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EXPLORING THE USE OF BAMBARA NUT (VIGNA SUBTERRANEAN (L) VERDE) OFFAL IN FINISHER BROILER CHICKEN PRODUCTION

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ABSTRACT: A 28 day feeding trial was conducted to evaluate performance, hematology, serum biochemistry, and carcass characteristics of finisher broilers fed a graded level of Bambara nut offal (BNO) as a partial replacement for maize. Four diets containing 0, 5, 10 and 15% levels of BNO coded T_1, T_2, T_3 and T_4, respectively, were fed to 120 Ross 308 strain broiler birds. The broiler birds were divided into 4 groups of 30 birds per treatment replicated 3 times with 10 birds per replicate. The treatment diets were randomly assigned to the experimental birds in a completely randomized design (CRD). At the end of the 4-week feeding trial, three birds were selected on the basis of average pen weight from each group and used for the determination of blood indices. Data collected were subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS) package. Results revealed that treatment significantly affected ($P<0.05$) the final body weight, body weight change and daily weight gain of finisher broiler birds. The highest final body weight of (2733.33g) was recorded in T_2 (5% inclusion) while the least body weight of (2266.67g) was recorded by birds in T_4 (15% inclusion). On hematological and serum biochemical parameters, the results showed that some values like hemoglobin (Hb), red blood cell (RBC), mean cell hemoglobin concentration and blood clotting time (BCT), respectively, were significantly influenced ($P<0.05$) by the treatment as some of these parameters increased progressively with increasing levels of BNO across the treatment groups while aspartate transferase (AST), Alanine aminotransferase (ALT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), urea, creatinine and cholesterol, decreased with increased inclusion of the BNO. The result of this study indicated that Bambara nut offal at a dietary level of 15% fully supports the productive performance of finisher broilers judging from the positive response in hematological and carcass/organ characteristics. Incorporating

BNO in poultry ration will therefore show a promise in enhancing serum enzymes and carcass mortgage values, and hence the innovation could be used to boost animal protein intake in Nigeria.

Key words: Growth response, Finisher broilers, Bambara nut offal, Replacement value, Agro-industrial by-products.

Introduction

Food and agriculture stand today at a crossroads, with an increasing population putting pressure on limited resources. As a mainstay of many worlds' economy, sustainable agriculture is the key for intensified economic, social, industrial and living standards in many countries.

The development of the livestock industry in Nigeria is fundamental to support economic transformation, social and health perspective especially at this period ie (2025) when the global poultry sector shows signs of recovering market growth. The Nigerian government can take advantage of the projected global poultry market growth of (1.5-2.0) % in 2024 (Poultry World, 2024) and reposition the sector for food security, job creation, export promotion and value addition. The Nigerian poultry industry currently experiencing a blend of technological advancements is still struggling to meet its challenges as a greater part of the operators are small-holder poultry keepers (Nkwocha *et al*., 2024). The market is therefore projected to grow, driven by the integration of digital platforms and the increasing demand for poultry products, particularly eggs and broiler meat.

A closer look at the Nigerian livestock industry speaks volumes of the harmful rise of commercial feeds, fuels and labor costs (Animal & Pet feed Production in Nigeria, 2024). The poultry industry is badly hit by the upsurge in feed prices, and this has negatively affected the market prices of the poultry products like egg, chicken and other byproducts of economic significance, leading to the closure of approximately 30% of poultry farms in the first half of 2024, according to the poultry Association of Nigeria (PAN).

The sustainability outlook in the poultry sector will focus on devising feeding strategies that will be less dependent on the importation of feed raw materials with full concentration on agro-industrial byproduct transformations and value additions.

Looking ahead toward the path to inclusive prosperity by enhancing the productivity of Bambaranut production in Nigeria will be a step in the right direction toward fighting food insecurity and malnutrition in the country.

Bambara groundnut is a climate resilient and nutritious leguminous crop that has gained prominence as a potential solution to food security challenges in various regions of the world (Mayes *et al.*, 2019). It plays a vital role in diversifying diets and improving nutrition because of its high protein content, essential vitamins, and mineral constituents (Ogundele *et al*., 2020).

