



# Economic Analysis of Using Bambara Nut Offal as a Cost-Effective Feed Ingredient in Weaner Rabbit Production

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## Abstract

## Original Research Article

This study evaluated the cost-benefit implications of replacing wheat offal with toasted Bambara nut offal (BNO) in the diets of weaner rabbits. 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, data on feed intake, weight gain, and prevailing market prices of feed ingredients were used to compute economic indices including feed cost per kilogram diet, total feed cost per rabbit, cost per kilogram weight gain, and cost savings. Results showed that feed consumed (4.03-4.23 kg) was not significantly ( $P>0.05$ ) affected by dietary treatment. However, feed cost per kilogram diet decreased progressively and significantly ( $P<0.05$ ) with increasing BNO inclusion, from ₦131.47 in the control diet to ₦105.15 in the 75% BNO diet. Similarly, total feed cost per rabbit was significantly ( $P<0.05$ ) reduced from ₦555.68 in the control group to ₦423.75 in the 75% BNO group, representing a cost saving of ₦131.93 per rabbit over the ten-week period. Feed cost per kilogram weight gain, though not significantly different ( $P>0.05$ ), was numerically lowest in the 75% BNO group (₦417.65) compared to the control (₦591.19). It was concluded that replacing wheat offal with toasted Bambara nut offal up to 75% significantly reduces feed costs without compromising growth performance, thereby improving profitability for rabbit farmers. The use of this locally available agro-industrial by-product is recommended as a cost-effective feeding strategy in weaner rabbit production.

**Keywords:** Bambara nut offal, weaner rabbits, cost-benefit analysis, feed cost, economic viability, wheat offal replacement.

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## Introduction

The high cost of feed remains the single most significant constraint to profitable livestock production in developing countries, accounting

for 70-80% of total production costs in intensive animal agriculture (Wafar et al., 2019). In Nigeria, this challenge is particularly acute due to intense competition between humans and



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livestock for conventional feed ingredients such as maize, wheat, soybean, and groundnut cake (Agunbiade et al., 2001; Onigemo et al. 2020). This competition drives up prices and often results in poor-quality feeds being sold to farmers, further compromising animal performance and enterprise profitability (Iheukwumere et al., 2002).

Rabbit production offers considerable potential for addressing animal protein deficiency in Nigerian households due to the species' high reproductive rate, rapid growth, short generation interval, and ability to utilize fibrous feeds (Hassan et al., 2012; Ubua et al., 2018; Oso et al., 2022). However, the economic viability of rabbit farming depends critically on feed costs. Even with rabbits' ability to utilize forages and by-products, the concentrate component of the diet—particularly energy and protein sources—represents a substantial investment for farmers. Wheat offal is a conventional fibre and energy source in rabbit diets, but its cost has increased substantially due to demand from the baking industry, poultry producers, and other livestock sectors. This price escalation has prompted researchers and farmers to seek alternative, cheaper feed ingredients that do not compete with human food systems. Agro-industrial by-products, including Bambara nut offal, cassava peel meal, maize offal, and various crop residues, have been investigated as potential alternatives.

Bambara groundnut (***Vigna subterranea* (L.) Verdc**) offal is a by-product of processing Bambara nuts into flour for human consumption (locally known as "okpa"). It has no direct human use and is often discarded, potentially creating environmental problems (Amaefule and Osuagwu, 2005). Previous studies (Onigemo, 2000; Onigemo et al., 2020) have demonstrated the nutritional potential of Bambara nut offal in animal feeding. 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. At 15% inclusion, they recorded a cost per kilogram live weight gain of ₦76.55, significantly lower than control diets.

Similarly, Nnenna (2021) evaluated the response of weaner rabbits fed graded levels of raw

Bambara groundnut offal and found that weaner rabbits could be fed 15% BGO diet to enhance daily weight gain and final weight while reducing feed costs. Ezuoke (2021) reported similarly for 5% inclusion level, both raw and toasted forms for rabbit with better economic returns than higher inclusion levels. Studies on other non-conventional feedstuffs (Mu'azu et al., 2025; Adamu et al., 2025) have consistently demonstrated the economic benefits of using locally available by-products with reduced feed cost per kilogram diet from ₦95.02 to ₦63.45, with a positive cost saving of ₦45.18 in the 100% replacement of wheat offal with sun-dried cattle rumen content. This study was designed to evaluate the cost-benefit implications of replacing wheat offal with toasted Bambara nut offal in weaner rabbit diets.

