



EFFECTS OF REPLACING WHEAT OFFAL WITH SUN-DRIED CATTLE RUMEN CONTENTS ON GROWTH PERFORMANCE AND COST BENEFIT OF WEANER RABBITS

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ABSTRACT

The study was carried out at the Rabbitry Unit of the Bauchi State College of Agriculture to evaluate the growth performance and cost-benefit of weaner rabbits fed diets containing graded levels of sun-dried cattle rumen contents (SDCRC) as a replacement for wheat offal. Fifty (50) weaner rabbits of mixed breeds were used in an eight-week feeding trial conducted using a completely randomized design. Five dietary treatments were formulated to contain 0 (control), 25, 50, 75, and 100% replacement of wheat offal with SDCRC, while all other dietary components remained constant across treatments. Each treatment had five replicates with two rabbits per replicate. Parameters measured consisted of feed intake, weight gain, feed conversion ratio, and economic indices such as feed cost per kilogram, total feed cost, cost per kilogram weight gain, and cost savings. Results showed no significant ($p > 0.05$) differences in initial weight, total weight gain, daily weight gain, daily feed intake and feed conversion ratio across the treatment groups, although final weight was significantly affected ($p < 0.05$), with rabbits on the control diet (0% SDCRC) having the highest final weight (1457.59 g). Total feed intake ranges from 4.04 to 4.19 kg, and feed cost per kilogram diet decreased progressively with increasing SDCRC levels, from ₦95.02 in the control diet to ₦63.45 in the 100% SDCRC diet. Feed cost per kilogram weight gain was lowest in the 100% SDCRC group (₦565.66) compared to the control (₦610.84). A positive cost saving of ₦45.18 was observed in the 100% SDCRC group relative to the control. In conclusion, SDCRC can effectively replace wheat offal in weaner rabbit diets up to 100% without adverse effects on performance while significantly reducing feed costs and improving economic returns.

Keywords: Rabbit, Wheat, Offal, Rumen, Content, Feed

INTRODUCTION

Rabbit production offers a rapid, efficient means of converting low-value forages and by-products into high-quality protein, making it an attractive enterprise for smallholder farmers in developing regions facing feed cost volatility and resource constraints (Shaahu *et al.*, 2024). However, feed expenses account for over 60% of total production costs, with conventional fiber sources such as wheat offal and maize bran subject to seasonal price fluctuations and supply shortages (Maina *et al.*, 2022). Consequently, there is growing interest in repurposing abattoir by-products particularly cattle rumen contents as alternative, cost-effective dietary fiber sources for monogastric livestock, including rabbits (Sibanda *et al.*, 2024). Sun-drying of bovine rumen content (SDCRC) reduces moisture to below 12% and stabilizes residual nutrients, yielding a fibrous feed ingredient with crude protein levels of 10–15% and crude fiber values up to 40% (Osita *et al.*, 2023). Studies have demonstrated that SDCRC can replace up to 30% of maize or wheat offal in rabbit diets without compromising growth performance or feed conversion ratio (FCR), thereby offering substantial feed cost savings (Osita *et al.*, 2023; Adamu *et al.*, 2022). For example, Osita *et al.* (2023) observed that weaner rabbits fed diets containing 20–30% SDCRC achieved average daily weight gains comparable to controls, with FCRs remaining within the optimal range of 3.3–3.6.

Beyond animal performance, the economic merits of SDCRC inclusion are compelling. Cost-benefit analyses indicate reductions in feed cost per kilogram by as much as 30% and net cost savings per rabbit of ₦40–₦50 when wheat offal is fully replaced by SDCRC, despite a modest decline in total weight gain at high inclusion levels (Saidu *et al.*, 2024). Similar economic advantages



have been reported in tropical settings by Maina *et al.* (2022), who documented improved profitability indices when sun-dried rumen digesta substituted maize in West African dwarf goat diets, suggesting cross-species applicability of this by-product strategy. Furthermore, the economics of rabbit production using rumen content-based diets showed variations in total feed intake, feed cost, and weight gain across different animal types (caprine, ovine, and bovine), with feed cost per kilogram of gain ranging from 137.7 N to 181.6 N depending on the dietary inclusion level (Abdullahi *et al.*, 2020). Moreover, the environmental and waste management implications of utilizing cattle rumen content are noteworthy. Abattoir rumen waste, if left untreated, contributes to pollution and greenhouse gas emissions; its incorporation into animal feeds thus embodies a circular-economy approach that valorizes waste while reducing feed-crop demand (Shaahu *et al.*, 2024). Processing methods such as sun-drying and milling not only enhance the hygienic quality of rumen content but also improve its palatability and shelf-life, ensuring consistent feed intake by rabbits (Saidu *et al.*, 2024).

