



RESPONSE OF WEANER RABBITS TO DIETARY LEVELS OF SORREL SEED MEAL AS REPLACEMENT FOR SOYA BEAN MEAL

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ABSTRACT

This study evaluated the effect of replacing soybean meal with sorrel seed meal (SSM) diets on the performance of weaner rabbits. A total of thirty-two (32) weaner rabbits were used in a completely randomized design consisting of four dietary treatments with eight rabbits per treatment and four replicates of two rabbits each. Sorrel seed meal was included at graded levels of 0, 33.33, 66.67 and 100% as a replacement for soybean meal. The study lasted for a period of eight (8) weeks. Data were collected on growth performance and carcass characteristics as well as economic parameters. Data collected were subjected to analysis of variance using SPSS 27.0 version. Differences between means were separated using Duncan's Multiple Range Test. The results showed that, dietary treatments significantly ($P < 0.05$) influenced growth performance. Rabbits fed 66.67% SSM recorded the highest final body weight (1680 g), daily weight gain (20.20 g), and total weight gain (1128.5 g), compared to the control group. Carcass evaluation revealed an improved carcass weight (1050 g) and dressing percentage (62.5%) at 66.67% SSM inclusion, while most organ proportions were not significantly ($P < 0.05$) affected. Economic analysis indicated a progressive reduction in feed cost from ₦1638 (T1) to ₦1365.3 (T4), with the highest cost savings of ₦501.59 (27.56%) recorded at 66.67% inclusion. The study concluded that, sorrel seed meal can effectively replace soybean meal in weaner rabbit diets up to 100% inclusion level without detrimental effect. It was recommended that farmers should adopt SSM at 66.67% inclusion level to achieve improved growth performance, better nutrient utilization and maximum economic returns.

Keywords: Sorrel, Soybean, Diets, Rabbits, Response

INTRODUCTION

The increasing global demand for animal protein, coupled with the persistent rise in the cost of conventional feed ingredients, has intensified the search for alternative, sustainable and affordable protein sources for livestock production. In rabbit production, feed accounts for over 60–70% of the total cost of production, making nutrition one of the most important determinants of profitability (Taiwo *et al.*, 2024). Soya bean meal (SBM), which is the conventional protein source in rabbit diets, has become increasingly expensive due to its competing demand for human consumption and industrial applications. This situation has created the need to identify locally available and underutilized feed resources that can partially or completely replace soya bean meal without compromising animal performance. One such promising alternative is sorrel (*Hibiscus sabdariffa* L.) seed, an underexploited by-product of the hibiscus plant commonly cultivated for its calyces used in beverages, food colouring and traditional medicine. Sorrel is widely cultivated across tropical and subtropical regions, particularly in Africa, Asia and the Caribbean. In Nigeria, cultivation is primarily for the calyces, while the seeds are often discarded despite their nutritional potential (Olaoye *et al.*, 2025). Previous studies have shown that sorrel seeds contain about 23–32% crude protein, appreciable quantities of essential amino acids, moderate levels of lipids and valuable minerals, indicating their suitability as an alternative plant protein source in livestock feeding (Salami and Afolayan, 2021). Despite its favourable nutrient composition, raw sorrel seed meal contains several anti-nutritional factors (ANFs), including phytic acid, tannins, oxalates and trypsin inhibitors, which interfere with nutrient utilization, reduce feed efficiency and ultimately depress animal performance (Olaoye *et al.*, 2025). Consequently, appropriate processing methods are necessary to reduce these anti-nutritional constituents and improve the nutritional quality of the seed meal before its inclusion in animal diets. Among the available processing techniques, toasting has been widely recognized as an effective and practical method for improving the feeding



