

Comparative performance, carcass traits, offals and internal organs of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite

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Received 17th March 2025; Accepted 21st April 2025

ABSTRACT: The study investigated the utilisation of yam peel meal (YPM), toasted bambara nut sievate (TBNS) and toasted bambara nut sievate–yam peel meal composite (TBNS-YPMC) as a dietary replacement for maize in broiler chicken diets. A total of 200 unsexed day-old broiler chicks were purchased and allowed a week of acclimatisation. Thereafter, 165 seven-day-old broiler chicks were randomly assigned to five dietary treatments in a completely randomised design with three replicates of 11 birds each for 56 days. The treatments included a control (T1: 0%), 20% yam peel meal (T2), 20% toasted bambara nut sievate (T3), 20% TBNS-YPMC (T4) and 40% TBNS-YPMC (T5). Results showed that birds on T3 and T5 (20% TBNS and 40% TBNS-YPMC) had significantly higher daily body weight gain (30.15 g/bird) and final body weight (1833.33 g/bird) compared to other treatments ($p < 0.05$). Feed conversion ratio (FCR) was significantly improved in T3 (2.95), while T2 had an FCR of 4.57. Mortality was highest and similar in T2, T3 and T4 (24.24%). Economic analysis revealed the lowest feed cost per kg (₦634.75) and highest gross profit (₦2,015.17) in T5 and T4, respectively. Carcass traits were significantly better in T3, with the highest plucked weight (1572.67 g), eviscerated weight (1319.00 g), and carcass weight (1197.00 g). The dressing percentage and primal cut yields, particularly breast and thigh, were also highest in T3 (67.69, 21.83 and 10.27%, respectively). The study concludes that partial replacement of maize with TBNS or its composite with yam peel meal, particularly at 40% TBNS-YPMC, can enhance broiler growth performance, carcass yield and economic efficiency. Toasted Bambara nut sievate (TBNS) or its combination with yam peel meal (TBNS-YPMC) be incorporated at a 40% replacement level for maize in broiler chicken diets is recommended.

Keywords: Composite, cost-benefit, organs, offal, peel, performance, sievate.

INTRODUCTION

The poultry sector in Nigeria, like other developing countries, plays a crucial role and economic development. It contributes more than 30% of the total animal protein consumed and serves as a vital source of income and livelihood for a significant portion of the population.

Globally, poultry meat and egg production are recognised as sustainable and efficient means of providing safe and quality dietary protein for human nutrition. Additionally, the sector supports job creation and income generation (Nasiru *et al.*, 2023).

However, the rapid growth in the poultry industry is having a profound effect on the demand for feed and raw materials. Hence, in Nigeria, feed accounts for 70-80% of the total cost of poultry production, and this is largely due to the high cost of conventional feedstuffs stemming directly from high demands as staple foods by humans (Harande *et al.*, 2023). It is worth noting that the Nigerian poultry feed industry is heavily dependent on conventional feedstuffs such as maize, soybeans, among others (Harande *et al.*, 2023).

In an effort to overcome this problem of over-dependency on conventional feedstuffs, animal nutritionists have been researching ways to utilise agro-byproducts, which have little or no cost on livestock production, as an alternative feedstuff to completely or partially replace conventional feed sources (Ardo *et al.*, 2019). These alternative and cheap agricultural by-products have been successfully used by animal scientists to drive down the cost of production and hence, the cost of edible animal products, making protein intake affordable to many Nigerians (Uza *et al.*, 2024).

Such promising agricultural by-products are the bambara nut sievate, a milling by-product of Bambara nut for flour production, and yam peel (White yam), a by-product of yam processing. Research has found that bambara nut sievate can be incorporated in the diets of livestock to boost their performance and reduce the cost of their edible products (Uza *et al.*, 2021). Nutritionally, raw and toasted bambara nut sievate contains 93.21 to 98.83% dry matter, 10.98 to 13.13% crude protein, 25.38 to 27.62% crude fibre, 48.90 to 52.00% nitrogen-free extract, 2.66 to 4.60% ash and 2,260.87 to 2,625.94 Kcal/Kg of Metabolisable energy (Uza *et al.*, 2021).