Bambara nut offal is the waste from the milling of Bambara groundnut seeds (*Vigna subterranae*). The insight into the use of the offal as an alternative energy and protein source could contribute to solving the problem of the high cost of poultry feed and could provide a better avenue for solving its environmental nuisance as it contains 18.30% crude protein, 20% crude fiber, 5.36% ether extract, 41.64% nitrogen-free extract, 10.2% moisture and 16.74% MJ/kg gross energy (Tuleun *et al*., 2020). These findings suggest that Bambara nut offal is a alternative source of protein and fiber, with notable energy content, making it a valuable component in animal feed formulation. Bambara groundnut hulls are rich in various bioactive compounds, including phenolic acids, flavonoids, saponins, and tannins (Okafor *et al*., 2022). These compounds contribute to the legume's antioxidant and antimicrobial properties. Moreover, the offal contains essential minerals, notably, calcium,

magnesium, and potassium, which are important for bone health and overall physiological functions. Many nutritional studies on Bambara nut offal have tried to establish the nutritional basis and application of this byproduct on animal feeding, but much impact is yet to be achieved.

Despite much work done on Bambara nut offal, there is still a dearth of information on the appropriate inclusion levels for optimum growth and productivity of broiler birds, hence the relevance of this study.

Materials and Methods

Location of the study

This study was carried out at the poultry unit of the livestock section of the Teaching and Research farm of the Department of agriculture, Alex Ekwueme Federal University Ndufu-Alike Ikwo, Abakaliki, Ebonyi State, located in Southeast of Nigeria, lies between latitudes $05^{0}40^{'}$N and 6º45'N and longitudes $07^{0}30^{'}$E and $08^{0}46$'E of the Greenwich meridian and Altitude of 55m above sea level. Ebonyi State is bordered by Benure State to the North, Cross River State to the east, Abia to the South, and Enugu State to the West (Onyeneke *et al*., 2022).

The annual rainfall is between 1000-1500 mm. The vegetation of the area is predominantly derived Savannah and the mean annual temperature is about 24^{0}C while the relative humidity is between 60% and 80% (Onyeneke *et al*., 2022).

Experimental animals and design

A total of 120 4-week-old ROX-306 strain broilers used in the study were obtained from a hatchery farm at Ogun State certified to be physically healthy. They were acclimatized for seven (7) days and fed a controlled diet. The birds were raised in a deep litter system whose floor was covered with wood shavings, and feed was provided throughout the experimental period. Standard management practices were strictly observed. Thereafter, the birds were randomly allocated to four (4) dietary treatments and were replicated three (3) times with each replicate having ten (10) birds in a completely randomized design (CRD). The broiler birds were weighed at the beginning of the experiment and body weight changes were taken after that on a weekly basis for 28 days. Daily feed intake was determined by obtaining the difference between the quantity of feed given and the quantity leftover. The feed conversion ratio and feed cost/kg live weight were computed accordingly. Feed and clean drinking water were supplied *ad-libitum* while other routine management practices were observed.

Ethical regulation of the experiment

This study was approved by the Faculty of Agriculture Board of the Alex Ekwueme Federal University, Ndufu-Alike Ikwo, Abakaliki, Ebonyi State, Nigeria. The Authors voluntarily participated and there was no deception, no risk of harm, and the accuracy of reporting was ensured and they complied with the ARRIVE guidelines.

Experimental Diets and Feed Formulation

Four (4) iso-caloric and iso-nitrogenous diets were formulated such that Bambara nut offal replaced maize at 0%, 5%, 10% and 15% dietary levels coded T_1, T_2, T_3 and T_4 respectively (Table 1). The control diet T_1 (0%) contained no Bambara nut offal to examine the performance of the finisher broilers with respect to the diets. The test ingredient (Bambara nut offal) was subjected to proximate analysis (AOAC, 2016) (Table 2).