value of oilseeds and legumes. Toasting involves the application of dry heat, which effectively destroys heat-sensitive anti-nutritional factors, improves protein digestibility and enhances the functional characteristics of feed ingredients (Vilakazi *et al.*, 2025). However, excessive heating during toasting may reduce the availability of heat-sensitive amino acids, particularly lysine, through Maillard reactions. Therefore, determining appropriate dietary inclusion levels of toasted sorrel seed meal is essential to maximize its nutritional benefits while minimizing any adverse effects on animal performance (Vilakazi *et al.*, 2025). Rabbits (*Oryctolagus cuniculus*) have gained considerable attention as an important source of high-quality animal protein because of their rapid growth rate, short reproductive cycle, high feed conversion efficiency and ability to utilize relatively fibrous feed resources. Weaner rabbits represent a particularly critical stage of production because they are highly sensitive to nutritional inadequacies and dietary imbalances that may adversely affect growth, health and survival (Dalle Zotte, 2014). Providing nutritionally balanced diets during the post-weaning period is therefore essential for achieving optimum growth performance and efficient meat production. The replacement of soya bean meal with toasted sorrel seed meal in rabbit diets offers a potential strategy for reducing feed costs while promoting the utilization of locally available feed resources. Such an approach is consistent with current efforts toward sustainable livestock production, improved resource utilization and environmental conservation through the productive use of agricultural by-products that would otherwise be discarded (FAO, 2023). The use of toasted sorrel seed meal also supports national and global initiatives aimed at enhancing food security through the development and utilization of indigenous feed resources. As the cost of imported and conventional protein ingredients continues to increase, exploiting locally available alternatives becomes increasingly important for improving the profitability of rabbit production, particularly among smallholder farmers. This study was therefore carried out to determine the response of weaner rabbits to dietary levels of sorrel seed meal.

MATERIALS AND METHODS

The Study Area

The experiment was carried out at the Rabbitry Unit of the Department of Animal Production, Abubakar Tafawa Balewa University (ATBU), Bauchi, Nigeria. ATBU is located within the main campus situated along the Bauchi–Dass road in Bauchi Local Government Area of Bauchi State. Bauchi State lies in the northeastern region of Nigeria and is positioned between latitudes 9°30' and 12°30' North and longitudes 8°50' and 11°00' East of the Greenwich Meridian. It is one of the largest states in Nigeria, with a total landmass covering approximately 49,259.01 square kilometres (NBS, 2022; Encyclopaedia Britannica, 2023).

Collection and Processing of Sorrel Seeds

The sorrel seeds (*Hibiscus sabdariffa* L.) and other ingredients used for this study were sourced from Muda Lawal Market in Bauchi Metropolis. Upon collection, the seeds were manually sorted to eliminate debris, broken seeds and other impurities. Only clean and intact seeds were selected for further processing. The seeds were then subjected to toasting under standardized conditions. The seeds were dry-toasted on a hot pan until golden brown and fermented naturally in airtight containers for 72 hours before milling. After processing, the seeds were milled and stored in airtight containers prior to their inclusion in the experimental rabbit diets.

Experimental Animals and their Management

The rabbits were randomly assigned to the different experimental diets containing processed sorrel seed meal, according to their treatment groups. Feed and clean water were provided *ad libitum* throughout the period of the experiment. Daily feed intake was monitored by weighing the quantity of feed offered each morning and the leftover feed the following morning. Body weights of the rabbits were measured weekly using a digital weighing scale.

Formulation of Experimental Diets

Four experimental diets were formulated with toasted sorrel seed meal replacing soya bean meal at varying inclusion levels of 0, 33.33, 66.67 and 100%, designated as Treatments 1 (T1), 2 (T2), 3 (T3) and 4 (T4), respectively. The ingredient composition of the diets is shown in Table 1



Table 1: Ingredients and Composition (%) of the Experimental Diets

Parameter	T1 (0%)	T2 (33.33%)	T3 (66.67%)	T4 (100%)
Maize	30.00	30.00	30.00	30.00
Soya bean Meal	16.00	10.67	5.33	0.00
Sorrel Seed Meal	0.00	5.33	10.67	16.00
Wheat Offal	30.00	30.00	30.00	30.00
Groundnut haulms	20.00	20.00	20.00	20.00
Salt	0.25	0.25	0.25	0.25
Premix	0.40	0.40	0.40	0.40
Bone Meal	3.00	3.00	3.00	3.00
Methionine	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated Analysis				
Crude Protein (%)	15.81	15.89	15.97	16.18
ME (kcal/kg)	2620.44	2610.22	2600.77	2599.89
Crude Fibre (%)	9.40	9.93	10.45	10.98
Calcium (%)	1.12	1.12	1.11	1.11
Phosphorus (%)	0.93	0.88	0.86	0.82
Lysine (%)	0.93	0.89	0.84	0.77
Methionine (%)	0.32	0.29	0.29	0.28

Experimental Design

The experiment was conducted using a Completely Randomized Design (CRD). Four dietary treatments were evaluated, with eight rabbits assigned to each treatment. Each treatment was replicated four times, with two rabbits per replicate. The feeding trial lasted for eight weeks.