## 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. Cost analysis was based on prevailing market prices of feed ingredients in Abeokuta markets during the experimental period (2024).

### 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 Elewera 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 scent developed and the seeds were uniformly browned, cooled, ground into flour, and sieved into uniform particle size.

### 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. Strict biosecurity measures were maintained throughout the experimental period. 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)

### Cost-Benefit Analysis

Cost-benefit analysis was conducted following the methods described by Anigbogu et al. (2010), Mu'azu et al. (2025), and Adamu et al. (2025).

**Feed Cost per Kilogram Diet (₦/kg):** This was calculated by summing the cost of each ingredient multiplied by its proportion in the diet, based on prevailing market prices during the experimental period.

Feed cost (₦/kg) =  $\Sigma$  (Proportion of ingredient in diet × Cost per kg of ingredient) / 100

**Total Feed Consumed per Rabbit (kg):** This was obtained from the growth performance data as the average total feed intake per rabbit over the ten-week experimental period.

**Cost of Total Feed Consumed per Rabbit (₦):** This was calculated by multiplying the total feed consumed (kg) by the feed cost per kilogram diet.

Cost of feed consumed (₦/rabbit) = Total feed intake (kg) × Feed cost per kg (₦)

**Feed Cost per Kilogram Weight Gain (₦/kg gain):** This was calculated by dividing the cost of total feed consumed by the total weight gain per rabbit. This index represents the feed cost required to produce one kilogram of live weight gain.

Feed cost per kg gain (₦) = Cost of total feed consumed (₦) / Total weight gain (kg)

**Alternatively:** Feed cost per kg gain (₦) = Feed conversion ratio (FCR) × Feed cost per kg (₦)

**Cost Savings (₦/rabbit):** This was calculated as the difference between the cost of feed consumed in the control group and the cost in each BNO treatment group.

**Cost savings (₦) =** Cost of feed consumed (control) – Cost of feed consumed (treatment). Positive values indicate cost savings relative to the control.

### Ingredient Costs

The prevailing market prices of feed ingredients at the time of the experiment are as shown in Table 1 and were used to calculate the cost per kilogram of each experimental diet.

**Table 1: Cost breakdown of experimental diets (₦/kg)**

Ingredients (%)	Cost (₦/kg)	Bambara nut offal inclusion levels			
		0%	25%	50%	75%
Maize	280.00	106.40	106.40	106.40	106.40
Soybean meal	350.00	59.50	59.50	59.50	59.50
Wheat offal	150.00	60.00	45.00	30.00	15.00
Bambara nut offal	80.00	-	8.00	16.00	24.00
Fish meal	450.00	2.25	2.25	2.25	2.25
Bone meal	150.00	3.75	3.75	3.75	3.75
Limestone	80.00	1.18	1.18	1.18	1.18
Premix	2,500.00	6.25	6.25	6.25	6.25
Salt	100.00	0.25	0.25	0.25	0.25
Toxin binder	1,200.00	0.24	0.24	0.24	0.24
Total Cost (₦/kg)		131.47	132.13	109.65	105.15

Note: Bambara nut offal cost was estimated at 50% of wheat offal cost due to its by-product status and lack of direct human use

### Statistical Analysis

Data on feed consumed, feed cost per kg diet, cost of feed consumed, and feed cost per kg weight gain 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

#### Feed Cost per Kilogram Diet

The calculated feed cost per kilogram of experimental diets is presented in Table 1. Feed cost decreased progressively with increasing levels of Bambara nut offal inclusion. The control diet (0% BNO) had a cost of ₦131.47/kg, while the 25% BNO diet had a slightly higher cost of ₦132.13/kg due to the combination of wheat offal (₦150/kg) and BNO (₦80/kg) at intermediate inclusion. The 50% BNO diet cost ₦109.65/kg, and the 75% BNO diet had the lowest cost at ₦105.15/kg.

#### Cost-Benefit Parameters

The effects of partial replacement of wheat offal with Bambara nut offal on cost-benefit parameters are presented in Table 2.

**Feed Consumed:** Total feed consumed per rabbit ranged from 4.03 kg to 4.23 kg across treatments. The control group had the numerically highest feed intake (4.23 kg), while the 75% BNO group had the lowest (4.03 kg). These differences were not statistically significant ( $P>0.05$ ), consistent with the growth performance results reported earlier.