Despite these promising findings, existing studies often focus on single inclusion levels or short-term performance metrics, with limited integration of comprehensive cost-benefit analyses under local production conditions (Mu'azu *et al.*, 2024). Furthermore, most research has examined SDCRC in isolation from other diet components, leaving a gap in understanding its interactive effects when replacing graded proportions of wheat offal in complete diets (Fredrick *et al.*, 2024). The present study addresses these gaps by evaluating both the productive performance and economic efficiency of weaner rabbits fed diets containing 0, 25, 50, 75, and 100% replacement of wheat offal with SDCRC. By simultaneously assessing growth and economic outcomes, this research aims to provide robust, actionable recommendations for smallholder rabbit producers seeking sustainable, low-cost feeding strategies.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Rabbitry Unit of the Bauchi State College of Agriculture, located in the Yelwan Makaranta area along the Bauchi–Dass Road, Bauchi State, Nigeria. The College lies at approximately 10°17'N latitude and 9°50'E longitude, on gently undulating terrain at about 609 m above sea level (Weather and Climate, n.d.). Bauchi State College of Agriculture is situated within the Southern Guinea Savannah agro-ecological zone, characterized by a mosaic of open grassland interspersed with *Vachellia* and *Isoberrlinia* tree species. The Rabbitry Unit comprises purpose-built wire-mesh cages arranged under open-sided sheltering structures, ensuring adequate ventilation and shade, while concrete flooring facilitates cleaning and biosecurity measures.

Sourcing and Processing of Cattle Rumen Contents

Abattoir collection

Rumen contents were collected immediately after slaughter at the Bauchi Main Abattoir. Upon incision of the rumen, contents were aseptically transferred into clean, shallow plastic containers within 15 minutes of evisceration to minimize microbial alteration. Animals were inspected by veterinary staff to ensure health status.

Initial handling and transport

Collected rumen content was kept in covered, food-grade plastic trays and transported within an insulated cooler to prevent heat accumulation and spoilage, as recommended for rumen fluid and digesta samples. Temperature during transport was monitored to remain below 25 °C to preserve substrate integrity.

Pre-drying preparation of cattle rumen contents

At the laboratory, large debris, such as undigested fibers and foreign materials were manually removed, and the material was homogenized using a stainless-steel scoop. Homogenization ensures uniform moisture distribution prior to drying, which is critical for consistent nutrient profiles.

Sun-drying of cattle rumen contents

Sun drying was conducted on raised plastic trays placed on concrete platforms to facilitate airflow beneath the trays and reduce contamination risk, for ruminal content mixtures. Material was

spread in a 3–5 cm layer depth to optimize drying rate and expose all particles to solar radiation. Trays were set outdoors at sunrise and covered indoors immediately after sunset each day to protect from nocturnal humidity and dew. Drying continued for seven consecutive days, with manual turning of the material two to three times daily to expose all surfaces and prevent mold growth. Moisture content was monitored using a portable moisture meter until $\leq 10\%$ residual moisture was achieved, signifying complete drying.

Post-drying processing and storage of cattle rumen contents

The dried, SDCRC was milled through a 2 mm mesh sieve to achieve a uniform particle size suitable for pelleting or direct mixing into diets. Ground material was then transferred into airtight, UV-resistant polyethylene bags and stored at ambient laboratory conditions (25–28 °C, <60% RH) until formulation, preventing moisture reabsorption and oxidative degradation.

Quality control and safety measures

To ensure microbial safety, samples were periodically tested for total coliform and *Salmonella* spp., following standard methods for animal feed hygiene. Chemical composition (proximate analysis) was determined on representative batches to confirm consistency in nutrient content after drying and milling.