Data Collection

Data were collected on performance parameters such as feed intake, body weight gain and feed conversion ratio. Data were also collected on carcass characteristics and economic evaluation was carried out using the prevailing market prices of feed ingredients during the experimental period.

Statistical Analysis

Data generated during the experiment were subjected to Analysis of Variance (ANOVA) as described by Steel and Torrie (1980) using the Statistical Package for the Social Sciences (SPSS) version 23.0. Where significant differences occurred among treatment means, they were separated using Duncan's Multiple Range Test (Duncan, 1955) to determine the level of variation between treatments.

RESULTS AND DISCUSSION

Growth Performance of Weaner Rabbits Fed Varying Levels of Toasted Sorrel Seed Meal

The results as presented in Table 2 indicated that the inclusion of toasted sorrel seed meal in the diets of weaner rabbits influenced several growth performance parameters. The result further revealed that, initial body weight did not differ significantly among the treatment groups, indicating that the rabbits were of comparable weight at the commencement of the experiment. This uniformity suggests that the observed differences in subsequent growth performance were attributable to the dietary treatments rather than pre-existing differences among the experimental animals. Similar observations have been reported by Iyeghe-Erakpotobor (2007), who emphasized the importance of comparable initial body weights in ensuring the validity of feeding trials involving rabbits. The significant ($P < 0.05$) differences observed in final body weight demonstrated that dietary inclusion of toasted sorrel seed meal influenced growth performance. Rabbits fed diet (T₃) containing 66.67% replacement level recorded the highest final body weight (1680.00 g), followed by those on T₂ (1600.00 g), while rabbits on the control diet (1450.00 g) and the 100% replacement level (1500.00 g) had comparatively lower final weights. The superior final body weight obtained at the intermediate replacement level suggests that properly processed sorrel seed meal can effectively support growth when included at appropriate levels. Toasting likely reduced the concentration of anti-nutritional factors while preserving essential



nutrients, thereby improving nutrient utilization. Similar improvements in growth performance following the inclusion of processed unconventional protein sources have been reported by Igila *et al.* (2025), who noted that rabbits efficiently utilize alternative plant protein ingredients when anti-nutritional compounds are adequately reduced through processing. Likewise, Igila *et al.* (2020) reported that processed sorrel seeds possess appreciable nutritional quality suitable for livestock feeding. Daily feed intake was not significantly ($P>0.05$) affected by dietary treatment, indicating that the inclusion of toasted sorrel seed meal did not adversely influence feed palatability or voluntary feed consumption. Rabbits across all treatments consumed relatively similar amounts of feed, suggesting that the toasted sorrel seed meal was readily accepted irrespective of inclusion level. This agrees with Gidenne *et al.* (2012), who reported that rabbits generally regulate feed intake according to dietary nutrient density provided that fibre requirements are adequately met. Similarly, Trocino *et al.* (2021) observed that properly processed alternative feed ingredients do not negatively affect feed intake when incorporated into balanced rabbit diets. Daily weight gain differed significantly ($P<0.05$) among treatments, with rabbits fed T3 recording the highest daily gain (20.20 g), followed by T2 (18.70 g), whereas T1 (16.10 g) and T4 (16.90 g) recorded significantly lower values. The higher daily weight gain observed in rabbits fed the 66.67% replacement diet indicates improved utilization of dietary nutrients for tissue growth. This finding suggests that moderate inclusion of toasted sorrel seed meal supplied adequate nutrients required for rapid growth without adverse effects associated with excessive inclusion. Similar observations have been reported by Adegbola and Okonkwo (2002), who demonstrated that balanced dietary protein and energy are essential for maximizing daily weight gain in growing rabbits. Cheeke (1987) also reported that growth rate is closely associated with dietary protein quality and nutrient digestibility.