Likewise, yam peel contains 10.2% crude protein, 13.3% crude fibre, and 3,020 Kcal/kg metabolizable energy (Adegun, 2020). According to Akinmutimi and Onen (2008), yam peel meal (YPM) can replace up to 15% of maize in diets of broiler chickens to reduce production cost and improve the growth of broiler chickens, which unveiled the possibility of using yam peel as another unconventional feedstuff in livestock production. Similarly, Tuleun *et al.* (2020) reported that inclusion of 30% bambara nut offal in enzymes-supplemented broiler chickens' diets had no adverse effect on performance and reduced feed cost per kg weight gain of broiler finisher chickens. The present study, therefore, evaluates performance, cost-benefit analysis, carcass traits, and internal organs of broiler chickens fed dietary replacement levels of yam peel meal (YPM), toasted bambara nut sievate (TBNS) and their composite.

MATERIALS AND METHODS

Location of Study

The study was conducted at the Poultry Unit of the

Livestock Teaching and Research Farm, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria. Makurdi lies on the geological coordinates of Latitude 7°44' North and longitude 8°22' East with an ambient temperature range of 17.3–35.6°C and the relative humidity of 47-48% (Google Earth, 2024).

Sources and preparation of experimental feed ingredients

Bambara nut sievate (BNS) was purchased at Ushoongo Town in Ushoongo Local Government Area of Benue State. Five kilograms (5 kg) of raw BNS was thoroughly mixed with 500 ml of clean, fresh water and toasted using a large aluminum frying pan, with the material frequently and cautiously turned to avoid charring until it turned light brown with a sweet aroma, after which it was allowed to cool to room temperature (25°C) before use. Fresh yam peels were collected from local farmers within Makurdi and its environs, sun-dried for 5–7 days until a constant weight was obtained, and then milled for use. Other feed ingredients, including maize, full-fat soybean, maize offal, salt, bone ash, vitamins, and mineral premix, were procured from Wurukum Market and a livestock feed shop in Makurdi, with ingredients requiring particle size reduction milled using an electric grinding machine.

Experimental diets

Five (5) diets were formulated with yam peel meal (YPM), bambara nut sievate (BNS) and Bambara nut sievate (BNS) - yam peel meal (YPM) composite (mixed in a ratio of 1:1) replacing maize in the diets; T1: control, T2: 20 YPM, T3: 20 TBNS, T4: 20 TBNS-YPMC and T5: 40% TBNS-YPMC, respectively, for starter and finisher broiler birds as shown in Tables 1 and 2 (100 kg).

Experimental design and management of birds

A total of 200 day-old unsexed broiler chicks (Ross 308) were purchased from Sayeed hatchery in Ibadan, Nigeria. These birds were allowed a week period for acclimatisation while on commercial broiler starter diet (24% crude protein). Thereafter, 165 seven-day-old unsexed broiler chicks were weighed and divided into five groups of 33 chicks and replicated thrice with 11 birds each. Each group was offered diets; T1: control, T2: 20% YPM, T3: 20% TBNS, T4: 20% TBNS-YPMC and T5: 40% TBNS-YPMC replacing maize, respectively. Each replicate was housed in an individual compartment. The experiment was a complete randomised design (CRD). The study lasted eight (8) weeks, while feed and clean, cool water were offered to the birds *ad libitum* throughout the study period. Gumboro and Newcastle "Iasota" vaccines were administered at the 7th and 14th day of age, respectively,

Table 1. Ingredients and proximate nutrient composition of broiler starter diets containing graded replacement of maize with BNS-YPM composite.

