



GROWTH PERFORMANCE AND ECONOMIC ANALYSIS OF REPLACING SOYA BEAN MEAL WITH TOASTED SORREL SEED MEAL IN THE DIETS OF WEANER RABBITS

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ABSTRACT

The study was conducted to evaluate the growth performance and economic analysis of replacing soybean meal with toasted sorrel seed meal (TSSM) in the diets of weaner rabbits. The experiment was carried out at the Rabbitry Unit of the Department of Animal Production, Abubakar Tafawa Balewa University, Bauchi, Nigeria. A total of forty (40) weaner rabbits were used in a Completely Randomized Design consisting of five dietary treatments (T1–T5) with four replicates per treatment and two rabbits per replicate. The diets contained TSSM at inclusion levels of 0, 25, 50, 75 and 100%, replacing soybean meal. The feeding trial lasted for six (6) weeks. Sorrel seeds (*Hibiscus sabdariffa* L.) were obtained locally, cleaned, toasted, milled into meal and incorporated into the experimental diets. Data collected included feed intake, body weight gain, feed conversion ratio (FCR) and economic indicators such as total feed cost, feed cost per kilogram gain and cost savings. Results showed that, final body weight increased significantly ($p < 0.05$) from 1,550.50 g in diet 1 to 1,795.60 g in diet 4, while daily weight gain also improved from 11.05 g in diet 1 to 14.90 g in diet 5. Feed intake remained stable across all treatments. Feed conversion ratio (FCR) improved from 5.79 (T1) to 4.30 (T5), while feed efficiency increased from 0.17 to 0.23. Economic analysis revealed that feed cost per kilogram decreased steadily from ₦290.55 (T1) to ₦205.01 (T5) and feed cost per kilogram weight gain reduced from ₦781.58 in the control to ₦463.86 in the 100% inclusion group. Correspondingly, cost savings increased from ₦0.00 in T1 to ₦317.72 in T5, indicating strong economic benefits. It was concluded that, toasted sorrel seed meal can effectively replace soybean meal up to 100% in the diets of weaner rabbits without adverse effects on their growth while significantly reducing feeding costs and improving profitability. It is therefore recommended that TSSM be included up to 100% in weaner rabbit diets to enhance growth performance and economic returns.

Keywords: Rabbits, Sorrel, Soybean, Performance, Economic

INTRODUCTION

Sustainable rabbit production in many low- and middle-income countries depends heavily on affordable, high-quality protein sources. Soybean meal is widely used because of its high crude protein content and favorable amino-acid profile, but its price volatility and reliance on imports make production costs unpredictable for smallholder and commercial producers alike. Global market pressures and feed policy changes increasingly motivate searches for alternative local protein sources (Salami *et al.*, 2021). Roselle (*Hibiscus sabdariffa* L) produces seeds that are locally available, under-utilized by-products with promising nutritive value. Proximate composition studies report that roselle seeds contain substantial crude protein, appreciable fat, fiber and mineral fractions, indicating potential as an energy- and protein-concentrate in livestock feeds (Angbulu *et al.*, 2019). Raw roselle seed contains antinutritional factors (ANFs) and relatively high fiber that can limit nutrient availability if fed untreated. Processing methods including boiling, fermentation and toasting have been shown to reduce ANFs and improve nutritive value and acceptability of sorrel seed meal. Toasting is a lower-cost, easily adoptable treatment for smallholder processors (Ari *et al.*, 2015). Empirical work has already examined sorrel seed meal as a substitute for soybean meal in poultry and, to a lesser extent, in rabbits. Broiler chicken studies replacing graded levels of processed roselle seed meal for conventional protein sources reported that moderate replacement levels sometimes produced comparable growth performance and improved feed-cost indicators, whereas very high replacement levels can depress growth unless diets are well balanced (Mohammed *et al.*, 2022). In rabbits, recent studies indicate that partial substitution of conventional protein sources with processed sorrel seed meal can be tolerated and, at optimized



inclusion rates, may sustain growth performance while reducing feed cost per unit gain (Aliyu *et al.*, 2024). Studies that included economic analyses found that diets containing processed sorrel seed meal reduced feed cost per unit gain compared with diets based fully on soybean meal, particularly where sorrel seed is locally cheap or a by-product (Obadire *et al.*, 2022). Given the nutritional potential of *H. sabdariffa* seed and the demonstrated benefits of processing, there is a clear rationale to evaluate toasted sorrel seed meal as a partial or full replacement for soybean meal specifically in weaner rabbits. The present study therefore investigates the growth performance and economic analysis when soybean meal is progressively replaced by toasted sorrel seed meal in diets formulated for weaner rabbits.

MATERIALS AND METHODS

The experiment was carried out at the Rabbitry Unit of the Department of Animal Production, Abubakar Tafawa Balewa University (ATBU), Bauchi, Nigeria. 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 kilometers (Yau *et al.*, 2022).

Experimental Design

The experiment was carried out using forty (40) weaner rabbits of mixed breeds. The experiment lasted for six (6) weeks. The rabbits were randomly assigned to the different experimental diets containing toasted sorrel seed meal, according to their treatment groups. There were five treatments which were replicated four (4) times with two (2) weaner rabbits per replicate. The experimental design of the study was Completely Randomized Design (CRD).

