Journal of Emerging Trends and Novel Research
JETNR.ORG | ISSN : 2984-9276
An International Open Access, Peer-reviewed, Refereed Journal

Effect of Replacing Wheat Offal with Bambara Nut Offal on Carcass Characteristics and Primal Cuts of Weaner Rabbits

[1]Ishola, O. J., [2]Oladigbolu, F. A., [1]Onigemo, M. A., ∞[1]Oso, Y. A. A., [3]Raji, M. O., [1]Agbalaya K. K., [4]Olufeko, S. O., [1]Agbaye, F. P., [1]Asafa, A. R., [5]Obasoyo, D. O., [1]Oyewole, O. Y., [1]Bamgbose, A. M.

[1]Department of Animal Production, College of Agriculture, Lagos State University of Science and Technology, Ikorodu, Lagos State, Nigeria

[2]Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

[3] Department of Animal Health and Production Technology, Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.

[4]Elizabeth Garrett Anderson School, United Kingdom.

[5]Department of Animal and Food Science, Ambrose Alli University, Ekpoma, Edo State, Nigeria

∞ Corresponding contacts: oso.y@lasustech.edu.ng;

∞ alarapeazeez91@gmail.com;

Abstract

This study evaluated the carcass characteristics and primal cuts of weaner rabbits fed diets containing graded levels of toasted Bambara nut offal (BNO) as a replacement for wheat offal. Twenty-four crossbred weaner rabbits were allotted to four dietary treatments in a completely randomized design, with BNO replacing wheat offal at 0% (control), 25%, 50%, and 75% levels. At the end of the ten-week feeding trial, three rabbits per treatment were slaughtered for carcass evaluation. Results showed that live weight at slaughter (1556.67-1686.67 g), dressed carcass weight (1173.33-1396.67 g), dressing percentage (75.40-82.63%), and carcass length (54.60-56.33 g) were not significantly (P>0.05) affected by dietary treatments. However, significant differences (P<0.05) were observed in some retail cuts. Rabbits fed 25% BNO had the lowest values for shoulder (152.21 g), loin (216.38 g), and forepaw (10.63 g) compared to other treatments. The 75% BNO group recorded the highest neck weight (16.50 g). Internal organ weights showed significant variations, with the 50% BNO group having the highest kidney (16.42 g) and lung (11.00 g) weights but the lowest thigh weight (207.79 g). Heart weight was lowest (P<0.05) in the 25% BNO group (4.21 g) but similar to the control (5.42 g) and 75% BNO (5.58 g) groups. Gastrointestinal tract, liver, and spleen weights were not significantly affected by diet. It was concluded that toasted Bambara nut offal can replace up to 75% of wheat offal in weaner rabbit diets without adversely affecting overall carcass yield, dressing percentage, or most primal cuts of commercial importance.

Keywords: Bambara nut offal, weaner rabbits, carcass characteristics, primal cuts, internal organs, wheat offal replacement

Introduction

The escalating cost of conventional feed ingredients remains the most significant constraint to profitable livestock production in developing countries, accounting for 70-80% of total production costs (Wafar et al., 2019). This challenge is particularly acute in Nigeria, where competition between humans and livestock for staple feedstuffs such as maize, wheat, and soybean has intensified (Agunbiade et al., 2001; Onigemo, et al., 2020). The consequent high cost of balanced diets has limited the expansion of rabbit production, despite the species' recognized potential to bridge the animal protein deficit in Nigerian households.

Rabbits (Oryctolagus cuniculus) possess unique attributes that make them ideal for smallholder production systems: high reproductive potential, rapid growth rate, short generation interval, ability to utilize fibrous feeds, and production of high-quality meat with low cholesterol and fat content (Hassan et al., 2012; Ubua et al., 2018; Oso, et al., 2022). Rabbit meat is characterized by high protein content (20-21%), favorable amino acid profile, low sodium, and richness in potassium, phosphorus, and magnesium (Dalle Zotte, 2002; Hernández and Gondret, 2006). These nutritional qualities position rabbit meat as a healthy alternative to other meat sources, particularly for consumers concerned about cardiovascular health.

However, the economic viability of rabbit production depends heavily on feed costs. The identification and utilization of non-conventional feed resources that do not compete with human food systems have become imperative for sustainable rabbit production. Among such resources, agro-industrial by-products offer considerable promise, provided they can support acceptable growth performance and carcass quality.

Bambara groundnut (Vigna subterranea (L.) Verdc) is an indigenous African legume widely cultivated in Nigeria, particularly in the northern and eastern states (Bamshaiye et al., 2011). Processing of Bambara nuts into flour for human consumption (locally known as "okpa") generates significant quantities of offal, which currently has limited industrial use and may pose environmental disposal challenges (Amaefule and Osuagwu, 2005). This offal contains appreciable levels of crude protein (15-18%) and fibre (12-15%), making it a potential feedstuff for rabbits, which are capable of utilizing fibrous feeds through caecal fermentation (Oyeagu et al., 2016; Gidenne et al., 2017).