Ingredients	Dietary replacement levels of maize with YPM, TBNS and their composite (%)				
	0	20 YPM	20 TBNS	20 TBNS-YPMC	40 TBNS-YPMC
Maize	37.27	26.97	26.97	26.97	16.67
Crop by-products	00.00	10.30	10.30	10.30	20.60
FFSB	46.83	46.83	46.83	46.83	46.83
Maize Offal	12.00	12.00	12.00	12.00	12.00
Bone ash	3.50	3.50	3.50	3.50	3.50
Salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Vit. Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated proximate nutrient composition					
Crude protein	22.00	22.03	22.03	22.31	22.62
Crude fibre	4.74	5.34	5.42	5.29	5.58
ME (Kcal/Kg)	3125.00	3017.27	3002.96	3051.76	2979.56

*TBNS-YPMC= Toasted Bambara nut sievate-Yam Peel Meal Composite, FFSB= Full Fat soybean, ME= Metabolisabel Energy, Kcal= Kilocalories, Kg= Kilogramme. **Vitamin premix contains B1, 1g; B2,6g; B12,0.02g; K3,3g; E,3g; Biotin,0.05g; Folic acid,1.5g; Cholinechloride,250g; Nicotineacid,30g; Ca- pantothenate,15g; Co,0.4g; Cu,8g; Fe,32g; I,0.8g; Zn,40g; Mn,64g; Se,0.16g, BHT,5g.

Table 2. Ingredients and proximate nutrient composition of broiler finisher diets containing graded replacement of maize with YPM, TBNS and their composites.

Ingredients	Dietary replacement levels of maize with YPM, TBNS and their composite (%)				
	0	20 YPM	20 TBNS	20 TBNS-YPMC	40 TBNS-YPMC
Maize	40.83	32.66	32.66	32.66	24.50
Crop by-products	00.00	8.17	8.17	8.17	16.33
FFSB	39.68	39.68	39.68	39.68	39.68
Maize Offal	14.00	14.00	14.00	14.00	14.00
Bone ash	3.50	3.50	3.50	3.50	3.50
Salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Vit. Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated proximate nutrient composition					
Crude protein	20.00	20.02	20.02	20.26	20.52
Crude fibre	4.65	4.72	4.75	4.73	4.81
ME (Kcal/Kg)	3060.73	2975.68	2964.33	3003.43	2966.12

*TBNS-YPMC= Toasted Bambara nut sievate-Yam Peel Meal Composite, FFSB= Full Fat soybean, ME= Metabolisable Energy, Kcal= Kilocalories, Kg= Kilogramme. *Vitamin premix contains B1, 1g; B2,6g; B12,0.02g; K3,3g; E,3g; Biotin,0.05g; Folic acid,1.5g; Cholinechloride,250g; Nicotineacid,30g; Ca- pantothenate,15g; Co,0.4g; Cu,8g; Fe,32g; I,0.8g; Zn,40g; Mn,64g; Se,0.16g, BHT,5g.

via drinking water. Vitalyte was given after vaccination, changing of litter materials and handling during weighing. Antibiotics and coccidian drugs were also administered appropriately

Data collection

Performance data

FI (g) = Weekly feed offered – weekly feed leftover

Weight gain (g) = Final body weight – initial body weight

$$\text{Feed conversion ratio} = \frac{\text{Total feed intake}}{\text{Total weight gained}}$$

$$\text{Mortality rate (\%)} = \frac{\text{Number of dead birds}}{\text{Total number of birds stocked}} \times 100$$

Cost-benefit analysis data

$$\text{Cost (₦)/ kg diet} = \frac{\text{CCFI used to formulate 100kg diet}}{100}$$

TPC (₦) = total cost (₦) of all operations

GP = Price per bird – Total production cost per bird

Where: FI = Food intakes, CCFI = Cost contribution of feed ingredients, TPC = Total production cost, and GP = Gross profit.

Carcass evaluation data

At the end of the feeding trial, three (3) birds were selected from each replicate across the treatment (representing the average live body weight of the treatment group). The selected birds were fasted off feed for 11 hours to avoid faecal contamination during evisceration and improve carcass yield (Rosa *et al.*, 2012). The selected birds were slaughtered by severing the neck at the first vertebrae with a Sharp knife and bled. They were dipped in hot water (70-80 °C) for one to two minutes, and their feathers were manually plucked. Each bird was eviscerated, and the dressed weight was measured.