Collection of and Processing of Sorrel Seeds

The sorrel seeds (*Hibiscus sabdariffa* L.) used for this study were purchased from Muda Lawal Market in Bauchi metropolis. 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 processing by toasting under standardized conditions to enhance comparability across treatments. After processing, the seeds were milled into meal and stored in airtight containers prior to their inclusion in the experimental rabbit diets.

Management of Experimental Animals

The weaner rabbits were purchased from reputable local breeders within Bauchi metropolis. The animals were allowed a week acclimatization period during which they were fed a standard grower diet and provided clean water *ad libitum* to adapt to the new environment. Pens, feeders, and drinkers were thoroughly washed and disinfected before and during the experiment to maintain hygiene. After acclimatization, the rabbits were randomly allotted to diets containing graded levels of toasted sorrel seed meal according to their treatment groups. Feed and water were supplied *ad libitum*, and feeding was done twice daily at 8:00 a.m. and 4:00 p.m. Routine medication, including deworming with albendazole and vaccination against Rabbit Hemorrhagic Disease, was carried out, while the health of the animals was monitored daily under standard ethical guidelines.

Experimental diets

The test ingredient in this study was sorrel seeds which were processed and used in the diets of weaner rabbits at varying levels of 0, 25, 50, 75 and 100% which were designated as T1 -5 respectively (table 1).

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

Ingredients	Diets				
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Maize	32.35	32.35	32.35	32.35	32.35
Soya bean meal	20.00	15.00	10.00	5.00	0.00
TSSM	0.00	5.00	10.00	15.00	20.00
Wheat offal	25.00	25.00	25.00	25.00	25.00
GNH	20.00	20.00	20.00	20.00	20.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100
Calculated Analysis					
Crude protein	17.85	17.40	16.95	16.50	16.05
M/kcal/kg energy	2700.74	2700.02	2634.67	2623.01	2605.09
Crude fibre	9.40	9.93	10.45	10.98	11.50
Calcium	1.12	1.12	1.11	1.11	1.10
Phosphorus	0.93	0.88	0.86	0.82	0.78
Lysine	0.93	0.89	0.84	0.77	0.69
Methionine	0.32	0.29	0.29	0.28	0.24

TSSM- Toasted sorrel seed meal; GNH- Groundnut haulms

Data Collection

The following were collected during the study

Feed intake

Feed consumption from each treatment was measured on daily basis by taking the difference between feed given and left over.

Body weight gain

The weaner rabbits were weighed at the beginning of the experiment and at weekly interval throughout the six (6) weeks of the experiment. This was done to observe body weight changes.

Feed conversion ratio (FCR)

Feed Conversion Ratio was calculated as gram feed intake per gram gain in weight as:-

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total feed consumed (g)}}{\text{Total body weight gain (g)}} \dots\dots\dots 1$$

Economic Analysis

An economic evaluation was carried out to determine the cost-effectiveness of replacing soya bean meal with sorrel seed meal in the diets of weaner rabbits. The analysis was based on the prevailing market prices of feed ingredients at the time of the experiment. The parameters evaluated included total feed intake (kg), feed cost per kilogram (₦/kg), total feed cost (₦), total weight gain (kg) and feed cost per kilogram gain (₦). These indices were used to determine the relative profitability of the different dietary treatments.

Data Analysis

Collected data were subjected to analysis of variance (ANOVA) using a Completely Randomized Design (CRD) in SPSS software. Differences among treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

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

Table 2 shows the growth responses of weaner rabbits fed graded levels of toasted sorrel seed meal (TSSM). The experimental groups were uniform at the start of the experiment (550–552 g),



confirming even allocation. By the end of the trial, rabbits receiving 75 and 100% TSSM recorded significantly higher final live weights ($P < 0.05$) (1,795.6 and 1,748.4 g respectively) than the control (550.5 g), while the 50% group (1,690.1 g) also outperformed the control. These results indicate that, in this experiment, high inclusion levels of toasted sorrel seed supported and improved growth compared with the soybean-based control. Daily feed intake remained essentially constant across treatments (64 g), which suggests good acceptability of diets even where soybean meal was fully replaced by toasted sorrel seed meal. Other investigators have reported mixed results for intake with sorrel and similar seeds depending on processing: Wafar *et al.* (2020) found no adverse effect on feed intake when fermented sorrel seed meal was included in weaner-rabbit diets up to 40%, whereas boiling for long durations has been associated with reductions in intake in some trials (Aliyu 2019). Average daily gain in the current study rose with increasing TSSM level, with the highest gains in T4 and T5 demonstrating that higher inclusion did not depress growth and in fact produced the strongest growth responses. This pattern accords with studies showing that appropriate heat or fermentation treatments lower anti-nutritional factors and can improve nutrient availability and growth (Duwa *et al.*, 2012; Yusuf *et al.*, 2023). At the same time, some processed alternative seed meals produce neutral outcomes at low inclusion rates. A study by Tarimbuka *et al.* (2017) revealed that toasted sickle-pod seed up to 10% produced no significant differences across the dietary treatments. Total feed intake for the trial was similar across treatments and feed conversion ratio improved numerically from 5.79 (control) to 4.30 (T5), while feed efficiency rose from 0.17 to 0.23. Although those FCR changes were not statistically significant in this experiment, the numeric trend toward better efficiency with higher TSSM inclusion is consistent with the idea that processing can reduce antinutritional factors and make the seed's nutrients more available, a mechanism reported in several proximate and digestibility studies of processed tropical seeds (Duwa *et al.*, 2012)