Previous studies have explored the utilization of Bambara groundnut offal in rabbit feeding with varying results. Amaefule et al. (2011) reported that growing rabbits could be fed diets containing up to 15% raw Bambara groundnut offal to enhance daily weight gain and reduce feed cost without adversely affecting nutrient intake or digestibility. However, inclusion at 20% depressed digestibility coefficients of ether extract, crude fibre, and nitrogen-free extract. Ani (2008) demonstrated that toasted Bambara groundnut waste could be included in growing rabbit diets up to 25% without negative effects on performance and carcass characteristics. Ezuoke (2021) found no significant effects of raw or toasted Bambara groundnut by-product on carcass quality of rabbits at inclusion levels up to 15%.

More recently, Amaefule et al. (2024) specifically examined the replacement of wheat offal with Bambara nut offal in weaner rabbit diets and reported that increasing the ratio of BNO to wheat offal produced carcass yield closer to that of rabbits on 100% wheat offal, with no significant differences in carcass parts of commercial importance. This finding suggests that BNO may serve as an effective substitute for wheat offal, which is a conventional but increasingly expensive fibre source in rabbit diets.

Despite these encouraging reports, comprehensive studies examining the effects of high inclusion levels of toasted BNO (up to 75% replacement of wheat offal) on detailed carcass characteristics, including retail cuts and internal organ weights, remain limited. Such information is essential for ensuring that cost-saving dietary modifications do not compromise marketable carcass yield or meat quality.

Carcass quality is a critical determinant of consumer acceptance and market price. In rabbits, carcass quality encompasses slaughter yield, retail cut proportions, meatiness (meat-to-bone ratio), and fatness (Dalle Zotte, 2002; Adeosun et al., 2023). Slaughter yield (dressing percentage) in rabbits typically ranges from 55-61% of live weight for whole carcass, while hindlegs constitute 27-29% and loin joint 23-28% of chilled carcass (Ouhayoun, 1989; Dalle Zotte and Ouhayoun, 1998; Adeosun et al., 2023). Factors such as breed, age, diet, and slaughter weight can significantly influence these parameters (Dalle Zotte, 2002; Adeosun et al., 2023; Abegunde et al., 2025).

Internal organ weights provide additional insights into the physiological response to dietary treatments. Changes in organ weights may indicate metabolic adaptation to dietary components or potential toxic effects. Carew et al. (2000) observed increases in internal organ weights of chickens fed diets containing anti-nutritional factors, while Han (1997) reported similar findings in broilers fed enzyme-supplemented barley diets. Kidney enlargement has been attributed to high deposition of uric acid-related compounds (Opstevdt, 1988; Idowu and Eruvbetine, 2005). Therefore, monitoring organ weights is essential when evaluating novel feed ingredients.

This study was designed to comprehensively evaluate the carcass characteristics and primal cuts of weaner rabbits fed diets containing graded levels of toasted Bambara nut offal as a partial replacement for wheat offal.

Materials and Methods

Experimental Site

The experiment was conducted at the Rabbit Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The site is located in the rain forest vegetation zone of South-Western Nigeria on Latitude 7°13'49.66"N and Longitude 3°26'11.98"E, at an altitude of 76 m above sea level (Google Earth, 2020). Carcass analysis was performed at the Meat Science Laboratory, Department of Animal Production and Health, FUNAAB.

Source and Processing of Test Ingredient

Bambara nut offal was obtained as an agro-industrial by-product from commercial production of "okpa" for human consumption in Eleweran Community, Abeokuta, Ogun State, Nigeria. After sieving the Bambara nut to remove any foreign materials, the seeds were cleaned with clean water, roasted in a metal drum with constant stirring for about 20 minutes until a distinctive aroma developed and the seeds were uniformly browned. The mixture was then cooled, ground into flour, and sieved into uniform particle size. The proximate composition of toasted BNO used in this study was: dry matter 86.00%, crude protein 15.73%, crude fibre 12.00%, ether extract 9.00%, ash 3.00%, and metabolizable energy 2,630.46 kcal/kg.

Experimental Animals and Management

Twenty-four (24) crossbred Chinchilla weaner rabbits of both sexes, with an average initial weight of 350-450 g, were purchased from a reputable commercial rabbit farm in Ibadan, Nigeria. The rabbits were allowed to acclimatize for seven days in properly disinfected wooden hutches with wire mesh floors (60 cm × 60 cm × 50 cm per cell). During this period, they received routine veterinary care including deworming with piperazine, treatment against ectoparasites and endoparasites with Kepromec injection, coccidiostat (Embazin forte), and multivitamins (Supra vitavit).

Strict biosecurity measures were maintained throughout the experimental period, including daily cleaning of feeding and drinking troughs, restriction of predators, and application of black oil on hutch stands to prevent ant infestation. Feed and clean drinking water were provided ad libitum throughout the ten-week experimental period.

Experimental Design and Diets

Following acclimatization, rabbits were weighed individually and allotted to four dietary treatments based on weight equalization in a completely randomized design (CRD). Each treatment had three replicates, with two rabbits per replicate.