**Feed Cost per Kilogram Diet:** Feed cost per kg diet was significantly ( $P<0.001$ ) affected by dietary treatment. The control and 25% BNO groups had the highest feed costs (₦131.47 and ₦132.13/kg, respectively) and were statistically similar. The 50% BNO group had a significantly lower feed cost (₦109.65/kg), and the 75% BNO group had the lowest feed cost (₦105.15/kg), which was significantly different from all other treatments.

**Cost of Feed Consumed per Rabbit:** Total feed cost per rabbit over the ten-week experimental period followed a similar pattern and was highly significant ( $P<0.001$ ). The control and 25% BNO groups had the highest feed costs (₦555.68 and ₦551.03, respectively) and were statistically similar. The 50% BNO group had a significantly lower feed cost (₦453.59), and the 75% BNO group had the lowest feed cost (₦423.75), which was significantly different from all other treatments.

**Feed Cost per Kilogram Weight Gain:** Feed cost per kg weight gain ranged from ₦417.65 to

₦591.19 across treatments. Although the 75% BNO group had the numerically lowest value (₦417.65) and the control group had the highest (₦591.19), these differences were not statistically significant ( $P>0.05$ ) due to variation within treatments.

**Cost Savings:** Relative to the control group, rabbits fed 25% BNO showed a marginal cost increase of +₦4.65 (negative saving), while rabbits fed 50% BNO showed a cost saving of ₦102.09 per rabbit. The 75% BNO group showed the highest cost saving of ₦131.93 per rabbit over the ten-week period.

**Table 2: Effect of experimental diets on cost-benefit analysis of weaner rabbits**

Parameters	Bambara nut offal inclusion levels				SEM	P-value
	0%	25%	50%	75%		
Feed consumed (kg)	4.23	4.17	4.14	4.03	0.03	0.229
Feed cost (₦)/kg	131.47 <sup>a</sup>	132.13 <sup>a</sup>	109.65 <sup>b</sup>	105.15 <sup>c</sup>	3.71	<0.001
Cost of feed consumed (₦/rabbit)	555.68 <sup>a</sup>	551.03 <sup>a</sup>	453.59 <sup>b</sup>	423.75 <sup>c</sup>	17.92	<0.001
Feed cost/kg weight gain (₦)	591.19	522.97	516.38	417.65	41.18	0.58
Cost savings relative to control (₦)	-	(-4.65)	102.09	131.93	-	-

<sup>abc</sup> Means within rows with different superscripts are significantly different ( $P<0.05$ ); SEM: Standard Error of Means

**Discussion**

**Feed Cost Reduction**

The progressive and significant reduction in feed cost per kilogram diet with increasing Bambara nut offal inclusion is one of the most important findings of this economic analysis. The control diet (0% BNO) cost ₦131.47/kg, while the 75% BNO diet cost only ₦105.15/kg—a reduction of ₦26.32 per kg of feed (20% decrease). This cost reduction is directly attributable to the lower unit cost of Bambara nut offal (₦80/kg) compared to wheat offal (₦150/kg). The slightly higher cost of the 25% BNO diet (₦132.13/kg) compared to the control (₦131.47/kg) reflects the fact that at this inclusion level, the combination of expensive wheat offal (still 30% of diet) and cheaper BNO (10%) did not offset the cost of other ingredients. However, as BNO inclusion increased to 50% and 75%, the cost benefits became substantial. These findings are consistent with numerous studies on non-conventional feedstuffs in rabbit production. Mu'azu et al. (2025) reported that replacing wheat offal with sun-dried cattle rumen contents up to 100% progressively reduced feed cost per kilogram diet from ₦95.02 to ₦63.45. Adamu et al. (2025) found that feed cost per kilogram

ranged from ₦391.52 in 100% maize offal diets to ₦402.14 in control diets, with progressive cost reduction as maize offal inclusion increased. Amaefule et al. (2011) observed that increased level of BGO in the diets resulted in a significant ( $p<0.05$ ) decrease in total feed cost, with rabbits fed 15% BGO having the lowest cost per kg live weight gain (₦76.55). Similarly, Nnenna (2021) reported that increase in inclusion level of BGO resulted in significant decrease in total feed cost, with 15% BGO producing the lowest cost per kg live weight gain.

