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# Effects of feeding sun-dried bovine rumen contents on growth and carcass quality of New Zealand White rabbits

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**Abstract:** This research study aimed to investigate the impact of sun-dried bovine rumen contents (SDBRC) on the growth and linear body measurements of New Zealand White rabbits. The experimental rabbits (n=12) were selected from four New Zealand White bucks and subsequently allocated into three distinct treatments, each with specific dietary compositions. The control group was provided with a standard diet of rabbit pellets, while the experimental groups received rabbit pellets supplemented with 30% (Treatment A) and 40% (Treatment B) of SDBRC. All animals were subjected to consistent and meticulous livestock management practices throughout the 12-week experimental period. There were no significant differences in the growth of rabbits given rabbit pellets and 30% SDBRC. However, the live weight gain and final weights of rabbits on 40% SDBRC inclusion were significantly lower than the 30% SDBRC inclusion and the control ($P<0.05$). Parameters, such as total feed intake, feed conversion ratio, and dressing percentage were not significantly different ($P>0.05$). The linear body measurements (heart girth, body length, and abdominal circumference), were not significantly ($P>0.05$) influenced by dietary variations. Carcass weight for the rabbits on 40% SDBRC inclusion was significantly lower than for rabbits on the control and 30% SBDRC inclusion diets ($p=0.001$). Other carcass parameters such as meat colour and pH exhibited no significant differences across all three treatments ($p>0.05$). These findings highlight the promising potential of incorporating SDBRC into rabbit diets, particularly up to 30%, without compromising growth performance and carcass characteristic.

**Keywords**: Rabbit; Animal by-products; Feed intake; Sustainable agriculture; sun-dried bovine rumen contents (SDBRC)

## INTRODUCTION

In recent years, alternative feed sources have garnered increasing attention as potential components of livestock diets, aiming to enhance animal growth and carcass quality while optimizing resource utilization (Ndudzo *et al.,* 2023). Among these alternatives, sun-dried rumen contents have emerged as a potential feed ingredient due the presence of partially digested feed. An animal by-product known as sun-dried bovine rumen content (SDBRC) is created when the animal's rumen is split open after slaughter and retrieved in abattoirs (Okpanachi *et al.,* 2010). Saliva microorganisms, digested feed at varying stages of decomposition, and the byproducts of their metabolic activities, including proteins, peptides, amino acids, lipids, vitamins, and volatile fatty acids (VFA), make up the content of rumen. However, there may be variations in the percentages of each component of the rumen content thus making its quality variable. This may be due to the quality of feed availed to the animals or it may be due to the stage of degradation of the feedstuffs at the time of slaughter (Okpanachi *et al.,* 2010).

Legislations and regulations surrounding animal by-products vary globally. In the European Union, for instance, the use of animal by-products is regulated by the European Commission's Regulation (EC) No 1069/2009, which sets guidelines for their safe use in animal feed. Similarly, in the United States, the Food and Drug Administration (FDA) regulates animal by-products under the Federal Food, Drug, and Cosmetic Act (FAO, 2022). In Zimbabwe, the Fertilizers, Farm Feeds and Remedies Act of 1996 governs the registration and use of farm feeds, restricting the use of ruminant by-products in ruminant diets. According to the Act, feeding ruminant by-products to ruminants is prohibited. The definition of ruminant, for the purposes of the regulations, is 'any cloven-hoofed cud-chewing animal' (Thomson & Penrith, 2011). Despite these restrictions, sun-dried rumen contents can be utilized as alternative feed for non-ruminant species like pigs, poultry, and rabbits. Rabbit production has gained popularity in Zimbabwe as evidenced by the formation of Zimbabwe Commercial Rabbit Breeders Association (ZICORBA) (Tembachako & Mrema, 2016; Herald, 2021) and globally, with the Food and Agriculture Organization (FAO) promoting rabbit meat as a sustainable and climate-resilient protein source (FAO, 2020).

Many developing countries have been greatly affected by the effects of climate change resulting in calls for an increased supply of animal protein to meet dietary requirements (Mugoti *et al.,* 2022). Consumers currently face a high cost of meat and meat products from beef, poultry, and pork. Also, the high demand for animal protein cannot be met by large animals alone, as they are limited by their long production cycles**.** The necessity of investigating alternative, less frequent, but potentially valuable sources of animal protein, like rabbits, is further supported by Okpanachi *et al.* (2010).