Management of Experimental Animals

Fifty (50) weaner rabbits of mixed breeds were used for the trial, which lasted eight weeks, all rabbits received subcutaneous Ivermectin (0.2 mg/kg body weight) to control internal and external parasites, along with intramuscular administration of a broad-spectrum antibiotic, Oxytetracycline (20 mg/kg body weight). During this period, they were also fed a uniform basal diet consisting of commercial grower mash mixed with groundnut haulms to ensure health uniformity and dietary adaptation. After acclimation, the rabbits were housed individually in disinfected wire-mesh cages and provided with feed and clean drinking water *ad libitum* throughout the experimental period. Feed offered and refusals were recorded daily to determine intake, while body weights were measured weekly to monitor growth. Rabbits were observed twice daily for any signs of illness, injury, or behavioral abnormalities, and veterinary attention were provided as needed to maintain animal welfare.

Experiment Diet

Five diets (Table 1) were formulated to contain 0% (Diet 1), 25% (Diet 2), 50% (Diet 3), 75% (Diet 4) and 100% (Diet 5) replacement of wheat offal by SDCRC. All other ingredients e.g maize, soybean meal, bone meal, groundnut haulms, vitamin–mineral premix, salt, lysine, and methionine were held constant across diets or adjusted only to maintain nutrient balance.

Table 1: Composition of Experimental Diets Containing Sun-dried Cattle Rumen Contents (SDCRC) as a Replacement for Wheat Offal

| Ingredients | 1(0%) | 2(25%) | 3(50%) | 4(75%) | 5(100%) |
|----------------------------|--------------|---------------|---------------|---------------|----------------|
| Maize | 36.5 | 36.5 | 36.1 | 35.8 | 35.4 |
| Soybean meal | 10.8 | 10.8 | 11.2 | 11.5 | 11.9 |
| Wheat offal | 30.0 | 22.5 | 15.0 | 7.5 | 0 |
| SDCRC | 0 | 7.5 | 15.0 | 22.5 | 30.0 |
| Bone meal | 2 | 2 | 2 | 2 | 2 |
| Groundnut haulms | 20 | 20 | 20 | 20 | 20 |
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Methionine | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Calculated Analysis | | | | | |
| Crude Protein (%) | 16.00 | 15.90 | 15.55 | 15.98 | 15.81 |
| Crude Fibre (%) | 9.46 | 11.17 | 14.64 | 14.66 | 16.43 |
| Ether Extract (%) | 3.49 | 3.47 | 3.47 | 3.46 | 3.46 |
| Ash (%) | 4.39 | 4.42 | 4.46 | 4.49 | 4.54 |
| ME (Kcal/kg) | 2209.95 | 2238.85 | 2261.55 | 2233.40 | 2314.60 |



Experimental Design

The trial employed a completely randomized design in which fifty (50) weaner rabbits were randomly allotted to five (5) dietary treatments, each replicated five (5) times with two (2) rabbits per replicate. The treatments consisted of five inclusion levels of sun-dried cattle rumen contents (0, 25, 50, 75 and 100%) as a replacement for wheat offal in the rabbit diets. Randomization was conducted to minimize selection bias and ensure equal representation across treatments. Sample size and replication were determined to ensure sufficient statistical power for detecting significant differences in growth and feed utilization metrics among treatments.

Data Collection

Production parameters

Feed Intake

Daily feed intake for each treatment group was determined by weighing the quantity of feed offered at 08:00 h and the refusals 24 hours later. The amount consumed was calculated as the difference between feed offered and feed left over, with all measurements made to the nearest 0.1 g using a precision laboratory balance. Feed was presented fresh each morning, and trays were cleaned before refilling to prevent spoilage or contamination.

Body Weight Gain

The rabbits were weighed individually at the same time each week (± 1 h) following an overnight fast (12 h) to minimize variations due to gut fill. Body weights were recorded to the nearest 1 g using a digital scale. Weekly weight gain was calculated as the difference between successive weekly weights, and total weight gain over the eight-week trial was computed by subtracting initial weight (day 0) from final weight (day 56).

Conversion Ratio

Feed conversion ratio (FCR) for each rabbit was calculated using the equation:

$$FCR = \frac{\text{Total feed intake (FI, g)}}{\text{(WG, g)}}$$

Where:

FI represents cumulative feed consumed over the trial, and WG represents the corresponding total weight gain. FCR was expressed as grams of feed required per gram of weight gain.

Mortality

Mortality events were recorded immediately upon occurrence. The date, rabbit identification, and suspected cause (based on clinical signs or necropsy findings) were logged. Mortality rate (%) per treatment was calculated as:

$$\text{Mortality rate} = \frac{\text{Number of deaths}}{\text{Number of rabbits initially allocated}} \times 100$$

Cost-Benefit Analysis

At the conclusion of the trial, an economic evaluation was performed to determine the cost-benefit of using sun-dried cattle rumen contents (SDCRC) as a fiber source in weaner rabbit diets.

