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Complementary Effect of Processed Broiler Offal and Feather Meals on Nutrient Retention, Carcass and Organ Mass of Broiler Chickens

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Abstract: Studies were carried out to assess the complementary effect of broiler offal (BOM) and broiler hydrolyzed feather meals (HBFM) processed using simple low cost technologies on the nutrient retention, carcass characteristics and organ mass of broiler chickens. Four diets each were formulated for the starter and finisher phases. Diet A was the control while, B and C contained 30g/kg diet of BOM or HBFM each, and D had a combination of 15:15g/kg of BOM: HBFM. The formulation was at the expense of fishmeal, which was 30g/kg in the control diet. The starter and finisher diets contained 230g and 210g crude protein/kg, respectively and supplied 3000 Kcal/kg of metabolizable energy for the two phases. 180 day-old *Anak* 2000 broilers were randomly divided into 12 groups of 15 birds each. Each diet was fed to three groups of the chicks in a fully randomize manner. Results showed that the retention of dry matter, crude protein, crude fiber, calcium and phosphorus were not significantly ($P>0.05$) affected in both the starter and finisher phases. The retention of ether extract was significantly ($P<0.05$) least in diet B, while birds fed on diet D had significantly ($P<0.05$) the highest retention. Eviscerated mass; drumstick, thigh and breast of broilers at 49 days old were not significantly ($P>0.05$) affected. The abdominal fat pad was significantly ($P<0.05$) least (0.67%) in the HBFM ingredient diet (C) but highest (1.33%) in BOM diet. The liver, spleen, heart, kidney and gizzard were not significantly ($P>0.05$) influenced by the combined effect of the by-products. It is concluded from the study that broiler offal and broiler hydrolyzed feather meals (Diet D) complemented each other as alternative feed ingredients in broiler nutrition.

Key words: Processing, offal and feather meals, nutrient retention, carcass weight

Introduction

Apart from the scarcity of feed ingredients and the high cost of finished feeds, no single ingredient is capable of providing all nutrients in both quantity and quality for optimal animal production. As a practice major protein, energy, vitamins and mineral sources are used to manufacture complete animal feeds. In addition, nutrient synergism and antagonism in ingredients have been documented (Arthur, 1975). Homer and Phillip (1980) stated that tryptophan amino acid is convertible to niacin while methionine is formed from homocysteine or methionine hydroxyl analogue in chicken.

The antagonistic action of des-oxypyridoxine is mitigated by normal amount of vitamin B6 incorporation in poultry feeds (Toride, 2004). Methionine, choline, taurine, homocysteine and betaine are collectively involved in amino acids synergism (Papadopoulos *et al*., 1985).

Several workers including Mohammed *et al*. (1990); Latshaw (1990) and Isika and Agom, 2005 showed that poultry offal and feather meals are alternative feed sources, but that the ingredients are abundant in some nutrients and deficient in others. van Der-Poel and El-Boushy (1990) reported that feathermeal is a good source of leucine and cystein, 4.65% and 3.92%, respectively while lysine, tryptophan and methionine were the first limiting amino acids. Latshaw (1990) showed that poultry offal was an excellent source of lysine (5.13%) and methionine (3.71%). It seems that the deficiency of these nutrients in feathermeal is not necessarily the absence *per se*, but their bio-unavailability. This may be due to the poor quality resulting from insufficient liberation of the amino acids in the keratin feathers, indicating the importance of processing methods in achieving high quality poultry by-product meals (Papadopoulos, 1986).

However, the existing processing methods developed in advanced countries involved not only a sophisticated technology and expertise, but also prohibitive in cost. In optimal animal productivity, nutrient digestibility, absorption, utilization and genetic factors are essential though researchers are often more concerned about introducing alternative feed ingredient at the expense of these factors. Previous works of Fanimo (1991) and Isika and Agom (2005) using easily processed poultry offal and feather meals did not provide information on the complementary or associative effect of the by-products on nutrients utilization and carcass conformation.