Table 1: Ingredient composition of the experimental diets fed to broiler birds

Ingredients	T_1	T_2	T_3	T_4
Pure maize	55	52.25	49.50	46.75
BNO	0.00	2.75	5.50	8.25
SBM	13	13	13	13

GNC	15	15	15	15
Wheat offal	10.50	10.50	10.50	10.50
Bone meal	2.25	2,25	2.25	2.25
Limestone	1.00	1.00	1.00	1.00
Fish meal	2.25	2.25	2.25	2.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Analysis				
Energy (Kcal/Kg)	2835	2816	2800	2780
Crude protein (CP)	20.44	20.39	20.35	20.10

Hematological and Serum Biochemical Examination

At the end of the 28-day feeding trials, six (6) birds were randomly selected from each treatment i.e 2 birds per replicate, starved of feed overnight but were given access to water. Blood samples were collected through the jugular vein with a 10ml hypodermic sterile syringe after disinfection with methylated spirit. Five (5) ml of blood samples were collected into Bijon bottles containing ethylene diamine tetra acetic acid (EDTA) as the anti-coagulant and shacked vigorously to avoid coagulation. The remaining 5ml of blood samples for serum biochemical indices were dispensed into a labeled bottle (without EDTA), and the blood sera were separated by centrifuging for 10 min at 2000 revolutions per minute (rpm) at 4^{o}C after which the sera was decanted into a well labeled bottle for further analysis. Blood samples for hematology were taken to the laboratory and analyzed for the following parameters namely hemoglobin (Hb), packed cell volume (PCV), white blood cell (WBC), red blood cell (RBC), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), and blood clotting Time (BCT) according to the Merck Veterinary Manuals, (Aiello et al., 2016). The serum biochemical indices variables taken were blood urea, serum creatinine, blood glucose, cholesterol, serum total protein, albumin, globulin, alkaline phosphatase, alanine aminotransferase (ALT) and aspartate aminotransferase (AST) and were determined according to Duncan and Prasse (2011).

Carcass Evaluation.

At the end of the experiment, one bird was randomly selected per replicate for carcass and organ evaluation. They were starved for about 12 hours but with water. Before slaughtering, the live weights of the birds were recorded accordingly, then bled, scalded, feathered, weighed after feathering (dressed weight), eviscerated and dissected for the determination of carcass and organ weights. Cut parts and organs were weighed on a fresh basis using a sensitive scale (Métier balance). The breast weight was assessed after dissecting the back from the breast and wing and thigh, while the thigh meat ratio and wing was got with the use of a measuring tape.

Dressing percentage (%) = $\frac{dressed\ weight}{live\ weight} x\ 100$

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using the Statistical Package for Service Solution (SPSS) version 23. The treatment means were separated by Fisher's Least Significant Difference (LSD) Test (Williams and Abdi, 2010).

Results and Discussion

Growth performance

The nutritive assessment of BNO showed that it contained 7.22% crude protein, while other compositional values of 2.59, 12.82, 1.81 and 64.00% were recorded for ash, crude fiber, ether extract and nitrogen-free extract, respectively (Table 2). The crude fiber level of BNO is relatively high, probably due to the presence of non-starch polysaccharides existing in the seeds (Bidhendi and Geitmann, 2016). The presence of a high level of nitrogen-free extractives indicates that the energy value of BNO is high, while the low level of ash content indicates that the total inorganic mineral content in BNO is low.

The test additive (BNO) significantly ($P<0.05$) effected the final body weight, body weight change and average daily weight gain of the finisher broiler birds (Table 3). However, there were no significant differences ($P>0.05$) in daily feed intake, feed conversion ratio, and feed efficiency among the treatments (Table 3).

Table 2: Proximate composition of the Bambara nut offal

Fractions	Percentage
Moisture Content	11.56
Crude Protein	7.22
Ether Extract	1.81
Ash	2.59
Crude Fiber	12.82
Carbohydrate (NFE)	64.00
Energy Value (Kcal/Kg)	2654

ME= Metabolizable energy calculated; ME (Kcal/kg) =37 × %CP+81 × %E.E+35 × %NFE (Pauzenga, 1985).

Table 3: Performance characteristics of finisher broilers fed varying dietary levels of BNO

Parameters	T1(0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM
Initial body weight(g)	910^a	891.67^a	903^a	895.33^a	4.09
Final body weight(g)	2696.66^a	2733.33^b	2616.67^c	2266.67^d	106.70
Body weight change(g)	1786.67^b	1841.66^b	1713.67^c	1371.34^d	105.63
Av. Daily Weight gain	63.80^c	65.77^d	61.2^d	48.98^c	3.77
Daily Feed intake(g)	138.10^b	140.31^b	143.05^b	120.65^b	5.06
Feed conversion ratio	2.16^c	2.13^c	2.34^c	2.46^c	0.08
Cost of feed/kg (₦)	214.75	212.28	209.80	207.27	3.22
feed efficiency	0.46^d	0.47^d	0.41^d	0.43^d	0.01

a,b,c = Means on the same row with different superscripts are significantly ($P<0.05$) different. SEM = Standard Error of means.