The following parameters were taken: live weight, bled weight, de-feathered weight, eviscerated weight, dressing weight and dressing percentage. The weights of the cut parts, such as breast, drumsticks, thighs, wings, back, shank, head, neck and organs, were expressed as a percentage of live weight (Aduku, 2004).

$$\text{Dressing \%} = \frac{\text{dressed weight}}{\text{live weight}} \times 100$$

$$\text{Cut parts} = \frac{\text{carcass cut Weight}}{\text{carcass weight}} \times 100$$

$$\text{Organ proportion} = \frac{\text{Weight of organ}}{\text{live weight}} \times 100$$

NOTE: Cut parts are expressed relative to the carcass weight, and organ proportion is expressed relative to the organ weight

Statistical analysis

The data collected were subjected to analysis of variance

(ANOVA) in a completely randomised design. Duncan Multiple Range Test (DMRT) was used to separate means that differed significantly ($p < 0.05$) as contained in the SPSS package (version 21).

RESULTS

Growth performance and cost benefit analysis of broiler chicks fed dietary replacement levels of maize with yam peel meal (YPM), toasted bambara nut sievate (TBNS) and their composite (TBNS-YPMC)

The results of the growth performance and cost-benefit analysis of broiler chicks fed dietary replacement levels of maize with yam peel meal (YPM), toasted bambara nut sievate (TBNS), and their composite (TBNS-YPMC) are presented in Table 3. Significant differences ($P < 0.05$) were observed among the dietary treatments for daily feed intake (DFI), daily body weight gain (DBWG), final body weight (FBW), feed conversion ratio (FCR), and mortality rate, indicating that the replacement levels had effects on these performance indicators. Birds fed diets containing TBNS and 40% TBNS-YPMC had the highest and similar daily feed intake (DFI) of 111.02 g/bird, while those fed diets containing 0, YPM and 20% TBNS-YPMC had the least and similar DFI (82.70 g/bird). Daily body weight gain (DBWG) was highest and similar for birds fed diets containing TBNS and 40 TBNS-YPMC (30.15 g/bird), while those fed other diets recorded the least and similar DBWG (21.93 g/bird). Final body weight (FBW) was highest and similar (1833.33 g/bird) for birds fed diets containing TBNS and 40% TBNS-YPMC, while birds on other treatment groups recorded the least and similar FBW (1300.00 g/bird). Feed conversion ratio was best for birds fed diets containing TBNS (2.95), though with the highest mortality (24.24%) compared to birds in other treatment groups.

Diet containing 40% TBNS-YPMC and control had the least (₦634.75) and highest (₦721.99) feed cost per kg diet, respectively. Total production cost was highest (₦4,899.65) and lowest (₦3,984.83) on bird fed diets containing 40 and 20% TBNS-YPMC, respectively. Gross profit was highest (₦2,015.17) and lowest (₦1,100.35) on bird fed diets containing 20 and 40% TBNS-YPMC, respectively.

Carcass traits of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite

Carcass traits of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite are presented in Table 4. Results showed that all carcass traits were significantly ($p < 0.05$) influenced, except the relative weight of drumstick and shank. Birds fed a diet containing 20%

Table 3. Growth performance and cost benefit analysis of broiler chicks fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite.

