in den Tropen bis zu 30 % Futterbeiprodukte in der Zusammensetzung PKM >BDG>MO ohne eine gesundheitliche Schädigung, bei höheren Raten treten gesundheitliche Probleme auf.

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