The highest final body weight of (2733.33g) was recorded in T_2 (5% inclusion) while the least body weight of (2266.67g) was recorded by birds in T_4 (15% inclusion). T_1 (control) and T_3 (10% inclusion) had (2696.66g and 2616.67g), respectively. These findings align with the report of Udeh *et al* (2018) who recorded similar growth patterns when comparing the effect of Bambara nut offal and soybean hull at different levels of inclusions in broiler finisher diets. Nevertheless, the final body weight change values of (2266.67-2733.33)g obtained in this study are higher than the value range of (1800-2350)g reported by Udeh *et al.* (2018); Ironkwe and Ukanwoko (2012) and also greater than the value (1200.54-1490.77)g reported by Ani *et al.,* (2012) who fed broiler chickens with raw Bambara nut waste. Increased growth rate is synonymous with high feed conversion ratio (FCR). T_2 recorded the highest FCR of 2.13 followed by T_1 (2.16), T_3 (2.34) and T_4 (2.46) in that order. However, there is no significant difference ($P<0.05$) between the treatment means in relation to FCR statistically. According to Leeson and summers, (2006), a feed conversion ratio of 2 to 4 is ideal for broiler chicken performance. The feed conversion ratio in this study was higher than the values reported by Tuleun *et al.* (2020). Birds on BNO-based diets had better feed use than those on the control diet.

The daily feed intake of T_3 (143.05g) was highest followed by T_2 (140.31g). T_4 recorded the least daily feed intake (120.65g), which of course may be attributed to the high level of fiber due to the increasing level of BNO in the treatment diet (Lindberg, 2014). T_1 promoted the highest feed cost of N214.75 per kg, which is statistically different ($P<0.05$) from Bambara nut offal-based diets. The feed cost of the diets reduced significantly as the dietary levels of BNO increased progressively. T_4 numerically recorded the least cost, though economically may not be the best for poultry farmers. The implication of this is that the poultry farmer will save more money, hence increasing the profitability of the enterprise by including BNO at the ideal level (Adeoti and Olawumi, 2013).

Effect of Bambara nut offal on the hematological estimates of finisher broiler birds

Table 4: Hematological estimates of finisher broilers fed graded levels of BNO as a replacement for maize

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	Ref. Value	SEM
Hb (g/dl)	11.7^{a}	9.9^{b}	11.8^{c}	12.8^{b}	7-13	0.60
PCV (%)	36.1^{a}	29.83^{a}	37.23^{a}	31.4^{a}	22-35	1.79
RBC($\times 10^{6}$)	2.95^{b}	2.33^{c}	3.32^{d}	2.94^{c}	4.2-4.84	0.20
WBC($\times 10^{6}$)	232^{b}	262.33^{b}	197.33^{b}	204.67^{b}	4.07-4.32	14.77
MCV (fl)	123.4^{c}	132.5^{c}	111.97^{c}	109.23^{c}	29.35	5.37
MCH (Pg)	40.13^{d}	44.13^{d}	35.70^{d}	35.47^{d}	30-40	2.06
MCHC (Pg)	32.57^{c}	33.4^{b}	31.8^{a}	33.17^{c}	32.41-33.37	0.36
BCT(sec)	35.00^{a}	36.00^{b}	36.20^{b}	40.20^{c}	32-39	2.60

$*^{a,b,c}$ = Means on the same row with different superscripts are significantly ($P<0.05$) different. SEM= Standard Error of means. Hb=Hemoglobin; PVC =Packed cell volume; RBC= Red blood cell; WBC=White blood cell; MCV=Mean corpuscular volume; MCH=Mean corpuscular hemoglobin; MCHC=Mean corpuscular hemoglobin concentration; CT=Clotting time.

Ref. Value=Reference value from Wikivet chicken hematology, (2013) .