Parameters	Replacement levels of maize with YPM, TBNS and TBNS-YPMC (%)					SEM
	0	20 YPM	20 TBNS	20 TBNS-YPMC	40 TBNS-YPMC	
IBW (g/bird)	145.33	142.00	145.00	145.00	145.00	1.11
DFI (g/bird)	82.70 ^c	100.29 ^{ab}	88.81 ^{bc}	79.80 ^c	111.02 ^a	3.46
DBWG (g/bird)	23.60 ^b	21.93 ^b	30.15 ^a	20.62 ^b	30.15 ^a	1.17
FBW (g/bird)	1466.67 ^b	1466.67 ^b	1833.33 ^a	1300.00 ^b	1833.33 ^a	62.64
FCR	3.51 ^{bc}	4.57 ^a	2.95 ^c	3.95 ^{ab}	3.68 ^{bc}	0.17
Mortality (%)	9.09 ^b	18.18 ^{ab}	24.24 ^a	18.18 ^{ab}	12.12 ^b	1.82
Feed cost/kg (₦)	721.99	677.81	663.23	678.37	634.75	-
Production cost (₦)	4,297.01	4,760.07	4,251.81	3,984.83	4,899.65	-
Gross profit (₦)	1,702.99	1,239.93	1,748.19	2,015.17	1,100.35	-

^{a,b,c} = Means with different superscript differ significantly ($p < 0.05$). YPM= Yam peel meal, TBNS= toasted bambara nut sievate and TBNS-YPMC= yam peel meal, toasted bambara nut sievate composite.

Table 4. Carcass traits of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite.

Parameters	Dietary replacement levels of maize with YPM, TBNS and their composite (%)					SEM
	0	20 YPM	20 TBNS	20 TBNS-YPMC	40 TBNS-YPMC	
Plucked weight (g/b)	1221.00 ^{bc}	1314.67 ^b	1572.67 ^a	1027.67 ^c	1267.67 ^b	53.46
Evisc. weight (g/b)	978.00 ^b	1034.67 ^b	1319.00 ^a	840.33 ^b	986.00 ^b	49.42
Carcass weight (g/b)	880.33 ^b	926.33 ^b	1197.00 ^a	749.00 ^b	875.33 ^b	46.13
Dressed %	60.05 ^{bc}	63.15 ^{ab}	67.69 ^a	62.46 ^{bc}	57.92 ^c	1.05
Cut parts expressed relative to the carcass weight						
D. stick	9.99	10.42	11.08	10.11	9.93	0.19
Thigh	9.04 ^b	9.10 ^b	10.27 ^a	9.27 ^b	8.86 ^b	0.17
Breast	17.88 ^b	18.75 ^b	21.83 ^a	18.67 ^b	16.59 ^b	0.56
Back	9.34 ^{ab}	9.31 ^{ab}	9.58 ^a	8.48 ^b	8.42 ^b	0.17
Wing	7.42 ^c	7.92 ^{abc}	8.11 ^{ab}	8.39 ^a	7.47 ^{bc}	0.12
Neck	4.79 ^c	5.73 ^a	5.05 ^{bc}	5.30 ^{ab}	5.07 ^{bc}	0.10
Shank	3.86	4.36	4.31	4.26	4.47	0.09
Head	2.83 ^{bc}	2.98 ^b	2.56 ^c	3.37 ^a	2.69 ^{bc}	0.08

^{a,b,c} = Means with different superscript differ significantly ($p < 0.05$). Evisc. = Eviscerated, D. stick = Drum stick, YPM= Yam peel meal, TBNS= toasted bambara nut sievate and TBNS-YPMC= yam peel meal, toasted bambara nut sievate composite.

TBNS replacing maize had the highest plucked (1,572.67 g/bird), eviscerated (1,319.00 g/bird) and carcass weight (1,197.00 g/bird), while birds fed a diet containing 20% TBNS-YPMC replacing maize had the least plucked weight of 1,027.67 g/bird.

However, birds fed other treatment diets recorded the least and similar eviscerated (840.33 g/bird) carcass weight (749.00 g/bird). Birds fed diets containing 20% YPM and TBNS separately as a replacement for maize had the highest and similar dressed percentage of 63.15%, while those fed a diet containing 40% TBNS-YPMC replacing maize had the least (57.92%) dressed percentage.