Ingredient costing

Market prices for all feed ingredients (₦/kg) were obtained from three major feed suppliers in Bauchi within one month of the trial.

Cost (₦/kg)

This is the cost per kilogram of each formulated experimental diet, based on the market price of individual ingredients:

$$\text{Feed cost (₦/kg)} = \sum_{i=1}^n (\text{inclusion Rate} \times \text{Price per Kg})$$

Where:

Inclusion Rate is the proportion of ingredient i in the diet

Price per kg is the market price of ingredient i in naira (₦)

Total Feed Cost (₦)

This is the total amount spent on feed per rabbit throughout the feeding trial:



$$\text{Total Feed Cost (₦)} = \text{Feed Intake (Kg)} \times \text{Feed Cost (₦/Kg)}$$

Where:

Feed Intake is the cumulative amount of feed consumed by each rabbit (or average per treatment group) during the experimental period (kg)

Feed Cost per Kilogram Gain (₦/kg gain)

This is the economic efficiency indicator showing how much was spent on feed to produce one kilogram of weight gain:

$$\text{Feed Cost (₦/kg gain)} = \frac{\text{Total Feed Cost (₦)}}{\text{Total Weight Gain (Kg)}}$$

Where:

Total Weight Gain is the difference between final and initial body weights of the rabbit over the trial (in kg)

Cost Saving per Rabbit (₦)

This shows the reduction in feed cost compared to the control diet (usually 0% SDCRC). The control diet serves as the reference.

$$\text{Cost Saving per rabbits (₦)} = \text{Feed Cost at 0\% SDCRC} - \text{Cost at test diet inclusion\%}$$

Where:

- Feed Cost at 0% SDCRC is the total feed cost per rabbit on the control diet.
- Feed Cost at test diet % SDCRC is the total feed cost per rabbit on a diet containing a given level of SDCRC

Data Analysis

All quantitative data collected throughout the study, including feed intake, weight gain, feed conversion ratio, and mortality rates, were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) version 23.0 (2015). The data were analyzed using one-way Analysis of Variance (ANOVA) to determine the existence of statistically significant differences among the various dietary treatments. Where significant differences ($p < 0.05$) were observed, the means were separated using Duncan's Multiple Range Test (DMRT) to identify which treatment groups differed from each other. Results were presented as mean values with their respective standard errors (Duncan, 1955).

RESULTS

Growth Performance and Costs-Benefit of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-dried Cattle Rumen Contents as a Replacement for Wheat offal

Table 2 showed the performance of weaner rabbits fed diets containing graded levels of sun-dried cattle rumen contents as a replacement for wheat offal. The result revealed that, initial body weights of the weaner rabbits did not differ significantly ($p > 0.05$) across all treatment groups. The mean initial weights ranged from 800.47 g in the 100% SDCRC group to 850.22 g in the 25% SDCRC group. The result further indicated a significant difference ($p < 0.05$) in final body weight of the rabbits across the different diets. The control group (0% SDCRC) had the highest final weight (1457.59 g), which was significantly higher than the other groups. The 25% SDCRC group had the second-highest final weight (1408.68 g), while the 50% and 75% SDCRC groups had progressively lower final weights, with values of 1372.01 g and 1289.04 g, respectively. The lowest final weight (1308.42 g) was recorded in the 100% SDCRC group. There was no significant difference ($p > 0.05$) in total weight gain across the treatments. Total weight gain ranged from 474.61 g in the 100% SDCRC group to 633.88 g in the 0% SDCRC group. The total feed intake varied significantly ($p < 0.05$) across the different treatments. The total feed intake was highest in the 100% SDCRC group (4194.19 g) and lowest in the 25% SDCRC group (4118.03 g). The feed intake in the other treatment groups (50% and 75% SDCRC) ranged from 4047.56 g to 4102.62 g. The daily weight gain was not significantly different ($p > 0.05$) across the treatments. The daily weight gain ranged from 72.19 g in the 50% SDCRC group to 74.89 g in the 100% SDCRC group, with no significant variations across the groups. Daily feed intake also did not show significant differences ($p > 0.05$) across the treatment groups. The

daily feed intake ranged from 8.49 g in the 75% SDCRC group to 11.32 g in the 0% SDCRC group, with no significant variation between the groups. The feed conversion ratio (FCR) did not differ significantly ($p>0.05$) among the treatment groups. FCR values ranged from 6.44 in the control (0% SDCRC) group to 8.69 in the 75% SDCRC group.