The results of this present study (Table 4) showed some level of influence of the treatment diets on hematological parameters of finisher broilers fed BNO-based diets. Hemoglobin, (Hb), mean cell hemoglobin (MCH), mean corpuscular volume (MCV), and blood clothing time (BCT) decreased numerically as the level of BNO increased across the treatment means, while packed cell volume (PCV), red blood cells (RBC), white blood cell and mean corpuscular hemoglobin concentration (MCHC) followed no definite trend, although their values fell within the normal range specified for optimum broiler performance as recommended by Wikivet chicken hematology, (2013). Hb, MCHC and BCT were significantly influenced ($P<0.05$) by the experimental diets while PCV, MCV, WBC, and MCH were not significantly ($P>0.05$) affected by the treatments. Udeh *et al.* (2018) reported significant differences ($P<0.05$) on WBC and PCV, which was contrary to this study. Hemoglobin varied marginally among the treatment means with T_4 (15%) having the highest (12.8g/dl) and T_2 (5%) recording the least value of (9.9g/dl). The Hb value obtained in this study is comparable with the value obtained by Udeh *et al*. (2018) and Olajide (2012) in their study on Bambara nut waste and soyabean hulls on growth performance, hematology, carcass and conformational traits of broiler chickens. The PCV was numerically highest at 37.23% in T_3 (10%), which is above the recommended range reported by Wikivet Chicken Hematology, (2013). However, there was no significant difference in the PCV value among the treatment means. The values of PCV that fell within the recommended range for normal chickens were indications of adequate nutrition for finisher birds. Ikhimioya *et al*. (2000) and Oladele *et al* (2001) linked lower PCV values to inadequate nutrition. The red blood cell (RBC) count was significantly ($P<0.05$) affected by the diets and the values (2.94 to 3.32 $\times 10^6_{\wedge}$) was lower than the recommended range of 4.2-4.84 $\times 10^6_{\wedge}$ according to Wikivet chicken hematology, (2013). T_2 and T_3 recorded the least and highest values (2.33 and 3.32$\times 10^6_{\wedge}$) respectively. Nuhu and Bashir (2022) in an experiment with hematological and biochemical characteristics of finisher broiler chickens fed roasted bambara nut-based diets recorded reduced RBC with higher dietary levels of Bambara nut inclusion and this agrees with the report of this present study where at 15% inclusion level of Bambara nut offal inclusion, the RBC significantly dropped to 2.94 $\times 10^6_{\wedge}$. However, the values obtained in this study align with the findings of Olajide (2012) and Udeh *et al* (2018) but are lower than the values reported by Ocheja *et al.* (2012). The normal range in the values of PCV, RBC and WBC of finisher broilers fed BNO-based diets indicates that the test materials helped in boosting the immune system of broiler finisher birds. Blood is a good indicator to determine the health of an organism (Joshi *et al*., 2002). It also acts as a pathological reflector of the whole body; hence hematological parameters are important in diagnosing the functional status of animals exposed to toxicants (Joshi *et al*., 2002). It is proposed that BNO in feeds can be used to manage birds that are immune suppressed and anemic. This is because of the drastic increase in PCV and total RBC count as well as increased WBC count stimulated by the feeds containing BNO. Mean cell hemoglobin (MCH) and mean cell volume (MCV) were not significantly ($P>0.05$) affected by the treatment. This agreed with the findings of Udeh *et al* (2018) and Olajide (2012) who obtained no significant effect on MCHC, MCV and MCH in broiler chickens. MCHC and blood clothing time (BCT) was significantly ($P<0.05$) affected by the treatment diets as those values decreased with increasing inclusion of the BNO although they are within the recommended range except T_4 (15%) which is slightly above the range. The control group T_1 (0%) recorded the least BCT of 35 Seconds, (which indicates efficient blood clotting ability), while T_4 (15%) recorded the highest value of 40.20 Seconds. A normal range of BCT in finisher broilers notably (32-39) minutes is an indication of the presence of blood clothing factors like prothrombin, fibrinogen stabilizing

factors, calcium and vitamin K (blood platelets), which has been manifested in the BNO-based diets (Sherilyn, 2019).