Relative thigh (10.27%) and breast (21.83%) weight were highest on birds fed a diet containing 20% TBNS

replacing maize, while those on other treatment groups had the least and similar thigh (8.86%) and breast (16.59%) values. Birds fed diets containing 0, 20% YPM and 20% TBNS replacing maize had the highest and similar relative back weight of 9.31%, while those on other treatment groups had the least and similar (8.42%) relative back weight. Wing relative weight was highest and similar (8.39%) for birds fed diets containing 20% YPM, TBN and TBNS-YPMC replacing maize, while those fed the control diet had the least relative wing weight of 7.42%. Birds fed diets containing 20% YPM and 20% TBNS-YPMC replacing maize had the highest and similar (5.73%) relative neck while birds fed the control diet had the least (4.79%) relative neck weight. Head relative weight was

Table 5. Internal organs of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite.

Parameters	Dietary replacement levels of maize with YPM, TBNS and their composite (%)					SEM
	0	20 YPM	20 TBNS	20 TBNS-YPMC	40 TBNS-YPMC	
Heart	0.75 ^a	0.77 ^a	0.68 ^{ab}	0.53 ^{ab}	0.49 ^b	0.04
Liver	2.29 ^b	2.94 ^a	2.41 ^{ab}	2.51 ^{ab}	2.33 ^{ab}	0.09
Empty gizzard	1.92 ^{ab}	2.40 ^a	2.12 ^{ab}	1.74 ^b	2.31 ^{ab}	0.10
Spleen	0.09	0.19	0.17	0.05	0.11	0.02
Lung	0.64	0.64	0.63	0.60	0.44	0.03
Abdominal fats	0.09 ^a	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.01
Crop	0.48	0.54	0.38	0.51	0.65	0.05
Proventriculus	0.72 ^{ab}	0.79 ^{ab}	0.49 ^b	0.63 ^{ab}	0.84 ^a	0.05
Pancreas	0.23 ^c	0.32 ^{ab}	0.34 ^a	0.28 ^{bc}	0.36 ^a	0.01
Full intestine	8.37 ^a	9.02 ^a	6.06 ^b	7.89 ^a	8.93 ^a	0.36
Kidney	0.80	0.88	0.87	0.82	0.78	0.03
Gall bladder	0.29	0.16	0.21	0.19	0.29	0.02

^{a, b, c} = Means with different superscript differ significantly ($p < 0.05$). YPM= Yam peel meal, TBNS= toasted bambara nut sievate and TBNS-YPMC= yam peel meal, toasted bambara nut sievate composite.

highest (3.37%) and lowest (2.56%) on bird fed diets containing 20% TBNS-YPMC and 20% TBNS replacing maize, respectively.

Internal organs of broiler chickens fed dietary replacement levels of maize with Yam Peel Meal, Toasted Bambara Nut Sievate and their composite

The results of the internal organ characteristics of broiler chickens fed dietary replacement levels of maize with yam peel meal (YPM), toasted bambara nut sievate (TBNS), and their composite (TBNS-YPMC) are presented in Table 5. The results showed that all internal organs considered in this study differed significantly ($p < 0.05$) except the spleen, lungs, crop, kidney and gall bladder. Birds fed all experimental diets had the highest and similar (0.77%) relative heart weight, except birds on the diet containing 40 TBNS-YPMC as replacement for maize, which recorded the least (0.49%) relative heart weight. Birds fed diets containing YPM, TBNS, and their composite had the highest and similar (2.94%) relative liver weight, while those fed the control diet recorded the least (2.29%) relative liver weight. Relative empty gizzard weight was highest and similar (2.40%) on birds fed all experimental diets except those fed the diet containing 20% TBNS-YPMC replacing maize, which recorded the least (1.74%) relative empty gizzard weight. Abdominal fat was highest in birds fed the control diet (0.09%), while all other treatments recorded 0.00%.

Relative proventriculus (0.79%) and full intestine (9.02%) weights were highest and similar on birds fed all experimental diets except those fed a diet containing 20% TBNS replacing maize, which recorded the least relative proventriculus (0.49%) and full intestine (6.06%) weight.