Table 2: Performance of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-dried Cattle Rumen Contents as a Replacement for Wheat offal

| Parameters | Diets | | | | | SEM |
|-----------------------|----------------------|-----------------------|-----------------------|----------------------|-----------------------|---------|
| | 1(0%) | 2(25%) | 3(50%) | 4(75%) | 5(100%) | |
| Initial weight (g) | 823.71 | 850.22 | 841.56 | 813.52 | 800.47 | 12.97NS |
| Final weight (g) | 1457.59 ^a | 1408.68 ^{ab} | 1372.01 ^{bc} | 1289.04 ^d | 1308.42 ^{cd} | 18.81* |
| Total weight gain (g) | 633.88 | 558.46 | 530.47 | 475.52 | 474.61 | 21.26NS |
| Total feed intake (g) | 4047.56 | 4118.03 | 4043.74 | 4102.62 | 4194.19 | 37.31* |
| Daily weight gain (g) | 72.28 | 73.53 | 72.19 | 73.26 | 74.89 | 0.67NS |
| Daily feed intake (g) | 11.32 | 9.97 | 9.47 | 8.49 | 9.07 | 0.37NS |
| Feed conversion ratio | 6.44 | 7.52 | 7.62 | 8.69 | 8.39 | 0.30NS |

^{abcd} - Means bearing different superscripts within a row are significantly different ($p<0.05$) SEM - Standard error of means NS -Not significant ($p>0.05$)

Cost-Benefit Analysis of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-Dried Cattle Rumen Contents (SDCRC) as a Replacement for Wheat Offal

Table 3 showed the cost-benefit analysis of weaner rabbits fed diets containing graded levels of sun-dried cattle rumen contents (SDCRC) as a replacement for wheat offal. The result showed that, total feed intake ranged from 4.04 kg (50% SDCRC) to 4.19 kg (100% SDCRC). Feed cost per kilogram decreased progressively with increasing SDCRC inclusion, from ₦95.02 in the control (0% SDCRC) to ₦63.45 at 100% replacement. Similarly, the total feed cost per rabbit reduced from ₦384.83 (control) to ₦265.86 (100% SDCRC). Weight gain declined with increasing SDCRC levels, from 0.63 kg in the control group to 0.47 kg at 100% replacement. The feed cost per kilogram of weight gain did not follow a linear trend. While the control group had a feed cost of ₦610.84/kg gain, the value was slightly higher in the 25%, 50%, and 75% SDCRC groups. However, the 100% SDCRC group had the lowest cost per kg gain (₦565.66). Cost savings were calculated relative to the control group. The 100% SDCRC group had a positive cost saving of ₦45.18 per rabbit, while the 25%, 50%, and 75% groups recorded negative cost savings (i.e., higher cost per kg gain than control), with the 75% group performing the worst (₦-68.31).

Table 3: Cost Benefit Analysis of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-dried Cattle Rumen Contents as a Replacement for Wheat Offal

| Parameters | Diets | | | | |
|------------------------|--------|--------|--------|--------|---------|
| | 1(0%) | 2(25%) | 3(50%) | 4(75%) | 5(100%) |
| Total feed intake (kg) | 4.05 | 4.12 | 4.04 | 4.10 | 4.19 |
| Feed cost (N/kg) | 95.02 | 83.24 | 81.51 | 79.51 | 63.45 |
| Total feed cost (N) | 384.83 | 342.95 | 329.30 | 325.99 | 265.86 |
| Total weight gain(kg) | 0.63 | 0.56 | 0.53 | 0.48 | 0.47 |
| Feed cost (N/kg gain) | 610.84 | 612.41 | 621.32 | 679.15 | 565.66 |
| Cost saving (N) | | -1.57 | -10.48 | -68.31 | 45.18 |

DISCUSSION

Growth Performance of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-dried Cattle Rumen Contents (SDCRC) as a Replacement for Wheat Offal

The present study evaluated the growth performance of weaner rabbits fed diets containing graded levels of sun-dried cattle rumen contents (SDCRC) as a replacement for wheat offal. The results, as shown in Table 2, provide critical insights into the effects of SDCRC inclusion on key



growth performance indicators, including initial body weight, final body weight, total weight gain, feed intake, and feed conversion ratio (FCR).