Effect of Bambara nut offal on the serum biochemical estimates of finisher broiler birds

Table 5: Serum biochemical estimates of finisher broilers on graded levels of BNO as a partial replacement for maize

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	SEM
Urea (mg/dl)	4.26 ± 1.97^{a}	2.69 ± 1.54^{b}	2.62 ± 0.47^{b}	2.02 ± 1.19^{c}	0.81
Creatinine (mg/dl)	2.07 ± 0.14^{a}	1.72 ± 0.25^{a}	1.73 ± 0.37^{b}	1.73 ± 0.37^{b}	0.17
Glucose (mg/dl)	204.3 ± 0.8^{a}	234.1 ± 0.23^{b}	241.5 ± 0.51^{b}	250.6 ± 0.27^{c}	0.29
Cholesterol (mg/dl)	138.33 ± 15.01^{a}	134.33 ± 21.54^{a}	135.67 ± 11.15^{b}	132.33 ± 10.02^{c}	8.73
Total Protein (g/dl)	3.22 ± 0.13^{a}	3.69 ± 0.14^{a}	3.88 ± 1.1^{b}	3.97 ± 0.12^{b}	0.32
Albumin (g/dl)	1.24 ± 0.19^{a}	1.14 ± 0.33^{b}	1.96 ± 0.23^{b}	1.91 ± 0.24^{c}	0.12
Globulin (g/dl)	1.67 ± 2.1^{a}	1.78 ± 1.8^{a}	1.88 ± 1.8^{b}	1.94 ± 1.7^{c}	1.10
AST (u/l)	9.83 ± 0.15^{a}	12.33 ± 1.53^{b}	11.4 ± 0.26^{b}	10.93 ± 0.06^{c}	0.16
ALT (u/l)	21.33 ± 1.53^{a}	22.33 ± 1.53^{a}	24.67 ± 3.21^{b}	22.00 ± 2.00^{c}	0.43
ALP (u/l)	18.42 ± 0.3^{a}	18.42 ± 0.4^{a}	18.43 ± 0.1^{a}	18.44 ± 0.4^{a}	0.16

$*^{a,b,c}$ = Means on the same row with different superscripts are significantly ($P<0.05$) different: SEM= Standard Error of means; AST (SGOT) = Aspartate aminotransferase, ALT (SGPT) = Alanine aminotransferase ALP = alkaline phosphatase

Serum biochemical constituents showcase the posture of the animal in terms of health, nutrition, climate and management conditions to which the animal is subjected to (Madubuike and Ekenyem, 2006; Ilo *et al*., 2024). The serum biochemical parameters of this study were used to evaluate the overall productive performance of the finisher broiler birds.

The analysis of blood serum obtained from this study indicated that significant differences ($P<0.05$) existed in some parameters like urea, creatinine, cholesterol, AST and ALT, respectively. The results showed no significant difference ($P>0.05$) in glucose, total protein, albumin, globulin and ALP. Total protein (TP) ranged from 3.22 to 3.97 g/dl, while albumin ranged from 1.24 to 1.91 g/dl. The level of the uric acid in the blood serum samples ranged between 2.02–4.26 mg/dl. The highest value of urea concentration was recorded in the control diet (4.26) mg/dl, although it was not significantly different ($P>0.05$) from the BNO-based diets. From the result, it was observed that an increased level of BNO-based diets reduced the level of urea build up across the treatment means significantly ($P<0.05$). Creatinine, cholesterol, and AST values also followed definite trends and decreased as dietary levels of BNO increased in the treatment diets. Aspartate amino transferase is a sensitive indicator of liver disease in birds. Although not specific, it is the best measure of liver disease in birds (Karen, 2019). Increased cholesterol levels are associated with hormonal and metabolic diseases, liver disease, and serious kidney disease; hence, the normal values obtained in the BNO-based diets are indications that the test ingredient is compatible with the normal healthy tone of stocks. The increase in the glucose values of BNO-based diets shows that the energy level of the Bambara nut offal is well metabolized and converted to glucose. Creatinine is an indication of muscle breakdown and an abnormal increase indicates the disease. In this study, creatinine production as influenced by the inclusion of BNO was reduced significantly ($P<0.05$) showing positive impact on nitrogen metabolism. Nuhu and Bashir, (2022) recommended a 30% level of inclusion of

roasted BNO for optimum hematological and serum biochemical stability of finisher birds, while in this study the maximum inclusion level was 15%.

Table 6: Carcass and organ estimates of finisher broilers on graded levels of BNO as partial replacement for maize.