Although total feed intake did not differ significantly among treatments, rabbits receiving T3 consumed slightly more feed than those in the other treatment groups. The absence of significant differences indicates that replacing soybean meal with toasted sorrel seed meal did not alter overall feed consumption throughout the experimental period. Similar findings were reported by Gidenne *et al.* (2012), who observed that the incorporation of alternative protein ingredients into rabbit diets had minimal influence on total feed intake provided dietary fibre and nutrient balance were maintained. The significant ($P<0.05$) increase in total weight gain among rabbits fed T3 further confirms the growth-promoting effect of toasted sorrel seed meal at moderate inclusion levels. Rabbits on T3 recorded the highest total weight gain (1128.50 g), followed by T2 (1048.00 g), while rabbits on T1 and T4 exhibited lower gains. These results suggest improved efficiency of nutrient utilization and protein deposition at the 66.67% replacement level. Similar reports by Iyeghe-Erakpotobor (2007) indicated that improved nutrient digestibility translates directly into higher weight gains in weaner rabbits. Furthermore, El-Adawy and Khalil (1994) reported that sorrel seed protein possesses a favourable amino acid profile capable of supporting animal growth when appropriately processed. Feed conversion ratio (FCR) was significantly ($P<0.05$) influenced by dietary treatment. Rabbits fed T3 recorded the lowest FCR (3.39), indicating superior feed utilization efficiency, whereas rabbits on the control diet recorded the highest FCR (4.04). Lower FCR values indicate that less feed was required to produce one unit of body weight gain, reflecting improved conversion efficiency. The improved FCR observed at the intermediate inclusion level may be attributed to enhanced nutrient digestibility following toasting, which reduced anti-nutritional compounds such as tannins and phytates known to impair protein utilization. This observation agrees with Samtiya *et al.* (2020), who reported that thermal processing effectively reduces anti-nutritional factors in plant-based feed ingredients, thereby improving feed efficiency. Similar improvements in feed conversion following the use of processed alternative feed resources were also reported by Adebo and Medina-Meza (2020). Feed efficiency showed significant ($P<0.05$) variation among treatments, with rabbits fed T3 recording the highest efficiency value (0.30), while rabbits on T1 had the lowest (0.25). Since feed efficiency is the reciprocal of FCR, the results further confirm that rabbits receiving the 66.67% toasted sorrel seed meal diet converted feed into body tissue more efficiently than rabbits in the other treatment groups. Improved feed efficiency has been associated with enhanced nutrient digestibility, reduced anti-nutritional effects and improved amino acid availability in processed plant protein sources (Samtiya *et al.*, 2020). Similar findings have also been reported by Igila

et al. 2025), who noted that improved protein quality directly enhances growth efficiency in rabbits. Mortality was minimal throughout the study, with no deaths recorded on T1, T2 and T3, while only one mortality occurred on T4. The generally low mortality across treatments suggests that toasted sorrel seed meal did not exert adverse health effects on the rabbits. This observation indicates that appropriate thermal processing was effective in reducing harmful anti-nutritional compounds to levels that did not compromise animal health. Similar observations have been reported by Adebo and Medina-Meza (2020), who concluded that proper processing substantially improves the safety of unconventional plant protein sources for animal feeding.

Table 2: Growth Performance of Weaner Rabbits Fed Varying Levels of Sorrel Seed Meal Diets

Parameters	T1 (0%)	T2 (33.33%)	T3 (66.67%)	T4 (100%)	SEM
Initial body weight (g)	550.00	552.00	551.50	553.00	2.10 ^{NS}
Final body weight (g)	1450.00 ^c	1600.00 ^b	1680.00 ^a	1500.00 ^c	35.00*
Total weight gain (g)	900.00 ^c	1048.00 ^b	1128.50 ^a	947.00 ^c	30.00*
Daily feed intake (g)	65.00	67.50	68.20	66.00	1.20 ^{NS}
Daily weight gain (g)	16.10 ^c	18.70 ^b	20.20 ^a	16.90 ^c	0.80*
Total feed intake (g)	3640.00	3780.00	3820.00	3690.00	45.00 ^{NS}
Feed conversion ratio	4.04 ^c	3.61 ^b	3.39 ^a	3.89 ^b	0.15*
Feed efficiency	0.25 ^c	0.28 ^b	0.30 ^a	0.26 ^c	0.01*
Mortality	0.00	0.00	0.00	1.00	-

abc - Means bearing different superscripts within a row are significantly different (*= $p < 0.05$); SEM=Standard error of means; NS=Not significant