The absence of significant difference ($p > 0.05$) observed in the initial body weight of rabbits across all treatment groups suggests that the animals started the feeding trial from a uniform baseline. This uniformity is critical for ensuring the reliability of subsequent comparisons in growth performance. It indicates that any differences observed in growth performance parameters, such as final body weight or total weight gain, can be attributed to the dietary interventions rather than pre-existing weight disparities (see Table 2). This finding supports the robustness of experimental design and reflects the consistency observed in similar studies by Saidu *et al.* (2024), who also reported no significant differences in initial body weight when different levels of sun-dried sheep rumen content replaced wheat offal.

A significant ($p < 0.05$) decline in final body weight was observed with increasing levels of SDCRC, with the highest weight recorded in the control group (0% SDCRC) and the lowest in the 75% replacement group. This trend suggests that excessive inclusion of SDCRC may have adverse effects on the final body weight of weaner rabbits. A similar pattern was documented by Okpanachi *et al.* (2010), who reported a decline in the final body weight of rabbits fed higher levels of sun-dried bovine rumen content (SBRC). However, it is noteworthy that total weight gain did not exhibit significant differences ($p > 0.05$) across treatments, indicating that while final body weights varied, the overall growth trajectory remained relatively stable (see Table 2). This observation is consistent with the findings of Osita *et al.* (2023), who found no significant negative impact on growth performance when maize was replaced by sun-dried bovine rumen content at varying inclusion levels.

Furthermore, Saidu *et al.* (2024) observed similar trends where different inclusion levels of sun-dried rumen content did not significantly affect weight gain. Interestingly, Adamu *et al.* (2022) observed that moderate inclusion (30%) of SBRC enhanced total weight gain in rabbits, which further underscores that moderate inclusion levels of rumen content may be optimal for maintaining growth performance. Despite the observed differences in final body weight, the total weight gain did not significantly vary across treatment groups. This finding suggests that, while long-term growth responses (i.e., final weight) were influenced by higher levels of SDCRC, the overall short-term growth, as measured by total weight gain, remained unaffected. This aligns with Okpanachi *et al.* (2010), who reported no significant differences in total weight gain when different levels of SBRC were included in rabbit diets. In contrast, Adamu *et al.* (2022) observed a decline in both final body weight and total weight gain at higher SBRC inclusion levels (40%), which is similar to the trend observed in the current study, where excessive inclusion (75%) of SDCRC led to a reduction in final body weight, though total weight gain remained consistent (see table 2).

Both daily weight gain and daily feed intake did not exhibit significant differences across the treatment groups. This consistency suggests that the inclusion of SDCRC up to 100% did not impair the daily growth rate or feeding behavior of the weaner rabbits. The stability in daily weight gain corroborates findings by Osita *et al.* (2023), who reported that sun-dried bovine rumen content could replace maize in rabbit diets without detrimental effects on daily growth performance. This also aligns with the work of Adamu *et al.* (2022) and Okpanachi *et al.* (2010), who documented non-significant differences in daily weight gain despite variations in feed composition. These findings support the idea that rumen content, as an ingredient, can provide a sustainable and adaptable feed resource without negatively impacting short-term growth rates. Total feed intake showed a statistically significant increase ($p < 0.05$) with higher levels of SDCRC, peaking at the 100% replacement group (see table 2). This increase in feed intake is likely a compensatory response to the lower energy density of SDCRC compared to wheat offal. Rabbits may consume more feed in an effort to meet their energy requirements when fed diets containing higher levels of SDCRC. Such compensatory feeding behavior has been observed in the study of Saidu *et al.* (2024), who reported similar trends in feed intake with increasing levels of sun-dried sheep rumen content.

Despite the increased feed intake at higher SDCRC levels, the feed conversion ratio (FCR) did not differ significantly among treatment groups. The FCR indicates the efficiency with which rabbits convert feed into body weight. While the control group exhibited the best feed conversion



efficiency, the other groups showed relatively similar FCR values, indicating that the efficiency of feed utilization remained consistent across the dietary variations. This suggests that while rabbits increased their feed intake to meet energy needs, their ability to convert feed into body weight remained unaffected by the inclusion of SDCRC, regardless of the inclusion level (see table 2). This is consistent with the findings of Adamu *et al.* (2022), who observed no significant changes in FCR with increasing levels of SBRC. Furthermore, Okpanachi *et al.* (2010) also found that while average daily feed consumption increased with higher inclusion levels, the FCR remained statistically unchanged, mirroring the current study's outcome.