Dietary treatment (%)					
VARIABLES	**T_1 (0%)**	**T_2 (5%)**	**T_3 (10%)**	**T_4 (15%)**	**SEM**
Starved Live weight (kg)	2.26[a]	2.10[a]	1.90[b]	2.80[a]	0.04
Full dressed Weight (kg)	1.36[c]	1.42[b]	1.50[b]	1.67[a]	0.03
Dressing percentage In Live Weight	78.71b	77.60[b]	71.88[b]	92.78[a]	0.23
Thigh Circumference	12.33[b]	12.67[b]	13.50[a]	13.33[a]	0.20
Head Circumference	12.17[a]	12.00[a]	12.67[a]	11.67[b]	0.18
Wing Length	2 Z4.50[a]	23.67[b]	23.83[b]	23.00[b]	0.16
Shank Length	9.83	9.50	9.84	9.67	0.16
Body Length	34.67[c]	34.33[c]	35.00[b]	36.17[a]	0.40
Heart%	1.43[a]	1.37[a]	1.24[b]	1.20[b]	0.03
Liver%	2.10[a]	2.73	2.07	2.32	0.15
Intestine %	6.68[a]	6.98[a]	4.39[c]	6.09[b]	0.39
Gizzard %	2.38[a]	2.91[a]	2.39[c]	2.78[b]	0.10

*a,b,c = Means on the same row with different superscripts are significantly
($P<0.05$) different. SEM = Standard Error of means

The data on carcass analysis and organ weights expressed as percentage of dressed weights are shown in table 6. The results obtained for the live weights were 2.26, 2.10, 1.90 and 2.80kg for birds on 0, 5, 10 and 15% dietary inclusion of BNO, respectively. The highest live weight was obtained from birds in treatment 4 (15%), while the least live weight was recorded by birds in treatment 3 (10%) dietary treatment. However, there was no significant difference ($P> 0.05$) among the starved live weights of birds fed BNO and the control diet, except at the 10% dietary level. Significant differences ($P<0.05$) existed between treatment means in full dressed weight, dressing percentage, thigh circumference and body length. The highest dressing percentage (92.78%) was recorded from birds in treatment 4 (15% level) while the least (71.88%) was recorded from finisher birds in treatment 3 (10%) level of inclusion.

The organ weights of the experimental broilers did not follow any definite trend. Organs such as the heart, intestines, and liver decreased, while gizzard increased with increasing levels of BNO. The relative increase in the weight of the gizzard in the BNO-based diets ($P<0.05$) above the mean value of all the experimental birds in the control may be attributed to the high fiber content in the test diets (Bihendi and Geitmann, 2016) and the presence of anti-nutritional factors (Apata, 1990). Apata (1990) studies on the effects of phytic acid on the performance and nutrient utilization in broiler birds revealed that unprocessed or under-processed Bambara nut offal may contain residual anti-nutritional factors like tannins and trypsin inhibitors, which can reduce nutrient digestibility, generating compensatory enlargement of digestive organs like gizzard to facilitate better digestion. The values for anthropometric traits such as thigh circumference and body length also increased with increasing levels of BNO ($P<0.05$). The decreased weight of the wing, breast meat and abdominal fat of birds fed a diet

containing Bambara nut offal at the 15% level of inclusion ($P<0.05$) may be due to the activities of the fiber, which must have acted as a dilutant to nutrient and reduction in adipose tissue.

Conclusion and Recommendation

This study revealed that the inclusion of BNO at 0-15% enhanced the growth performance, hematological and serum biochemical estimates, and carcass characteristics of finisher broiler birds. From the economic, blood parameters and carcass yield viewpoint, the result shows that T_4 (15% inclusion) performed better than other levels of inclusion and hence recommended to poultry farmers for optimum performance, hematology, serum biochemical stability and higher carcass values so as to make animal protein available at a reduced cost and maximize profit.

DECLARATIONS

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Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contribution

G. Nkwocha = Conceptualization, Statistical design, data analysis, section writing, reference sorting, editing, and proofreading.

Ahaotu, E.O and Ugwuanyi, D.O = Data analysis, results editing, proof-reading and grammar checking.

Ogwa, E.A. = Results and Discussion, Conclusion/Recommendation section writing.

Edih, M.C & Iwuagwu, C.E = Materials & Methods, data processing, data sorting and coding.

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Competing interests

The authors declare no competing interests in this research and publication.

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