Birds fed diets containing YPM, TBNS, and 40% TBNS-YPMC had the highest and similar relative pancreas weight of 0.36%, while birds fed the control diet had the least (0.23%) relative pancreas weight.

DISCUSSION

Growth performance and cost benefit analysis of broiler chicks fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite

The high DFI for birds fed the diet containing 20% YPM and 40% TBNS-YPMC (111.02 g/bird) could be attributed to the elevated fibre and low energy density of the diet. This would most likely encourage the birds to consume more feed in a bid to acquire adequate daily energy. Similarly, the increased DFI in the birds that were given the 20% TBNS diet (88.81 g/bird) could be explained by the aromatic odour generated upon toasting, which could have enhanced palatability and led to increased feed intake (Table 3). Higher daily weight gains and final body weight of birds on diet containing 20% TBNS and 40% TBNS-YPMC could be attributed to the fact that these diets provided the basic nutrients required for nourishment of their body leading to tissue accretion which aligns with the findings of Udeh *et al.* (2018) who reported that inclusion of 10% toasted bambara nut offal in broiler chickens' diets enhanced optimum growth performance. Similarly, Oguntoye *et al.* (2018) observed significant ($p < 0.05$) influence on all growth parameters measured except FCR when broiler chickens were fed diets containing 0, 15 and 30% yam pee meal with or without enzymes as a replacement for maize which is in harmony with the findings of the present study.

Daily feed intake of broiler chickens in the present study is comparable with the range of values of 70.50 to 92.20 g when broiler chickens were fed diet containing bambara nut offal (BGO) as replacement for maize (0, 10, 15 and 20%) with or without enzyme supplementation (Oyeagu *et al.*, 2016). The FCR of broiler chickens is lower compared to the FCR of 4.07 to 5.12 of broiler chickens reported by Ekenyem and Onyeagoro (2006) when bambara nut sievate replaced soybean meal in the diets of finisher broiler chickens (Table 3). The reduction in cost per kg diet and improved gross profit are attributed to the low cost of procuring these agricultural by-products. Uza *et al.* (2024) reported a reduction in cost per kg diet and improved gross profit when noiler birds were fed dietary replacement levels of TBNS-YPMC supplemented with or without Lactic Dry[®], which is in line with the results of the present study. The findings also align with the earlier report by Amaefule *et al.* (2011), who observed lower values for cost per kg diet on rabbits fed diets containing BGO. Improved gross profit on birds fed diets containing YPM, TBNS and their composite observed in the study buttresses the report of Amaefule *et al.* (2011) who observed a reduction in feed cost due to inclusion of BGO that increased farmers' income and profit (Table 3).

Carcass traits of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite

The increased plucked weight, eviscerated weight, carcass weight, dressing percentage, the optimal nutrients necessary for growth thigh, breast, back, and wing relative weights in the birds on 20% TBNS replacement for maize reveal that TBNS supplemented provided the optimal nutrients necessary for growth and accretion of tissues in comparison to other treatment groups (Table 4). The aroma present with the consequent toasting of TBNS could have contributed to palatability and feed intake and is accountable for the enhancements observed here. This aligns with the results of Ugwu and Onyimonyi (2008), who observed that eviscerated weight in animals tends to be dictated by the nutrient quality of what they consume and, in turn, affects carcass characteristics. Plucked and carcass weights of birds in this study are comparatively lower than the values of 1.53 to 2.05 and 1.27 to 1.73 kg, respectively, for broiler finisher chicken reported by Udeh *et al.* (2018) when fed diets containing 10, 20 and 30% soybean hull and toasted bambara nut waste, respectively. Eviscerated weight of birds in the present study is comparable with values of 1.15 to 1.37 kg for spent layer fed diets containing 0, 5, 10, 15 and 20% bambara nut sievate reported by Ugwu and Onyimonyi (2008). Dressing percentage is a better indicator of total edible meat after the visceral organs, blood, and feathers have been plucked (Ugwu and Onyimonyi, 2008). The percentages of dressing witnessed in this study correlate fairly well with the results of 64.28 to