Large volumes of rumen content wastes generated on a daily basis at abattoirs create disposal challenges (Uddin *et al.,* 2018). The option to use the waste as feed for livestock, is one way of disposal that can be explored. In a survey on the use of sun-dried goat rumen contents in livestock in Uganda about 36% of respondents were reported to use dried rumen contents in pig and poultry layer rations (Robert *et al.,* 2020). Therefore, indicating a high potential for use in monogastrics including rabbits. Rabbits are hindgut fermenters and they can be fed ruminant by-products with minimum risk of disease transfer to the rabbits. Utilization of rumen contents as rabbit feed may play a role in reducing high feed costs associated with the use of commercial feeds, as well as provide an environmentally friendly option for disposing of the abattoir waste. Therefore, the objective of the study was to determine the effects of sun-dried bovine rumen contents on the growth and carcass characteristics of New Zealand White rabbits.

## MATERIALS AND METHODS

### Study area

The study was carried out at Jabula Batoka Secondary School, which is located along Bulawayo - Victoria Falls Road, in Hwange. The area is in Matabeleland North province of Zimbabwe and in natural region IV, coordinates of the area are latitude 18° 3′ 0″ S longitude 26° 15′ 0″ E. The area falls under the Savannah climate and the altitude and rainfall patterns favour woodlands and grasslands. Rains are generally low but peak in summer. Rainy summers stretch from mid-November to mid-March. Winter periods are generally dry. Temperatures easily reach 35°C and October is the hottest month of the year.

### Experimental design and layout

The study was conducted in the form of an experiment using a Completely Randomised Block Design (CRBD), where the doe was used as a blocking factor. The design had three treatments and four blocks and thus 12 experimental units. Experimental rabbits were selected from four does with three male rabbits being selected from each doe. The rabbits from each doe were distributed across the three treatments. Cattle under feedlot system were slaughtered and their rumen contents collected for use in the study.

### Preparation of diets

The rumen content (with fluid) was collected and put into perforated bags to drain. The drained rumen content was then sun-dried to preserve and, in the process, eliminate disease-causing agents. The drying process was done to remove moisture from rumen content, such that microorganisms (bacteria, yeasts, and molds) were less likely to grow. The rumen content was placed on iron sheets, well spread into thin layers and sun-dried for 4 days. The sun-dried bovine rumen content was milled and then incorporated with rabbit pellets at 30 and 40% inclusion levels for treatment A and B, respectively. The control feed comprised of commercial rabbit pellets.

### Management of the experiment

Twelve New Zealand white bucks that were four weeks old were used in the study. Weighing was done before the administration of the treatments and this was to ensure that each block has rabbits of the same mass. The rabbits had mean initial weights of 0,81kg for the control and 30% SDBRC treatments and 0,85kg for the 40% SDBRC treatment. The experimental rabbits were sourced from Batoka Secondary School. The rabbits were weighed, dosed with pyrazine and given multi-vitamins. Each rabbit was tagged with a number to differentiate them during data collection. The rabbits were housed in a cage subdivided into 12 compartments with each rabbit randomly allocated a compartment. Cleaning and disinfection of the cage and the entire house was done two weeks before the arrival of the rabbits. The cage had sliding trays below each compartment, to collect animal droppings and to ensure dryness and cleanliness of the cage.

Rabbit pellets and SDBRC were analysed for the following nutrient composition parameters, dry matter (DM), crude protein (CP), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), and ether extract (EE).

The nutrient composition of the two experimental diets were from the values a of sun-dried rumen contents and rabbit pellets and are shown in Table 1.

The four-week-old male rabbits were fed for 12 weeks starting with feeding at 3% of their body and thereafter increasing feed offered by 10% of the previous day's feed intake. Borehole water was offered *adlibitum*. Routine monitoring of feed and water levels was made three times a day (in the morning, afternoon, and evening). To maintain the optimal health and well-being of the rabbits, close monitoring of various environmental factors was implemented throughout the experiment.