Carcass Characteristics of Weaner Rabbits Fed Varying Levels of Toasted Sorrel Seed Meal

The carcass characteristics as presented in Table 3 showed that, dietary inclusion of toasted sorrel seed meal influenced only a few carcass parameters, while most carcass components were not significantly affected. This suggested that replacement of soybean meal with toasted sorrel seed meal did not adversely influenced carcass development or organ proportions of the weaner rabbits. Live weight differed significantly ($P < 0.05$) among the dietary treatments, with rabbits fed the 66.67% toasted sorrel seed meal diet (T3) recording the highest live weight (1680.00 g), followed by rabbits fed T2 (1600.00 g), whereas rabbits receiving the control diet (1450.00 g) and the 100% replacement diet (1500.00 g) had significantly lower live weights. The higher live weight obtained at the intermediate inclusion level indicates that toasted sorrel seed meal provided adequate nutrients to support normal growth and body development when included at an optimum level. This finding agrees with Igila *et al.* (2025), who reported that dietary protein quality and nutrient availability are major determinants of body development and live weight in growing rabbits. Similarly, Gidenne *et al.* (2012) observed that balanced diets containing highly digestible protein sources enhance growth performance and body weight development. Carcass weight was also significantly ($P < 0.05$) influenced by dietary treatment. Rabbits fed T3 recorded the highest carcass weight (1050.00 g), followed by T2 (980.00 g), while rabbits on T1 (870.00 g) and T4 (900.00 g) produced significantly lower carcass weights. Since carcass weight is closely related to live weight and muscle deposition, the superior carcass weight observed at the 66.67% replacement level suggests improved utilization of dietary nutrients for lean tissue development. This observation is consistent with the findings of Dalle Zotte and Szendrő (2011), who reported that adequate dietary protein and amino acid balance enhance carcass yield and muscle accretion in rabbits. Cullere and Dalle Zotte (2018) similarly noted that appropriate dietary nutrient composition promotes efficient carcass development while minimizing undesirable fat deposition. Dressing percentage was not significantly affected by dietary treatments, indicating that the proportion of carcass obtained relative to live weight remained similar across all treatment groups. This suggests that the inclusion of toasted sorrel seed meal did not alter carcass dressing characteristics. Similar findings were reported by Dalle Zotte and Szendrő (2011), who observed that dressing percentage is generally stable when dietary nutrient requirements are adequately met. The proportions of the head, skin, forelimbs and hind limbs were not significantly influenced by dietary treatment, indicating that



replacement of soybean meal with toasted sorrel seed meal had no adverse effect on the normal distribution of carcass components. The similarity in these carcass parts across treatments suggests that skeletal and muscular development progressed normally irrespective of dietary inclusion level. Igila *et al.* (2025) reported that carcass cut proportions generally remain relatively constant when animals receive nutritionally balanced diets that adequately support growth. Similarly, the weights of the heart, lungs, liver, kidneys and intestine were not significantly affected by dietary treatment. The absence of significant differences in these internal organs indicates that toasted sorrel seed meal did not impose physiological stress or pathological enlargement of vital organs. Organ weights are frequently used as indicators of the safety and physiological suitability of feed ingredients, and the comparable values observed across treatments suggest that the processed sorrel seed meal was well tolerated by the rabbits. Gidenne *et al.* (2012) reported that properly balanced rabbit diets maintain normal organ development and physiological function without causing abnormal enlargement or shrinkage of internal organs. Similarly, Mailafia *et al.* (2010) observed that normal organ development reflects good nutritional status and the absence of toxic dietary effects. The caecum weight differed significantly ($P<0.05$) among treatments, with rabbits fed T3 recording the highest caecum weight (4.60%), followed by T2 (4.30%), while rabbits fed the control diet recorded the lowest value (4.00%). The larger caecum observed in rabbits receiving the intermediate level of toasted sorrel seed meal may reflect enhanced development of the hindgut fermentation chamber, which plays a vital role in fibre digestion and microbial fermentation in rabbits. The rabbit caecum is the primary site of microbial activity responsible for the digestion of structural carbohydrates and synthesis of microbial protein. Adequate dietary fibre and well-processed plant ingredients are known to promote normal caecal development and digestive efficiency. This observation agrees with Gidenne *et al.* (2012), who reported that dietary fibre quality significantly influences caecal development and digestive function in rabbits. Similarly, Trocino *et al.* (2021) noted that balanced fibre sources enhance gastrointestinal development and optimize digestive efficiency in growing rabbits.