70.58% presented by Akinmutimi and Onen (2008) for broilers that were on diets supplemented with 0–15% yam peel meal as a substitute for maize (Table 4). In addition, Torhemen *et al.* (2020) obtained higher relative breast (22.52–24.88%), back (14.73–15.77%), and thigh (10.78–12.85%) weights in broiler chickens fed diets supplemented with 20% toasted and raw Bambara groundnut offal, which were a little higher than the respective figures obtained in this study. Similarly, they reported the relative weights for the drumstick, wing, neck, head, and shank as 10.30–12.57, 7.50–8.90, 4.04–4.48, 2.23–2.70 and 3.08–3.78%, respectively, and these results are varied from those in the present study (Table 4). Any variation in the present results and other researchers could be attributed to processing methods, a mixture of the test ingredient and environmental factors.

Internal organs of broiler chickens fed dietary replacement levels of maize with yam peel meal, toasted bambara nut sievate and their composite

There is a reduction in relative heart values of birds fed diet containing 40% TBNS-YPMC as replacement for maize in the present study which may be attributed to the presence of high levels of anti-nutritional factors in this diet which could have caused hypertrophy that could have hampered efficient exchange of oxygen and carbon dioxide via the pumping action of the blood between the body cells and the environment. Torhemen *et al.* (2020) also found smaller relative heart weights of 0.42 to 0.47%, which are in close agreement with the values of the current study. The liver is one of the organs responsible for detoxification of harmful substances. The rise in relative liver weights of birds fed diets containing TBNS, YPMC, and the blends could be an indication of the physiological response of the birds to the residual anti-nutritional factors in yam peel and Bambara nut sievate, despite the processing treatment administered. The increased liver weight could be a pointer to the increased metabolic burden on the organ to detoxify these compounds upon ingestion. The relative weights of the liver in this study are higher than the 1.65 to 1.84% stated by Torhemen *et al.* (2020) (Table 5). The relative weights of the empty gizzards in this study are in the range of 1.65 to 2.55% stated by Torhemen *et al.* (2020) for broiler chickens (Table 5), indicating a similar response to treatments. Abdominal fat reduction in birds receiving diets with test ingredients can be explained by these diets' lowered energy density due to increased consumption of fibre, most likely. Hence, dietary fibre and energy go hand in hand, although inversely to each other, the birds would have consumed lower amounts of low dietary energy, and therefore fat content was reduced. On the other hand, birds on the control diet with higher energy consumption likely absorbed more energy than required, which was then deposited as abdominal fat, resulting in higher fat values. Abdominal fat values in the present study are lower

than the 0.77 to 1.17% range provided by Torhemen *et al.* (2020) (Table 5). Increased relative pancreas weight observed in the birds fed test diets formulated using the test ingredients can be an adaptive response for enhanced production of enzymes to aid in digestion of nutrients contained in the non-starch polysaccharides of the dietary fibre ingredients. Torhemen *et al.* (2020) reported a relative pancreas weight range of 0.21 to 0.27%, which is in line with results obtained in this study (Table 5). Lastly, the lower relative weights of the proventriculus and entire intestine in birds fed with diets containing 20% TBNS may be due to the efficient action of digestive enzymes in breaking down the fibrous components of TBNS. This likely allowed for complete gastrointestinal evacuation within the 11-hour feed withdrawal period prior to slaughtering (Table 5).

Conclusions and Recommendations

Birds fed diets containing TBNS and 40% TBNS-YPMC recorded improved final body weight and lower cost per kg diet, while the highest gross profit was recorded on birds fed a diet containing 20% TBNS-YPMC. However, birds fed diets containing TBNS had improved plucked, eviscerated, carcass weight, dressed %, relative weight of thigh, breast, back and wing. Birds fed diets containing test ingredients had increased relative weight of liver, pancreas and reduced abdominal fats. It is recommended that poultry farmers may substitute maize in broiler chicken diets with 20% TBNS and 40% TBNS-YPMC to improve final body and carcass traits.

CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

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