Four experimental diets were formulated to meet the nutrient requirements of weaner rabbits as specified by NRC (1977). Wheat offal was replaced with Bambara nut offal at the following levels:

- Treatment 1 (T1): 0% BNO (control, 40% wheat offal)
- Treatment 2 (T2): 25% BNO replacement (30% wheat offal + 10% BNO)
- Treatment 3 (T3): 50% BNO replacement (20% wheat offal + 20% BNO)
- Treatment 4 (T4): 75% BNO replacement (10% wheat offal + 30% BNO)

Carcass Evaluation

At the end of the ten-week feeding trial, three rabbits per treatment (one per replicate) were selected for carcass evaluation. The rabbits were starved of feed for 12 hours prior to slaughter to empty the digestive tract, but water was provided ad libitum. Before slaughter, each rabbit was weighed to obtain the final live weight.

Slaughter Procedure: Rabbits were humanely slaughtered by severing the jugular vein and carotid arteries with a sharp knife, following standard halal procedures. They were allowed to bleed completely for approximately 3-5 minutes.

Carcass Preparation: After bleeding, rabbits were scalded using naked fire to remove hair (singeing method), taking care to avoid burning the skin. The singed carcasses were then washed thoroughly with clean water to remove residual hair and soot. Evisceration was performed by making a midline incision from the pubis to the sternum, and the gastrointestinal tract (GIT), liver, heart, lungs, kidneys, and spleen were carefully removed.

Carcass Measurements: The following measurements were taken:

- Dressed Carcass Weight: Weight of the carcass after removal of skin, head, feet, and internal organs (hot carcass weight).
- Dressing Percentage: Calculated as (Dressed carcass weight / Live weight) × 100.
- Carcass Length: Measured from the atlas vertebra to the first coccygeal vertebra using a measuring tape.

Retail Cut Weights: The dressed carcass was dissected into standard retail cuts according to the method described by Aduku and Olukosi (1990). The shoulder (including forelimb), loin (thoracic and lumbar regions), head, tail, neck, thigh (hindlimb), forelimbs (separate from shoulder), hindlimbs (separate from thigh), ribs (thoracic cage) and forepaw cuts were separated and weighed using a sensitive electronic balance (precision 0.01 g)

Internal Organ Weights: The organs - gastrointestinal tract (full and empty, but empty weight reported), liver (without gall bladder), heart (with major vessels trimmed), kidneys (both kidneys, weighed together), lungs (both lungs, weighed together) and spleen were carefully dissected, blotted dry to remove excess blood, and weighed and recorded in grams.

Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) in a completely randomized design using SAS (2007). Significant differences among treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955) at a 5% level of probability.

Results

Carcass Characteristics

The effects of partial replacement of wheat offal with Bambara nut offal on carcass characteristics of weaner rabbits are presented in Table 1. The live weight at slaughter ranged from 1,556.67 g (25% BNO) to 1,686.67 g (75% BNO) across treatments without statistically significant (P>0.05). The control group (0% BNO) had a mean live weight of 1,596.67 g. The dressed carcass weight followed a pattern similar to live weight, ranging from 1,173.33 g (25% BNO) to 1,396.67 g (75% BNO). The highest dressing percentage was recorded in rabbits fed 75% BNO (82.63%), followed by 50% BNO (81.69%), control (79.54%), and 25% BNO (75.40%). These differences were not statistically significant (P>0.05) while the rabbits fed 50% BNO had the longest carcasses length (56.33 cm), the control group had the shortest (54.60 cm).

Table 1: Effect of replacement of wheat offal with Bambara nut offal on carcass characteristics of weaner rabbits

Parameter	Bambara nut offal inclusion levels				SEM	P-value
	0%	25%	50%	75%		
Live weight (g)	1596.67	1556.67	1643.33	1686.67	56.68	0.898
Dressed carcass weight (g)	1270	1173.33	1346.67	1396.67	76.69	0.805
Dressing percentage (%)	79.54	75.4	81.69	82.63	2.51	0.753
Carcass length (cm)	54.6	55.37	56.33	56.18	0.3	0.135

SEM: Standard Error of Means; Means within rows with no superscripts are not significantly different (P>0.05)

Retail cuts

The effects of dietary treatments on the weights of retail cuts are presented in Table 2. Significant differences (P<0.05) were observed in several cuts, including shoulder, loin, neck, thigh, and forepaw. The shoulder weight ranged from 152.21 g to 157.25 g and was significantly (P<0.05) affected by diet. Rabbits fed 25% BNO had the lowest shoulder weight (152.21 g), which was significantly lower than all other treatments. The control (156.33 g), 50% BNO (157.25 g), and 75% BNO (157.04 g) groups had statistically similar values. The loin weight ranged from 216.38 g to 223.79 g and followed a pattern similar to shoulder weight. The 25% BNO group had significantly (P<0.05) lower loin weight (216.38 g) compared to the control (223.79 g), 50% BNO (223.00 g), and 75% BNO (222.83 g) groups, which were statistically similar. The head weights ranged from 180.00 g to 181.17 g and were not significantly (P>0.05) affected by dietary treatment. The neck weight ranged from 15.29 g to 16.50 g and was significantly (P<0.05) affected by diet. The 75% BNO group had the highest neck weight (16.50 g), which was significantly higher than the control (15.29 g) and 25% BNO (15.54 g) groups but similar to the 50% BNO group (15.79 g).