The aim of this present study, therefore, was to investigate the associative effect of broiler offal and

Table 1: Composition and determined analysis of broiler starter and finisher diets in which BOM and HBFM replaced fishmeal

	Treatments							
	Starter				Finisher			
Ingredients (g/kg)	Diet A	Diet B	Diet C	Diet D	Diet A	Diet B	Diet C	Diet D
Maize	485.0	485.0	485.0	485.0	515.0	515.0	515.0	515.0
Fishmeal	30.0	-	-	-	30.0	-	-	-
Broiler offal meal, BOM[1]	-	30.0	-	15.0	-	30.0	15.0	-
Hydrolysed feathermeal, HBFM[2]	-	-	30.0	15.0	-	-	30.0	15.0
Fixed ingredients[a],[b]	485.0	485.0	485.0	485.0	455.0	455.0	455.0	455.0
Determined composition (g/kg)								
Dry matter	922.0	911.0	912.0	924.0	913.0	920.09	921.0	921.0
Crude protein	231.0	232.0	230.0	233.0	211.0	212.0	209.0	212.0
Ether extract	57.0	68.0	65.0	63.0	53.0	61.0	56.0	58.0
Crude fibre	58.0	55.0	56.0	55.0	57.0	57.0	61.0	59.0
Methromie (% of diet)	4.2	4.1	3.3	4.1	3.2	4.0	3.2	4.1
Lysine (% of diet)	12.1	11.2	11.0	10.0	11.2	11.1	10.0	10.2
ME[3] (Kcal/kg)	2925.0	2943.0	2914.0	2929.0	2918.0	2936.0	2906.0	2921.0

[a] Fixed ingredients starter diet (g/kg): cotton seed meal, 30; Fulfat soybean meal, 315; wheat offal, 105; Bone meal, 20; oyster shell, 10; mineral-vitamin premix*. [b] Fixed ingredients finisher diet (g/kg): cotton seed meal, 30; fulfat soybean meal 260; wheat offal, 130; Bone meal, 20; oyster shell, 10; vitamin-mineral premix* 2.5; and salt, 2.5. *Vitamin-mineral premix (mg/kg diet): vitamin A, 1200IU; vitamin D_3, 1500IU; Vitamin, 30; vitamin k_3, 5,; Vitamin $b_1$3; vitamin B_2 6; vitamin B_6, 5; vitamin B_{12} 0-03; Nicotine amide, 40; calcium D-Pantothenate, 10; Folic acid, 0.75; D-biotin, 0.075; Choline-chloride, 375mg, Antioxidant, 10; Mn, 80; Fe, 80; Zn, 60; Cu, 8; I, 0-5; Co, 0-2; Se, 0.15. [1] proximate composition of BOM, (g/kg): Dry matter, 88.5g; crude protein, 555.0; crude fiber 49.3; Ether extract, 233.6 and ash, 1141. [2] proximate composition of HBFM (g/kg): Dry matter, 897.6; crude protein, 809.3; crude fiber, 26.3; Ether extract, 44.8; ash, 32.7. [3] According to NRC (1994). Diet A: Control without BOM and HBFM. Diets B and C with 30g/kg each, Diet D, mixture of BOM and HBFM (1:1).

feather meals obtained from simple low lost technologies on nutrient retention, organ mass and carcass characteristics of *Anak 2000* broiler chickens.

Materials and Methods

The study was conducted at the poultry section of the Teaching and Research Farm of the University of Calabar, Nigeria. The temperature and relative humidity ranges were 21.4°-38.3°C and 50-93%, respectively. The average minimum and maximum rainfall were 1171 mm and 1483mm, respectively while the average solar radiation was 14.60 mg/m^2/day (Meteorological Services, University of Calabar, 2003)

Processing of broiler offal and feather meals: Fresh and additive-free offal from eight to nine weeks old *Anak2000* broilers slaughtered at a batch in a commercial broiler-processing firm were collected with precaution to minimize contamination from blood. The offal which included intestines, gut content, heads and feet were cooked (wet-rendered) using firewood at a temperature range of 95°-110°C for 40-45 minutes to remove fat and sterilize the material (Fanimo, 1991).

To further drain the offal of water and fat to about 50-55% moisture content, a screw press was used. The material was pre-sun-dried at 37.5°C and later oven-dried at 65°C for 48 hours to obtain 90-92% dry matter, while common salt was added and mixed at the rate of 0.025% weight of the offal as preservative. A hammer mill of 10mm mesh-size was used to reduce the material to a uniform particle size as broiler offal meal (BOM) according to the methods of Isika *et al. (*1999).

Similarly, feathers from the same birds were collected and wet-rendered as in the case of broiler offal with a slight modification in cooking conditions. Feathers were cooked for four to five hours at a temperature range of 95°–110°C to hydrolyze and sterilize. The feathers were drained of water and further screw pressed to bring the moisture content to 50-55%. They were pre-dried under the sun at 37-38°C and finally dried in an oven at 105°C for 24 hours to obtain a glassy brittleness and 90-92% dry matter content. The processed material was thus hammer-milled for fine and uniform consistency to obtain hydrolyzed broiler feather meal (HBFM).