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

Parameters	Diets					SEM
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	
Initial body weight (g)	550.00	551.20	552.10	550.80	551.90	1.25 ^{NS}
Final body weight (g)	1550.50 ^c	1602.30 ^{bc}	1690.10 ^b	1795.60 ^a	1748.40 ^a	5.40*
Daily feed intake (g)	63.95	63.90	64.10	64.15	64.05	0.18 ^{NS}
Daily weight gain (g)	11.05 ^c	12.90 ^{bc}	13.80 ^b	14.82 ^a	14.90 ^a	0.22*
Total feed intake (g)	2685.90	2683.80	2694.30	2690.40	2690.10	10.35 ^{NS}
Total weight gain (g)	1000.50 ^c	1051.10 ^{bc}	1138.00 ^b	1244.80 ^a	1195.50 ^a	6.80*
Feed conversion ratio	5.79	4.95	4.64	4.33	4.30	0.05 ^{NS}
Feed efficiency	0.17	0.20	0.22	0.23	0.23	0.02 ^{NS}

^{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

Table 3 presents the economic implications of replacing soybean meal with varying levels of toasted sorrel seed meal (TSSM) in the diets of weaner rabbits. The results indicated that total feed cost, feed cost per kilogram of weight gain and cost savings all improved with increasing inclusion of TSSM. This demonstrates that substituting soybean meal with TSSM can significantly lower production costs without negatively affecting growth performance. Feed cost per kilogram of diet declined consistently from ₦290.55 in the control (T1) to ₦205.01 in T5 (100% replacement). The decline is primarily due to the comparatively lower market price of sorrel seed relative to soybean meal. Toasting enhances the nutrient availability and reduces anti-nutritional factors, thereby improving its feeding value and cost-effectiveness. Similar patterns of reduced feed cost have been reported when other processed plant-based protein sources were used to replace soybean meal in rabbit diets (Aliyu 2019; Wafar *et al.*, 2020). Total feed cost per rabbit followed a similar downward trend, decreasing from ₦781.58 in T1 to



₦551.49 in T5. This implies that even though feed intake remained relatively constant across treatments, the inclusion of TSSM effectively lowered the unit cost of the diets. Consequently, rabbits consumed nearly the same quantity of feed at a reduced overall expenditure. Comparable findings were documented by Esonu *et al.* (2001), who demonstrated that properly processed unconventional feed ingredients can markedly lower the cost of feeding in monogastric livestock. Feed cost per kilogram of weight gain also declined substantially, from ₦781.58 in the control group to ₦463.86 in T5. This indicated improved cost efficiency, as rabbits on the highest inclusion levels achieved better weight gains for less feed expenditure. This aligns with the observation by Yusuf *et al.* (2023), who reported that rabbits fed processed *Afzelia africana* seed meal showed better feed cost efficiency and profitability compared with those on soybean-based diets. The analysis of cost savings further confirms the economic advantage of TSSM. Cost savings increased progressively from ₦0.00 in the control to ₦317.72 in T5, illustrating that higher inclusion of TSSM provides substantial financial benefits while maintaining acceptable growth performance. These findings are consistent with the results of Tarimbuka *et al.* (2017), who observed significant reductions in feed cost per unit gain and improved profitability when rabbits were fed processed leguminous seed meals as partial replacements for soybean meal.

Table 3: Economic Analysis of Feeding Varying Levels of Toasted Sorrel Seed Meal to Weaner Rabbits

Parameters	Diets				
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Total feed intake (kg)	2.69	2.68	2.69	2.69	2.69
Feed cost/kg (₦)	290.55	270.50	250.70	230.64	205.01
Total feed cost (₦)	781.58	725.74	674.38	620.42	551.49
Total weight gain (kg)	1.00	1.05	1.14	1.24	1.19
Feed cost/kg gain (₦)	781.58	691.18	591.91	500.34	463.86
Cost savings (₦)	0.00	90.40	189.67	281.24	317.72

CONCLUSION AND RECOMMENDATIONS

The study demonstrated that replacing soybean meal with toasted sorrel seed meal (TSSM) in weaner rabbit diets improved growth performance and reduced feeding costs without adverse effects on feed intake or health. Rabbits fed diets containing 100% TSSM showed the highest final weights and best feed conversion efficiency, while feed cost per kilogram gain and total feed cost decreased progressively with higher inclusion levels. Therefore, TSSM can serve as an effective, economical and sustainable alternative to soybean meal in rabbit production. It is recommended that toasted sorrel seed meal be included in weaner rabbit diets up to 100% as a complete replacement for soybean meal to enhance growth and profitability.

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