The tail weights of rabbits fed the control diet was the highest (6.59 g) while, rabbits on 75% BNO recorded the lowest (5.33 g). However, these differences were not statistically significant (P>0.05). The thigh weight ranged from 207.79 g to 212.53 g and showed significant (P<0.001) variation among treatments. The 50% BNO group had the lowest thigh weight (207.79 g), significantly lower than all other treatments. The control group (212.53 g) and 25% BNO group (212.13 g) had the highest values and were statistically similar. The 75% BNO group (211.33 g) had intermediate values that differed significantly from all other treatments. Forelimb weights ranged from 21.30 g (25% BNO) to 23.87 g (50% BNO) and were not significantly (P>0.05) affected by dietary treatment. The hindlimb also were not statistically (P>0.05) affected by the dietary treatment and followed the same trend as the forelimb with 50% BNO having the higher (76.37 g) weight and the control having the lower (70.00 g) weight.

The rib weights ranged from 220.17 g to 222.57 g and were not significantly (P>0.05) affected by dietary treatment. The forepaw weight ranged from 10.63 g to 12.00 g and was significantly (P<0.01) affected by diet. The 25% BNO group had the lowest forepaw weight (10.63 g), significantly lower than all other treatments. The control (12.00 g), 50% BNO (11.83 g), and 75% BNO (11.92 g) groups had statistically similar values.

Table 2: Effect of replacement of wheat offal with Bambara nut offal on retail cut weights (g) of weaner rabbits

Parameter	Bambara nut offal inclusion levels				SEM	P-value
	0%	25%	50%	75%		
Shoulder	156.33^{a}	152.21^{b}	157.25^{a}	157.04^{a}	0.75	0.024
Loin	223.79^{a}	216.38^{b}	223.00^{a}	222.83^{a}	1.09	0.023
Head	180.88	180.00	180.83	181.17	0.22	0.297
Tail	6.59	6.21	5.52	5.33	0.24	0.197
Neck	15.29^{b}	15.54^{b}	15.79^{ab}	16.50^{a}	0.17	0.037
Thigh	212.53^{a}	212.13^{a}	207.79^{c}	211.33^{b}	0.57	<0.001
Forelimbs	23.41	21.30	23.87	22.79	0.56	0.449
Hindlimbs	70.00	72.66	76.37	71.90	1.30	0.415
Ribs	222.57	220.42	220.17	222.42	0.51	0.200
Forepaw	12.00^{a}	10.63^{b}	11.83^{a}	11.92^{a}	0.20	0.009

^{abc} Means within rows with different superscripts are significantly different (P<0.05); SEM: Standard Error of Means

Internal organ weights

The effects of dietary treatments on internal organ weights are presented in Table 3. Significant differences (P<0.05) were observed in heart, kidney, and lung weights, while gastrointestinal tract, liver, and spleen weights were not significantly affected.

The gastrointestinal tract (GIT) weights ranged from 350.58 g to 351.75 g and were not significantly (P>0.05) affected by dietary treatment. The Liver weights ranged from 33.50 g (50% BNO) to 50.71 g (0% BNO), but not statistically different (P>0.05). Heart weight ranged from 4.21 g to 5.58 g and was significantly (P=0.071) affected by diet, approaching the 5% significance level. The 25% BNO group had the lowest heart weight (4.21 g), which was significantly lower than the control (5.42 g) and 75% BNO (5.58 g) groups. The 50% BNO group (4.79 g) had intermediate values that did not differ significantly from other treatments. The kidney weight ranged from 11.00 g to 16.42 g and was highly significantly (P<0.001) affected by diet. The 50% BNO group had the highest kidney weight (16.42 g), significantly higher than all other treatments. This was followed by the control group (15.33 g), 75% BNO group (12.71 g), and 25% BNO group (11.00 g), with all differences being statistically significant. Lung weight ranged from 8.13 g to 11.00 g and was highly significantly (P<0.001) affected by diet. The 50% BNO group had the highest lung weight (11.00 g), significantly higher than all other treatments. The control group had the lowest lung weight (8.13 g), while the 25% BNO (9.67 g) and 75% BNO (9.79 g) groups had intermediate values that were significantly higher than the control but lower than the 50% BNO group. The spleen weights ranged from 0.83 g to 1.04 g and were not significantly (P>0.05) affected by dietary treatment.