Table 3: Carcass Traits of Weaner Rabbits Fed Varying Levels of Toasted Sorrel Seed Meal

Parameters	T1 (0%)	T2 (33.33%)	T3 (66.67%)	T4 (100%)	SEM
Live weight	1450.00 ^c	1600.00 ^b	1680.00 ^a	1500.00 ^c	35.00*
Carcass weight	870.00 ^c	980.00 ^b	1050.00 ^a	900.00 ^c	30.00*
Dressing %	60.00	61.20	62.50	60.00	1.20 ^{NS}
Carcass characteristics	expressed as	% live weight			
Head	6.50	6.40	6.30	6.50	0.20 ^{NS}
Skin	12.00	11.80	11.60	12.10	0.40 ^{NS}
Forelimbs	8.00	7.90	7.80	8.10	0.20 ^{NS}
Hind limbs	14.50	14.80	15.00	14.60	0.30 ^{NS}
Heart	0.30	0.32	0.33	0.31	0.02 ^{NS}
Lung	0.50	0.52	0.53	0.51	0.02 ^{NS}
Liver	3.20	3.30	3.40	3.25	0.10 ^{NS}
Kidney	0.60	0.62	0.63	0.61	0.02 ^{NS}
Intestine	10.50	10.80	11.00	10.70	0.30 ^{NS}
Caecum	4.00 ^c	4.30 ^b	4.60 ^a	4.20 ^{bc}	0.20*

abc - Means bearing different superscripts within a row are significantly different ($*=p<0.05$); SEM=Standard error of means; NS=Not significant

Economic Analysis of Feeding Varying Levels of Toasted Sorrel Seed Meal to Weaner Rabbits

The economic analysis result as presented in Table 4 demonstrated that, replacing soybean meal with toasted sorrel seed meal had a positive effect on the economics of weaner rabbit production. The results indicate that the inclusion of toasted sorrel seed meal progressively reduced feed costs while maintaining satisfactory growth performance, thereby improving the overall profitability of rabbit production. Total feed intake varied only slightly among the treatment groups, ranging from 3.64 kg in the control diet to 3.82 kg in rabbits fed the 66.67% replacement level. The relatively similar feed consumption across treatments indicates that the inclusion of toasted sorrel seed meal did not adversely



affect feed acceptance or voluntary intake. Since feed intake remained relatively constant, the observed differences in production costs were primarily attributable to differences in feed ingredient costs rather than feed consumption. This observation agrees with Gidenne *et al.* (2012), who reported that alternative feed ingredients can reduce production costs without substantially altering feed intake when diets are nutritionally balanced. The cost of feed per kilogram declined steadily as the level of toasted sorrel seed meal increased, decreasing from ₦450.00/kg in the control diet to ₦370.00/kg at the 100% replacement level. This reduction reflects the lower cost of sorrel seed meal compared with conventional soybean meal. The result supports the growing interest in utilizing locally available unconventional feed resources to reduce dependence on expensive conventional protein sources. Similar observations have been reported by FAO (2019), which emphasized that locally sourced feed ingredients offer practical opportunities for lowering feed costs and improving the profitability of livestock production systems. Saleem *et al.* (2017) also noted that the utilization of agricultural by-products contributes to more cost-effective and sustainable feed formulation.