**Total Feed Cost per Rabbit**

The significant reduction in total feed cost per rabbit (from ₦555.68 in controls to ₦423.75 in the 75% BNO group) represents a cost saving of ₦131.93 per rabbit over the ten-week experimental period. For a smallholder farmer raising 50 rabbits per cycle, this translates to potential savings of approximately ₦6,600 per production cycle. Over multiple cycles per year, the cumulative savings become substantial. This finding aligns with Ezuoke (2021), who reported that at 5% inclusion level, both raw and toasted Bambara groundnut by-product showed better economic returns than higher inclusion levels,



though the study focused on replacing soybean meal rather than wheat offal. The results also support Usman et al. (2025), who found that proportionate increase in inclusion of African locust bean fruit pulp in rabbit diets resulted in relative decrease in production costs. The cost savings observed in this study are particularly significant because they were achieved without compromising growth performance (Onigemo et al., 2020). This demonstrates that BNO is not merely a cheaper ingredient but also a nutritionally adequate substitute for wheat offal at the inclusion levels tested.

### Feed Cost per Kilogram Weight Gain

Although the differences in feed cost per kilogram weight gain were not statistically significant ( $P>0.05$ ), the numerical trend is economically meaningful. The 75% BNO group had the lowest cost per kg gain (₦417.65), which was 29% lower than the control group (₦591.19). This suggests that farmers could achieve nearly 30% reduction in the cost of producing each kilogram of live rabbit by using the 75% BNO diet. The lack of statistical significance is likely due to variation within treatments and the relatively small sample size for economic parameters. However, from a practical farming perspective, a 29% reduction in production costs is highly significant and would substantially improve profit margins. These findings are consistent with Mafimidiwo et al. (2025), who reported that although growth performance parameters were not significantly affected by tiger nut waste substitution for wheat offal, the best feed conversion ratio was observed at 30% substitution, with implications for economic efficiency. The study noted that for better weight gain and feed conversion ratio, rabbit diet can be substituted with 30% tiger nut waste for wheat offal.

Previous studies on Bambara groundnut offal have suggested optimal inclusion levels of 15% for raw material. Amaefule et al. (2011) concluded that growing rabbits could be fed diets containing up to 15% raw BGO to enhance daily weight gain and reduce feed cost, while 20% depressed nutrient digestibility. Onigemo (2000); Onigemo et al. (2020), and Nnenna (2021) similarly found that 15% BGO produced

the best performance and lowest cost per kg gain. The present study demonstrates that with toasting, inclusion levels can be substantially increased—up to 30% of total diet (75% replacement of wheat offal)—without adverse effects on performance, and with even greater cost savings. This highlights the importance of processing in unlocking the nutritional and economic potential of Bambara nut offal. The toasting process likely inactivates anti-nutritional factors that would otherwise limit utilization at higher inclusion levels.

The economic implications of these findings for smallholder rabbit farmers in Nigeria translate to reduction in rabbit feed cost per kg by 20% through BNO inclusion hence, directly improving profit margins. The cost saving of ₦131.93 per rabbit over ten weeks translates to improved profitability per production cycle. For farmers with limited capital, this can make the difference between profit and loss. Again, the utilization of Bambara nut offal creates value from waste and reduces dependence on imported or industrially processed feed ingredients and reducing reliance on wheat offal—whose price fluctuates with market conditions and import policies—farmers can achieve greater stability in their production costs.

In conclusion, dietary inclusion of toasted Bambara nut offal significantly reduced feed cost per kilogram diet by 20%, with the 75% replacement diet costing ₦105.15/kg compared to ₦131.47/kg for the control diet while, a cost saving of ₦131.93 per rabbit was realized from the significant reduction in the total feed cost per rabbit over the ten-week experimental period from ₦555.68 in the control group to ₦423.75 in the 75% BNO group. Also, there was improved economic efficiency gained from feed cost per kilogram weight gain, that was lowered by 29% lower in the 75% BNO group (₦417.65) compared to the control group (₦591.19). These cost savings were achieved without compromising growth performance, hence, confirming that toasted Bambara nut offal is both nutritionally adequate and economically advantageous as a replacement for wheat offal. Therefore, toasted Bambara nut offal at 75% replacement of wheat offal (30% of total diet) is recommended for cost-effective weaner rabbit production.

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