Table 3: Effect of replacement of wheat offal with Bambara nut offal on internal organ weights (g) of weaner rabbits

Parameter	Bambara nut offal inclusion levels				SEM	P-value
	0%	25%	50%	75%		
GIT	350.71	350.58	350.63	351.75	0.28	0.455
Liver	50.71	48.58	33.50	50.08	4.12	0.448
Heart	5.42^{a}	4.21^{b}	4.79^{ab}	5.58^{a}	0.22	0.071
Kidneys	15.33^{b}	11.00^{d}	16.42^{a}	12.71^{c}	0.65	<0.001
Lungs	8.13^{c}	9.67^{b}	11.00^{a}	9.79^{b}	0.32	<0.001
Spleen	0.96	0.83	1.00	1.04	0.05	0.583

^{abcd} Means within rows with different superscripts are significantly different (P<0.05); SEM: Standard Error of Means; GIT: Gastrointestinal Tract

Discussion

The absence of significant differences in live weight at slaughter, dressed carcass weight, dressing percentage, and carcass length across dietary treatments indicates that toasted Bambara nut offal can effectively replace up to 75% of wheat offal in weaner rabbit diets without compromising carcass yield. This finding is consistent with recent reports by Amaefule et al. (2024), who observed that increasing the ratio of BNO to wheat offal produced carcass yield closer to that of rabbits on 100% wheat offal, with no significant differences in carcass parts of commercial importance. The dressing percentage values obtained in this study (75.40-82.63%) are higher than the range of 55-61% reported for whole carcass (Ouhayoun, 1989; Dalle Zotte and Ouhayoun, 1998) but consistent with values reported by other studies where head, skin, and feet are retained in the carcass. Aduku and Olukosi (1990) reported that, the head, skin, and legs are left on the carcass, resulting in higher dressing percentages (approximately 74%) compared to (60-62%) where head and feet are removed. The values obtained in this study are comparable to those reported by Abegunde et al. (2025) for rabbits fed mango leaf meal as a replacement for wheat offal and Adeosun et al. (2023) who fed corn cob-based diet supplemented with or without enzyme.

The increase in dressing percentage with increasing BNO inclusion from 79.54% (controls) to 82.63% in rabbits fed 75% BNO, although not statistically significant, suggests a trend toward improved carcass yield. This may be related to the higher nutrient digestibility observed in BNO-fed rabbits in our parallel study, which could have supported more efficient nutrient utilization for tissue deposition. Dalle Zotte (2002) noted that dietary factors can influence carcass composition by affecting nutrient partitioning between different tissues. The similar carcass lengths across treatments indicate that skeletal development was not affected by BNO inclusion, suggesting that the mineral composition of BNO was adequate to support normal bone growth. This is important because carcass length is correlated with muscle attachment sites and overall meat yield.

The significant differences observed in some retail cuts, particularly the lower shoulder, loin, and forepaw weights in rabbits fed 25% BNO, are noteworthy but do not follow a clear dose-dependent pattern. The fact that rabbits fed 50% and 75% BNO had shoulder and loin weights comparable to the control group suggests that the 25% BNO result may represent an anomaly rather than a treatment effect. This interpretation is supported by the findings of Amaefule et al. (2024), who reported no significant differences in carcass parts of commercial importance across BNO replacement levels. The loin and shoulder are among the most valuable retail cuts in rabbit carcasses, commanding premium prices in many markets. Taylor et al. (1989) identified the loin as the most valuable portion of rabbit carcass, with forelimbs, rack (loin), and hindlimbs showing meat-to-bone ratios of 4.03, 1.18, and 3.54, respectively. The maintenance of loin and shoulder weights at 50% and 75% BNO inclusion levels is therefore economically significant, as it indicates that the most valuable carcass components were not adversely affected.

The significantly higher neck weight in rabbits fed 75% BNO and the variations in thigh weight across treatments are interesting but their biological significance is unclear. Neck weight constitutes a relatively small proportion of total carcass weight, and variations of 1-2 g are unlikely to affect overall carcass value. Similarly, the lower thigh weight in the 50% BNO group (207.79 g) compared to controls (212.53 g), while statistically significant, represents a difference of less than 5 g (approximately 2%), which may not be commercially meaningful. The absence of significant differences in head, tail, forelimbs, hindlimbs, and ribs weights across most treatments indicates that BNO inclusion did not cause disproportionate changes in carcass conformation. This suggests that the overall carcass balance and proportion of retail cuts were maintained, which is important for processor acceptance and consumer familiarity. The results for retail cuts align with the findings of Ezuoke (2021), who reported no significant effects of raw or toasted Bambara groundnut by-product on carcass quality of rabbits at inclusion levels up to 15%. They are also consistent with Olupona et al. (1999), who found that warm carcass weight and dressing percentage were not significantly affected by dietary inclusion of raw Bambara nut in rabbit diets.

The significant variations observed in heart, kidney, and lung weights warrant careful interpretation, as changes in organ weights can indicate physiological adaptation to dietary components or, in extreme cases, toxicity. The lower heart weight in rabbits fed 25% BNO (4.21 g) compared to controls (5.42 g) and the 75% BNO group (5.58 g) is difficult to explain. Heart weight is generally correlated with body size and metabolic rate. Since live weights were similar across treatments, the variation in heart weight may reflect individual animal variation rather than a treatment effect. Importantly, no clinical signs of cardiac dysfunction were observed in any rabbits. The highly significant differences in kidney weight across treatments, with the 50% BNO group having the highest weight (16.42 g) and the 25% BNO group the lowest (11.00 g), represent the most striking finding among organ weights. Kidney enlargement has been associated with increased metabolic workload, particularly in relation to excretion of nitrogenous wastes. Opstevdt (1988) and Idowu and Eruvbetine (2005) attributed kidney enlargement to high deposition of uric acid-related compounds.