Feeding trial: Four diets each were formulated for the starter and finisher phases such that the control (Diet A) contained neither BOM nor HBFM. Diets B and C contained 30g/kg BOM or HBFM each, while diet D had a mixture of 15:15g/kg BOM/HBFM at the expense of fishmeal which was 30g/kg of the control diet. The gross and chemical composition of the experimental diets is as shown in Table 1. The isonitrogenous starter and finisher diets contained 230g/kg and 210g/kg crude protein, respectively and supplied 3000 Kcal/kg metabolizable energy for the two phases.

One hundred and eighty (180) day-old *Anak2000* broiler chicks were randomly divided into 12 groups of 15 birds each. Each diet was fed to three groups of the chicks in a completely randomized experimental design under

Table 2: Amino acids composition of BOM and HBFM

Amino acid/g/kgN	BOM	HBF
Marginine	2.56±0.22	5.80±0.03
Aspartic acid	4.26±0.20	-
Cystine	1.97±0.25	6.70±0.91
Glutamic acid	6.72±1.10	3.25±0.21
Glycine	2.64±0.06	6.51±0.08
Histidine	1.51±0.33	0.30±0.01
Isoleucine	1.88±0.03	3.63±0.06
Leucine	3.42±1.00	6.71±1.08
Lysine	2.03±0.04	0.46±0.01
Methionime	0.69±0.22	0.35±0.01
Phenylalanine	2.59±0.19	3.45±1.01
Serine	1.88±0.03	-
Threonine	1.85±0.05	4.03±1.06
Typtophan	-	0.56±0.12
Tyrosine	1.62±0.13	5.30±1.03
Valine	2.40±0.11	5.62±0.72

deep litter system. Feed and water were given *ad libitum*. Vaccinations and other routine broiler management techniques in the tropics were adopted (Oluyemi and Robert, 2000).

Nutrient retention and carcass measurement: On the 22nd and 36th days of the experiment, two birds from each replicate, making a total of 24 were transferred to metal metabolic cages (60cm x 30 cm x 30cm) fitted with feeders, drinkers and polythene sheet for collection of droppings. The polythene sheet was spread with acetate solution to trap nitrogen. The birds were allowed four days adjustment period and droppings collected for the next three days. The droppings were pre-sun-dried, weighed and oven-dried at 65°C for 72 hours and re-weighed. Daily collections were pooled and milled through 1mm mesh according to the treatment groups. Representative samples were then drawn for the determination of nutrients retention (Church and Pond, 1982)

At the end of the experimental period (49th day), six birds from each treatment group which were starved of feed alone for eighteen hours were weighed and slaughtered through cervical dislocation followed by ex-sanguination. Plucked mass was obtained as a percentage of live mass after removing the feathers. The viscera and internal organs were removed and eviscerated mass obtained as a percentage of plucked mass, while the carcass yield was calculated as a percentage of eviscerated mass. Organs such as the liver, spleen, kidney, heart and gizzard were weighed and calculated as percentage of eviscerated mass.

Chemical and data analyses: The proximate composition of the starter and finisher diets were determined using official methods of analysis (AOAC, 1990). For the mineral analysis, samples were ash at 600°C, acid digested (AOAC, 1990) and the minerals value recorded using atomic absorption spectrophotometer (AAS Model 403, Perkin Elmer), while Phosphorus was calorimetrically determined by Phospho-vanado molybdate method (AOAC,1990). Amino acids composition of BOM and HBFM were determined by High Performance Liquid Chromatography (Knaure, Germany) after acid digestion (Nestares *et al*., 1993). All data were subjected to one way analysis of variance (Steel and Torrie, 1980) followed by Duncan multiple range test (Duncan, 1955) to determine significant mean differences at 5% level.

Results and Discussion

The proximate composition of BOM showed crude protein, ether extract and crude fiber to be high; 556.0, 233.6 and 49.3g/kg, respectively, while 809.3, 26.3 and 44.8g/kg were recorded for crude protein, crude fiber and ether extract, respectively in HBFM (Table 1) and appeared closely comparable to previous work (Mohammed *et al.,* 1990; Latshaw, 1990; Isika *et al.*, 1999). The amino acids profile of BOM and HBFM is presented in Table 2. The result shows lysine and methionine to be 2.03 and 0.69g/kgN, respectively which are considered high. Tryptophan was completely absent in BOM, but lower in HBFM which did not have serine and aspartic acids at all (Latshaw, 1990).