Total feed cost followed a similar trend, decreasing from ₦1,638.00 in the control group to ₦1,365.30 in rabbits fed the 100% toasted sorrel seed meal diet. This gradual reduction demonstrates the economic advantage associated with increasing inclusion levels of the processed sorrel seed meal. The lower expenditure on feed reflects the affordability of the alternative protein source and its potential to reduce production costs for rabbit farmers. Similar findings were reported by FAO (2019), which identified feed cost reduction as one of the major economic benefits associated with the use of locally available feed resources. Total weight gain was highest in rabbits fed the 66.67% replacement level (1.13 kg), followed by rabbits fed 33.33% replacement (1.05 kg), while rabbits on the control and 100% replacement diets recorded lower weight gains of 0.90 kg and 0.95 kg, respectively. The superior weight gain obtained at the intermediate inclusion level indicates that toasted sorrel seed meal not only reduced production costs but also supported efficient growth when included at an optimum level. This finding is consistent with Igila *et al.* (2025), who reported that the economic value of alternative feed ingredients depends not only on their cost but also on their ability to sustain optimal animal performance. Feed cost per kilogram of weight gain, one of the most important indicators of production efficiency, decreased markedly with increasing inclusion of toasted sorrel seed meal. Rabbits fed the control diet required ₦1,820.00 to produce one kilogram of live weight gain, whereas rabbits fed the 66.67% replacement level required only ₦1,318.41. This substantial reduction indicates superior economic efficiency and demonstrates that rabbits utilized the toasted sorrel seed meal more efficiently at the intermediate inclusion level. Lower feed cost per unit of weight gain is generally associated with improved feed utilization and enhanced profitability. Similar observations have been reported by Samtiya *et al.* (2020), who noted that proper processing of unconventional plant protein sources improves nutrient utilization and reduces the cost of animal production. The calculated cost savings further demonstrate the economic benefit of replacing soybean meal with toasted sorrel seed meal. Rabbits fed the 66.67% replacement diet recorded the highest cost savings of ₦501.59, followed by rabbits fed the 100% replacement level (₦382.84) and the 33.33% replacement level (₦308.00). Likewise, percentage cost savings increased from 16.92% on T2 to 27.56% on T3 before slightly declining to 21.04% on T4. The highest percentage cost saving obtained at the 66.67% replacement level indicates that this level provided the most economically efficient balance between feed cost reduction and growth performance. These findings support the assertion of Saleem *et al.* (2017) that the utilization of agricultural by-products in livestock feeding enhances economic sustainability by lowering production costs while maintaining productivity. Similarly, FAO (2019) emphasized that incorporating locally available feed resources into livestock diets contributes to improved farm profitability and greater resilience of smallholder production systems.



Table 4: Economic Analysis of Feeding Varying Levels of Toasted Sorrel Seed Meal to Weaner Rabbits

Parameters	T1 (0%)	T2 (33.33%)	T3 (66.67%)	T4 (100%)
Total feed intake (kg)	3.64	3.78	3.82	3.69
Feed cost/kg (₦)	450.00	420.00	390.00	370.00
Total feed cost (₦)	1638.00	1587.60	1489.80	1365.30
Total weight gain (kg)	0.90	1.05	1.13	0.95
Feed cost/kg gain (₦)	1820.00	1512.00	1318.41	1437.16
Cost savings (₦)	-	308.00	501.59	382.84
Cost saving (%)	-	16.92	27.56	21.04

CONCLUSION AND RECOMMENDATIONS

From the findings of this study, it can be concluded that toasted sorrel seed meal (SSM) can successfully replace soybean meal in the diets of weaner rabbits up to 100% replacement level without causing detrimental effects on the overall growth performance and carcass yield of the animals. However, the 66.67% replacement level produced the best overall performance, as it resulted in the highest final body weight, daily weight gain, total weight gain, feed efficiency and the most favourable feed conversion ratio. It also gave the best carcass yield and economic benefits. Sorrel seed meal is therefore recommended as a suitable alternative protein source and can replace soybean meal at 66.67% inclusion level in weaner rabbit diets for optimal performance. Farmers should adopt the use of sorrel seed meal, especially in regions where it is readily available, to reduce feed cost by 27.56%.

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