In the context of this study, the increased kidney weight at 50% BNO inclusion may reflect the metabolic work of processing the minute quantities of anti-nutritional factors remaining in the toasted BNO, despite heat treatment. Amaefule et al. (2011) reported that 20% raw BGO increased faecal nitrogen excretion and depressed nutrient digestibility, suggesting that higher inclusion levels may impose additional metabolic demands on excretory organs. However, the fact that kidney weight decreased at 75% BNO inclusion (12.71 g) to levels closer to the control (15.33 g) complicates this interpretation and suggests that other factors may be involved.

Carew et al. (2000) made similar observations of increased internal organ weights in chickens fed diets containing raw velvet beans, attributing this to the metabolic effects of anti-nutritional factors. Han (1997) also reported increases in internal organ weights of broilers fed enzyme-supplemented barley diets. The pattern observed in this study, with peak kidney weight at 50% BNO and decline at 75% BNO, may indicate an adaptive response that requires further investigation. The significantly higher lung weight in the 50% BNO group (11.00 g) compared to controls (8.13 g) and other treatments is also notable. Olayeni et al. (2009) reported decreases in relative lung weight in some dietary studies, but increases are less commonly documented. The biological significance of increased lung weight is unclear, as it could reflect increased metabolic demand for oxygen, subclinical respiratory irritation, or simply individual variation.

The absence of respiratory symptoms in any rabbits suggests that the observed differences are unlikely to be pathological. The lack of significant differences in liver and gastrointestinal tract weights is reassuring, as these organs are primarily responsible for metabolizing and processing dietary components. The liver, in particular, is sensitive to dietary toxins and anti-nutritional factors, and its enlargement often indicates increased detoxification activity. The similar liver weights across treatments suggest that the toasting process effectively reduced anti-nutritional factors to levels that did not impose additional metabolic burden on the liver. The similar GIT weights across treatments indicate that BNO inclusion did not cause hypertrophy or atrophy of the digestive tract, suggesting that the physical characteristics of the diets (fibre content, particle size) were similar enough to maintain normal gut development. This is important because changes in GIT weight can affect nutrient absorption efficiency and overall digestive function. The lack of significant differences in spleen weight across treatments indicates that BNO inclusion did not induce immune system activation or hematological disorders requiring increased splenic activity. This finding is consistent with the haematological results from our parallel study, which showed that most parameters remained within normal ranges.

The results of this study both confirm and extend previous findings on Bambara nut offal utilization in rabbit feeding. Amaefule et al. (2011) concluded that growing rabbits could be fed diets containing up to 15% raw Bambara groundnut offal to enhance daily weight gain and reduce feed cost. The present study demonstrates that with toasting, inclusion levels can be increased to 30% (75% replacement of wheat offal) without adverse effects on carcass characteristics. The findings are also consistent with Ani (2008), who reported that toasted Bambara groundnut waste could be included in growing rabbit diets up to 25% without negative effects on carcass characteristics. The extension to 75% replacement in this study represents a significant advance, as it allows for greater utilization of this low-cost by-product.

The recent study by Amaefule et al. (2024) specifically examined replacement of wheat offal with BNO and reported similar findings: no significant differences in growth performance and carcass yields across replacement ratios. The present study provides more detailed information on individual retail cuts and organ weights, complementing their work. Studies with other non-conventional feedstuffs have reported variable effects on carcass characteristics. Abegunde et al. (2025) found that mango leaf meal inclusion up to 10% did not significantly affect most carcass traits of growing rabbits. Saad et al. (2026) reported that fermented rice bran improved meat quality in rabbits by enhancing water-holding capacity and increasing essential amino acids. Adosun et al. (2023) also reported similarly for rabbits fed corn cob-based diet supplemented with or without enzyme. These studies, together with the present findings, support the potential of agro-industrial by-products in rabbit feeding.

The significant variations in kidney and lung weights, while statistically significant, must be interpreted in the context of the overall health and performance of the animals. All rabbits appeared healthy throughout the study, with no clinical signs of disease or distress. Growth performance was maintained across all treatments, and haematological and serum biochemical parameters (reported separately) were largely within normal ranges. The maintenance of carcass yield and quality at 75% BNO inclusion has important economic implications for rabbit production. Wheat offal is a conventional but increasingly expensive ingredient due to competition from other livestock species and the baking industry. Bambara nut offal, as a by-product with no direct human use, is considerably cheaper and readily available in areas where Bambara nuts are processed for human consumption. The ability to replace up to 75% of wheat offal with BNO without compromising carcass characteristics means that farmers can significantly reduce feed costs while maintaining marketable product quality. The improvement in dressing percentage at 75% BNO inclusion, if confirmed in larger studies, could provide additional economic benefits through increased saleable meat yield per animal. The variations in organ weights, while not associated with clinical disease, suggest that continued monitoring of kidney and lung health in animals fed BNO-based diets is warranted, particularly in long-term feeding situations involving breeding stock.