Nutrient retention: The nutrient retention of the starter and finisher *Anak 2000* broiler fed diets containing BOM and HBFM in replacement for fishmeal shows dry matter and crude fiber contents to be statistically ($P>0.05$) similar among the treatment groups in the starter and finisher phases (Table 3). Calcium and phosphorus in the two phases were also statistically ($P>0.05$) the same among the treatment groups. The retentions of ether extract and crude protein in the starter phase were significantly ($P<0.05$) lowest in the HBFM containing diet, with the highest being recorded in diet D. In the finisher phase, neither ether extract nor crude protein differed significantly ($P>0.05$) among the treatments.

The idea of nutrient utilization being dependent on the dietary nutrient density and digestibility of feed ingredient is indicative of appreciable usage of BOM and HBFM stuffs in the study. The high fiber content of BOM and perhaps the improper hydrolysis of keratin feather (Papadapoulos, 1986) did not necessarily impair nutrient utilization in the study. This is irrespective of the contention that high fiber content of a diet increases bulk and dilute nutrient density (El-Sherbiny *et al*., 1989). Mohammed *et al.* (1990) contended that inefficient breakdown of feather keratin obstruct nutrient retention due to it resistance to enzymatic action. The recorded high fat content of BOM probably lowered the general nutrients retention in the study. This was more so for ether extract in the BOM diet during the starter phase, but not finisher, which is in agreement with Anonymous (1983) that high fat content in poultry by-product

Table 3: Nutrient retention of broilers fed on the experimental diets (Dry matter basis)

	Treatments				
Parameter (g/kg)	Diet A	Diet B	Diet C	Diet D	±SEM
Starter phase:					
Dry matter	70.32	68.70	70.31	73.45	11.81
Crude protein	68.8^{a}	66.67^{b}	68.04^{a}	69.52^{a}	9.43
Crude fiber	66.44	67.40	68.52	70.14	6.21
Ether extract	68.51^{a}	68.22^{b}	64.72^{a}	72.61^{a}	12.02
Calcium	59.11	63.35	59.06	60.17	7.3
Phosphorus	57.11	56.09	58.63	59.86	8.13
Finisher phase:					
Dry matter	69.10	67.82	71.55	70.31	0.27
Crude protein	71.63	71.05	69.81	68.03	9.44
Crude fibre	67.24	68.23	67.84	68.03	4.73
Ether extract	69.40	67.51	62.13	68.81	11.08
Calcium	60.17	59.46	63.83	62.34	8.92
Phosphorus	53.35	55.03	54.66	56.80	0.18

^{a,b} Means with different superscripts in a row differed significantly at 5% level.

negatively affect nutrients digestibility.

Given that ether extract and crude fiber retentions *per-se* were not adversely affected was unexpected because of their high content in BOM (Anonymous, 1983). Their effect was perhaps ameliorated by the mixing of feather meal which was low in ether extract and the possible beneficial effect of fat soluble vitamins in BOM (Tumova and Skvivan, 1991) though it is contentious that nutrient is improved when oils high in unsaturated fatty acids are used in broiler rations (Anonnymous, 1983). It is known that age does not affect nutrient digestibility except for dietary fiber (Plavnik *et al.,* 1986) and the high retentions recorded at the early stage in this study coincided with when birds were supposedly actively building up tissues.

The comparable retention values of Calcium and Phosphorus did not depict any predictable trend at both the starter and finisher phases. The retentions were generally poor, neither was any disadvantage of the associative effect of BOM and HBFM observed. Also the study could not ascertain mineral antagonism, in which nutrients retention would have been justifiably low, consistent with the earlier reports of Schliffka (1987); Han and Parson (1990) and Heinz and Sichtling (1990) that high mineral content impairs digestibility.

Carcass characteristics: The result of the measurement of live mass, plucked mass and eviscerated mass of broilers fed the treatment diets is presented in Table 4. No significant differences were observed for all the parameters measured. Also the carcass yield; drumstick, thigh and breast were statistically ($P > 0.05$) similar, whereas abdominal fat was significantly ($P < 0.05$) lowest in HBFM diet. The highest abdominal fat value was recorded in the group of birds fed on BOM diet followed by the mixed BOM/HBFM and control diets which were statistically ($P > 0.05$) the same. The total edible meat yield was significant ($P < 0.05$) highest in birds fed the mixed ingredients and control diets but this parameter was statistically similar in broilers on BOM and HBFM diets.