Cost-Benefit Analysis of Weaner Rabbits Fed Diets Containing Graded Levels of Sun-Dried Cattle Rumen Contents (SDCRC) as a Replacement for Wheat Offal

The cost-benefit analysis of feeding weaner rabbits diets containing graded levels of sun-dried cattle rumen contents (SDCRC) as a replacement for wheat offal revealed significant cost savings, demonstrating the economic potential of SDCRC as a viable feed ingredient for rabbit production. The total feed intake (4.04–4.19 kg) was similar across treatments, aligning with the reports of Adamu *et al.* (2022), who found that rabbits maintained consistent feed consumption when sun-dried bovine rumen content (SBRC) replaced wheat offal up to 30% inclusion (4.28–4.56 kg). Likewise, Saidu *et al.* (2024) observed constant weekly feed consumption (428–559 g/week) across graded SBRC levels, indicating that palatability and bulk intake were not compromised (see table 3). Feed cost per kilogram of diet decreased markedly from ₦95.02 at 0% SDCRC to ₦63.45 at 100% SDCRC. This trend aligns with the findings of Okpanachi *et al.* (2011), who reported feed costs declining from ₦85 to ₦60 per kg when SBRC inclusion increased from 0% to 40%. The reduction reflects the lower market price of rumen content compared to processed wheat offal, corroborating the economic advantage of incorporating animal by-products into rabbit diets (Fredrick *et al.*, 2024). Total feed cost per rabbit ranged from ₦265.86 (100% SDCRC) to ₦384.83 (0% SDCRC). Despite lower total weight gain at higher inclusion levels (0.47–0.63 kg), the cost per kilogram of gain showed an unexpected dip at 100% SDCRC (₦565.66), compared to the control (₦610.84). Similar non-linear cost–gain relationships were documented by Adamu *et al.* (2022), who found the lowest cost per kg gain (₦450) at 30% SBRC, despite reduced gains at 0% and 50% inclusion levels. Conversely, Okpanachi *et al.* (2010) reported a steady increase in cost per kg gain (₦550–₦700) with increasing SBRC levels, attributing this to diminished nutrient digestibility at high inclusion rates (see table 3). The disparity in cost–gain trends highlights the importance of feed formulation, processing methods, and nutrient balancing when using rumen content. Cost savings relative to the control diet were minimal or negative at 25% (–₦1.57) and 50% (–₦10.48) inclusion levels, but substantial savings (₦45.18) were realized at 100% SDCRC (see table 3). This pattern mirrors the findings of Saidu *et al.* (2024), who reported significant net savings only at the highest SBRC inclusion (559 g/week feed consumption; cost savings ₦40/rabbit). In contrast, moderate inclusion levels (10–30%) generally yielded better growth performance and moderate cost benefits in Adamu *et al.* (2022) and Cherdthong *et al.* (2014) studies on cattle, underlined species-specific responses to rumen-based diets. The steep cost savings at 100% replacement, despite lower weight gains, suggest that in contexts where feed ingredient availability and cost constraints are severe, full replacement with SDCRC could be economically viable, especially for smallholder producers seeking to minimize cash outlays.

CONCLUSION AND RECOMMENDATION

Sun-dried cattle rumen contents can replace wheat offal up to 100% in weaner rabbit diets without negatively affecting growth performance, and it is recommended as a cost-effective alternative feed ingredient for improved economic returns. Future studies should investigate the long-term health effects, nutrient digestibility, and carcass characteristics of rabbits fed sun-dried cattle rumen contents, as well as explore its use in breeding stock and different animal species to enhance sustainable livestock production.