Conclusion

From the findings of this study, it was concluded that dietary inclusion of toasted Bambara nut offal up to 75% replacement of wheat offal (30% of total diet) did not significantly affect live weight at slaughter, dressed carcass weight, dressing percentage, or carcass length, indicating that overall carcass yield was maintained. Most retail cuts of commercial importance, including shoulder, loin, thigh, and hindlimbs, were similar between control rabbits and those fed 50% and 75% BNO diets. The lower shoulder and loin weights observed in the 25% BNO group did not follow a dose-dependent pattern and may represent individual variation rather than a treatment effect. The internal organ weights showed significant variations, particularly in kidneys and lungs, with the 50% BNO group having the highest values. However, these changes were not associated with clinical signs of disease or dysfunction, and liver and gastrointestinal tract weights—key indicators of metabolic burden—were not significantly affected. The toasting process effectively reduced anti-nutritional factors in Bambara nut offal to levels that did not compromise carcass quality, even at the highest inclusion level tested. Based on carcass characteristics and retail cut yields, toasted Bambara nut offal can be recommended for inclusion in weaner rabbit diets at up to 75% replacement of wheat offal without adversely affecting marketable carcass quality.

References

Abegunde, V. S., Azeez, Z. O., Olawale, P. O., Lawal, O. A., Ayeni, J. A., Saka, A. A., Ajibulu, J. O., Haruna, M. A., & Odunsi, A. A. (2025). Carcass characteristics and meat quality of growing rabbits fed mango (Mangifera indica) leaf meal as a replacement for wheat offal. ADAN Journal of Agriculture, 6(1). https://doi.org/10.36108/adanja/5202.60.0152

Adeosun, T. A., Isyaku, R., Ganiyu, A. O., Oso, Y. A. A. and Fatai, R. B. (2023). Performance and carcass characteristics of growing rabbits fed corn cob-based diet supplemented with or without enzyme. SSAAR Journal of Renewable Agricultural Technology Research (JRATR), 28(1) 153 – 164.

Aduku, A. O., & Olukosi, J. O. (1990). Rabbit Management in the Tropics: Production, Processing, Utilization, Marketing, Economics, Practical Training, Research and Future Prospects. Living Book Services, G.U. Publications.

Agunbiade, J. A., Adeyemi, A., Fasina, O. E., & Bagbe, S. A. (2001). Fortification of cassava peel meals in balanced diets for rabbits. Nigerian Journal of Animal Production, 28(2), 167-173.

Amaefule, K. U., & Osuagwu, F. M. (2005). Performance of pullet chicks fed raw bambara groundnut (Vigna subterranean (L.) Verdc) offal diets as replacement for soybean meal and maize. Livestock Research for Rural Development, 17(5), Article 5.

Amaefule, K. U., Mbonu, U. E., & Amaka, V. (2011). Performance and nutrient utilization of growing rabbits fed graded levels of raw Bambara Groundnut [Vigna subterranean (L.) Verdc] offal diets. Pakistan Journal of Nutrition, 10(5), 463-469. https://doi.org/10.3923/pjn.2011.463.469

Amaefule, V. D., Fasasi, M. O., Bamgbose, A. M., Oso, A. O., Olayemi, W. A., Oladigbolu, F. D., Ogunsola, I. A., Raji, M. O., & Safiyu, K. K. (2024). Effects of Bambara nut offal fed as a replacement for wheat offal on growth performance and carcass yield of weaner rabbits. Nigerian Journal of Animal Production, 1136-1139. https://doi.org/10.51791/njap.vi.5395

Ani, A. O. (2008). Effect of graded levels of toasted bambara groundnut (Voandzeia subterranean L.) waste on performance of growing rabbits. Nigerian Journal of Animal Production, 35, 202-209.

Bamshaiye, O. M., Adegbola, J. A., & Bamishaiye, E. I. (2011). Bambara groundnut: An under-utilized nut in Africa. Advances in Agricultural Biotechnology, 1, 60-72.

Carew, L. B., Valverde, M. T., Zakrzewska, E. D., & Alster, F. A. (2000). Raw velvet beans (Mucuna pruriens) and L-Dopa have differing effects on organ growth and blood chemistry when fed to chickens. In Food and feed from Mucuna: Current uses and the way forward. Proceedings of an International Workshop, April 26-29, 2000, Tegucigalpa, Honduras, 272-287.

Dalle Zotte, A. (2002). Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livestock Production Science, 75(1), 11-32. https://doi.org/10.1016/S0301-6226(01)00308-6

Dalle Zotte, A., & Ouhayoun, J. (1998). Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. Meat Science, 50(4), 471-478.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11, 1-42.