Since carcass characteristic is a sensitive index in profit margin and consumer desirability of the product, the measured parameters appeared comparable across the treatment groups. A large body surface often implies a higher amount of feathers and the general apparently observed low live mass of the experimental birds required a commensurately small surface area and amount of feathers, with a consequent higher plucked mass in the study.

Similarly, eviscerated mass was influenced by live mass and viscera. High mass viscera results in low eviscerated mass (Hulan and Proudfoot, 1981) which is consistent with result of this study. The inclusion of BOM and HBFM in the diet resulted in a comparable values for drumstick, thigh and breast despite the high fat of BOM and some deficient amino acids in HBFM, which evidently complemented each other in meat or muscular synthesis.

Abdominal fat pad is closely related to protein energy ratio of diets so that in high dietary energy, abdominal fat deposition increases. In this study, the high abdominal fat must have been caused by an offset in protein-calorie ratio in favor of BOM diet due to the high fat content of the ingredient. This is in agreement with Bartov *et al.* (1974) who noted high abdominal fat when excess dietary energy was fed or Mabray and Waldroup (1981) who reported that narrowing of calorie-protein ratio prevents excessive fat deposition. The Calcium and Phosphorus of BOM and HBFM in the diets could not significantly influence bone formation of birds since the ingredients were not the major source of minerals. On the other hand, the high edible meat recorded in the mixed BOM/HBFM diet suggested more nutrient bio-availability for anabolic processes, perhaps more so, in protein synthesis than other diets. This was more indicative or

Table 4: Carcass characteristics of experimental broilers on the 49th day.

Parameter	Treatments Diet A	Diet B	Diet C	Diet D	±SEM
Livemass (g/bird)	1480.01	1480.32	1430.1	1520.26	16.18
Pluckmass (% live mass)	90.72	90.96	89.96	93.02	8.27
Evicerated mass (%plucked mass)	72.13	70.33	69.6	72.18	9.44
Carcass yield (%Eviceratd mass):					
Drumstick	14.07	12.76	13.1	13.86	4.73
Thigh	12.33	12.44	11.56	12.24	11.08
Breast	20.52	19.31	20.25	22.1	8.92
Abdominal fat	0.87^{b}	1.33^{a}	0.67^{c}	0.88	0.18
Total bone	24.24	22.87	23.16	20.64	13.03
Edible meat	70.76^{a}	65.93^{b}	66.42^{b}	73.25^{a}	10.28

^{a,b} Means with different superscripts in a row differed significantly (P<0.05

Table 5: Organ weight of broilers at 49th day fed on the experimental diets

Parameter	Treatments Diet A	Diet B	Diet C	Diet D	±SEM
Liver^{ns}	3.62	3.44	3.21	3.10	I.03
Spleen^{ns}	0.46	0.42	0.44	0.48	0.01
Kidney^{ns}	0.82	0.70	0.76	0.81	0.23
Heartns	0.65	0.71	0.69	0.65	0.17
Gizzard^{ns}	3.6	4.00	3.73	3.27	0.94

Means in the row for each parameter did not differ significantly (P>0.05). NS –Not significant

evidential of the complementary or associative effect of BOM and HBFM which agreed with the view of Papadapoulos *et al.* (1986) and Mohammed *et al.* (1990) who found deficiency of some amino acids in HBFM and their surplus in BOM.

The organ mass expressed as a percentage of eviscerated mass are as presented in Table 5. The result showed that the mass of liver, spleen, kidney, heart and gizzard were not significantly (P>0.05) affected among the treatment rations. The BOM and HBFM ingredients did not pose extra work on the gizzard, whose musculature could have been more challenged to comminute the feed particles in all the dietary groups. This was also true for the spleen, kidney and heart organs.

Conclusion: It is concluded from the study that a combination of BOM and HBFM in diets for starter and finisher *Anak 2000* broiler chickens does not adversely affect the retention of dry matter, crude protein, crude fiber, calcium and Phosphorus in both the starter and finisher phases, but decreased ether extract and crude protein retentions at the finisher phase more than other diets. The carcass characteristics and organ mass were also favorably comparable to the control, but a depressed abdominal fat pad and highest edible meat portion were observed in the BOM/HBFM mixed diet compare to others. The combination of broiler offal and hydrolyzed broiler feather meals in poultry nutrition has positive effect as alternative feed ingredients from broiler processing industry using simple low cost processing technologies.

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