REFERENCES

- Abdullahi, A. M., Maidala, A., Doma, U. D., Lawan, A., Abdullahi, U., Chana, I. M., Makinde, O., Oyawoye, E., & Tamburawa, M. S. (2020). Carcass yield and economics of production of growing rabbits (*Oryctolagus cuniculus*) fed different types and levels of rumen content. In *Proceedings of the 45th Annual Conference of the Nigerian Society for Animal Production (NSAP)* (pp. 1062–1069). Bauchi, Nigeria.
- Adamu, N., Bazam, A., Sani, I., Jama'a, N. A., Muhammad, A. S., & Maikano, Y. (2022). Growth performance and cost benefit of weaner rabbits fed graded levels of sun-dried bovine rumen content. In *Proceedings of the 27th Annual Conference of the Animal Science Association of Nigeria (ASAN)* (pp. 743–746). Bauchi, Nigeria
- Cherdthong, A., Wanapat, M., Saenkamsorn, A., Waraphila, N., Khota, W., Rakwongrit, D., Anantasook, N., & Gunun, P. (2014). Effects of replacing soybean meal with dried rumen digesta on feed intake, digestibility of nutrients, rumen fermentation and nitrogen use efficiency in Thai cattle fed on rice straw. *Livestock Science*, **169**: 71–77. <https://doi.org/10.1016/j.livsci.2014.09.008>
- Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, **11**(1): 1–42. <https://doi.org/10.2307/3001478>
- Fredrick, U. U., Chika, E. O., Augustine, A. O., Adewole, A. T., & Francis, L. B. (2024). Nutrient digestibility and physiological parameters of crossbreed weaner rabbits provided dehydrated bovine rumen digesta. *International Journal of Veterinary Science*, **13**(6): 757–765. <https://doi.org/10.47278/journal.ijvs/2024.180>
- Maina, A., Makinde, O. J., Mohammed, C., Bagudu, I. A., & Husa, H. (2022). Dried rumen waste as feedstuff for growing rabbits. *International Journal of Science and Technology Research Archive*, **2**(2), 95–102. <https://doi.org/10.53771/ijstra.2022.2.2.0044>
- Mishra, J., Abraham, R. J., Rao, V. A., Rajini, R. A., Mishra, B. P., & Sarangi, N. R. (2015). Chemical composition of solar dried blood and the ruminal content and its effect on performance of Japanese quails. *Veterinary World*, **8**(1): 82–87. <https://doi.org/10.14202/vetworld.2015.82-87>
- Mu'azu, M. S., Bello, K. M., Muhammad, A. S., Egbo, M. L., & Jatutu, S. S. (2024). Effects of replacing wheat offal with sun-dried cattle rumen contents on hematology and serum biochemistry of weaner rabbits. *Nigerian Journal of Agriculture and Agricultural Technology*, **4**(3): 48–52. <https://doi.org/10.59331/njaat.v4i3.775>
- Okpanachi, U., Aribido, S. O., Daikwo, I. S., *et al.* (2010). Growth and haematological response of growing rabbits to diets containing graded levels of sun-dried bovine rumen content. *African Journal of Food, Agriculture, Nutrition and Development*, **10**(11): 4444–4457.
- Osita, C. O., Ezenwosu, C., Odum, N. C., & Ani, A. O. (2023). Growth performance, nutrient digestibility, and organ characteristics of weaner rabbits fed sun-dried bovine rumen content as a replacement for maize. *Journal of Agriculture, Food, Environment and Animal Sciences*, **4**(2): 137–149. Retrieved from <https://www.jafeas.com/index.php/j1/article/view/65>
- Saidu, I., Mbap, S. T., Abubakar, M. M., Bello, K. M., Yakubu, N., Muazu, S. M., & Sa'id, M. (2024). Performance and economics of production of weaner rabbits fed with sun-dried sheep rumen contents as a replacement for wheat offal. *Nigerian Journal of Animal Production*, **11**: 1167–1169. <https://doi.org/10.51791/njap.vi.6741>
- Shaahu, D. T., Ojabo, L. D., & Ityokaa, T. E. (2024). Effects of graded levels of sun-dried cattle rumen digesta on growth performance and economics of producing growing rabbits. *Agricultural Science: An International Journal (AGRIJ)*, **1**(2): 63–73. Retrieved from <https://airccse.com/agrij/papers/1224agrij08.pdf>
- Sibanda, B., Moyo, M. T., & Mugoti, A. (2024). Effects of feeding sun-dried bovine rumen contents on growth and carcass quality of New Zealand White rabbits. *Bulgarian Journal of Animal Husbandry*, **61**(3): 39–47.
- SPSS Inc. (2015). *IBM SPSS Statistics for Windows* (Version 23.0). IBM Corp.
- Weather and Climate. (n.d.). Average temperature and precipitation by months and years: Bauchi. Retrieved May 2, 2025, from <https://www.weatherandclimate.eu/history/65055>