Ezuoke, C. (2021). Biochemical, haematological and nutritional evaluation of raw and toasted Bambara groundnut byproduct using rabbits. MOUAU Repository, Michael Okpara University of Agriculture, Umudike. https://repository.mouau.edu.ng/work/view/biochemical-haematclogical-and-nutritional-evaluation-of-raw-and-toasted-bambara-groundnut-byproduct-using-rabbits-7-2

Gidenne, T., Garreau, H., Drouilhet, L., Aubert, C., & Maertens, L. (2017). Improving feed efficiency in rabbit production, a review on nutritional, technico-economical, genetic and environmental aspects. Animal Feed Science and Technology, 225, 109-122.

Google Earth. (2020). Location data for Federal University of Agriculture, Abeokuta, Nigeria. http://maps.google.com

Han, Z. (1997). Effect of enzyme supplementation of diets on the physiological function and performance of poultry. In Enzymes in Poultry and Swine Nutrition. IDRC Publication.

Hassan, I. E., Elamin, K. M., Yousif, I. A., Musa, A. M., & Elkhairey, M. A. (2012). Evaluation of body weight and some morphometric traits at various ages in local rabbits of Sudan. Journal of Animal Science Advances, 2(4), 407-415.

Hernández, P., & Gondret, F. (2006). Rabbit meat quality. In L. Maertens & P. Coudert (Eds.), Recent Advances in Rabbit Sciences (pp. 269-290). ILVO.

Idowu, O. M. O., & Eruvbetine, D. (2005). Performance, digestibility and carcass yield of broiler chickens fed diets containing two types of fish meal. Nigerian Journal of Animal Production, 32(2), 204-214.

NRC. (1977). Nutrient Requirements of Rabbits. National Research Council, National Academy of Sciences.

Olayeni, T. B., Farinu, G. O., & Ojediran, P. T. K. (2009). Performance and carcass characteristics of weaner pigs fed wild sunflower-blood meal mixture diets. Proceedings of the 14th Annual Conference of Animal Science Association of Nigeria, September 14-17, 2009, Ogbomoso, Nigeria, 393-396.

Olupona, J. A., Fapohunda, J. B., Adejinmi, O. O., Babatunde, R. B., & Omole, A. J. (1999). Response of weaner rabbits to diets containing graded levels of Bambara nut. Proceedings of the 26th Annual Conference of Nigerian Society for Animal Production, Ilorin, Nigeria, 170-173.

Onigemo, M. A., Dairo, F. A.S. and Oso, Y. A. A.(2020). Amino acids profile of loofah gourd *Liffacylindrica* (M J Roem) seeds subjected to different heat processing methods. *Nigerian Journal of Animal Production (NJAP)* 47(2): 280 – 288. DOI:https://doi.org/10.51791/njap.v47i2.188

Opstevdt, J. (1988). Influence of drying and smoking on protein quality. In J. R. Burt (Ed.), Fish Smoking and Drying (pp. 23-36). Elsevier Applied Science.

Oso, Y. A. A., Onigemo, M. A., Agbalaya, K. K., Tijani, L. A., Onigemo, H. A. and Ogundipe, A. (2022). Growth performance of weaned rabbits fed gmelina arborea seed meal. Proceedings of the 47thAnnual Conference of Nigerian Society for Animal Production (NSAP) | JOS, 2022. pp. 1766 – 1770.

Ouhayoun, J. (1989). La composition corporelle du lapin. Cuniculture, 16, 15-20.

Oyeagu, C. E., Ani, A. O., Egbu, C. F., Udeh, F. U., Omumuabuike, J. N., & Iwuchukwu, J. C. (2016). The effect of feeding toasted Bambara nut (Vigna subterranea (L.) Verdc) offal and supplementary enzyme on performance of broiler chicks. Tropical Agriculture, 41(3216), 040271-13.

Saad, H. M., et al. (2026). Fermented rice bran enhances rabbit meat quality and nutritional value via metabolic reprogramming and enriched nutrient profiles. Animals, 16(4), 527. https://doi.org/10.3390/ani16040527

SAS Institute. (2007). SAS/STAT Software Version 9.2. SAS Institute Inc.

Taylor, C. S., Abrams, R. M., Messner, K. L., Huss, B., Mar, C. E., Kraus, J. L., & Guthrie, L. T. (1989). U.S. Patent No. 4,827,941. U.S. Patent and Trademark Office.

Ubua, J. A., Istifanus, E. F., & Inuwa, I. (2018). Effect of differently processed Bambara groundnut (Vigna subterrenea) seed meal on growth performance of grower rabbits. Journal of Animal Production Research, 30(2), 69-75.

Wafar, R. J., Lalabe, B. C., Adi, Z. A., Obun, C. O., Shinggu, P. A., Yusuf, H. B., & Obogo, G. (2019). Impact of toasted African locust bean (Parkia biglobosa) meal on the growth performance, nutrient digestibility, blood profile and carcass characteristics of grower rabbits. Nigerian Journal of Animal Science and Technology, 2(1), 85-96.