## DATA COLLECTION

### Feed Intake and Growth

Feed intake was measured daily and growth was measured through weekly body weight and linear body measurements. Linear body measurements taken were chest girth, body length, nose-to-shoulder length, and abdominal circumference. Measurements were taken every week until slaughter at 16 weeks of age.

**Table 1.** Nutrient composition of Rabbit pellets, SDBRC and composite diets (g/kg DM)

| Laboratory Analysis | Nutritional Composition | | | |
|---|---|---|---|---|
| | Rabbit Pellets | SDBRC | 30% SDBRC | 40% SDBRC |
| Dry matter (g/kg) | 922.3 | 913.6 | 918.2 | 933.4 |
| Crude protein | 178.3 | 128.1 | 163.2 | 158.2 |
| Neutral detergent fibre | 379.1 | 772.8 | 497.2 | 536.6 |
| Acid detergent fibre | 163.7 | 484.8 | 260.0 | 292.1 |
| Hemicellulose | 215.4 | 288.0 | 237.2 | 244.5 |
| Ether extract | 64.1 | 31.3 | 54.3 | 51.0 |
| Ash | 84.7 | 94.8 | 87.7 | 88.7 |

**Carcass Measurements**

Rabbits were slaughtered after 12 hours without feed. Rabbits were weighed before slaughter to get the live weight. The slaughter process included stunning, bleeding, evisceration, and chilling. Stunning was achieved by hitting the back of the rabbit with a heavy object. Bleeding was done by cutting the jugular vein in the neck. Animals were allowed to bleed for about 90 seconds. Intestines and other internal organs were removed, followed by chilling at $4^0$C using a refrigerator. The following parameters were measured: dressing percentage, feed conversion efficiency, and carcass quality.

The dressing percentage was determined using the following formula:

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Final Live weight}} \text{ x } 100\%$$

Feed conversion efficiency was determined using the formula:

$$\text{Feed conversion ratio} = \frac{\text{total weight of feed}}{\text{Final weight of rabbits} - \text{initial weight of rabbits}}$$

**Carcass parameters**

Meat colour and ultimate pH were determined. Meat colour was observed within 10 minutes after slaughter using HunterLab Miniscan EZ4500 (HunterLab) colorimeter. Meat colour focused on the lightness and yellowness of the longissimus muscle and also on the general meat redness. Guidelines from the international colour evaluation described in the American Meat Science Association (AMSA, 2012) were used. Meat pH was determined 24 hours after slaughter using Horiba Meter LAQUAact PH-110. The instrument was calibrated before use with the standard buffer solutions of pH 4 and 10. The pH of the longissimus muscle was measured by piercing the probe into the meat sample to a depth of about 10 mm.

## DATA ANALYSIS

The obtained data was put through tests for equality of variance and normality using Levene's and Shapiro-Wilk tests, respectively. After that, the data was run through an analysis of variance. Then, at the 5% level of significance, means were separated using the Duncan Least Significant Difference (LSD).

## RESULTS AND DISCUSSION

**Feed intake and growth of rabbits fed with different inclusion levels of sundried rumen contents**

Total feed intake was not significantly different (P>0.05) across the dietary treatments as shown in Table 2. Feed intake ranged from 4.72kg to 5.85kg per rabbit. Both the final live-weights and live-weight gain of rabbits were not significantly different for the control and 30% SDBRC diets, but were significantly higher than those fed on 40% SDBRC diet (Table 2). There were no significant differences in feed conversion ratios (P>0.05).

**Table 2.** Feed intake and growth of rabbits fed with different levels of Sundried bovine rumen contents (SDBRC)

| Parameter | Treatments | | | | |
|---|---|---|---|---|---|
| | 0%SDBRC | 30%SDBRC | 40% SDBRC | P-value | LSD |
| Total feed intake (kg) | 5.85 | 5.85 | 4.72 | 0.279 | 2.07 |
| Final live-weight (kg) | 2.20[a] | 2.15[a] | 1.91[b] | 0.000 | 0.08 |
| Live-weight gain (kg) | 1.35[a] | 1.34[a] | 1.10[b] | 0.000 | 0.07 |
| FCR | 4.33 | 4.35 | 3.85 | 0.402 | 1.09 |

*SDBRC= Sundried Bovine Rumen Content. LSD = Least Significant Difference, ab = Means in the same row with different superscripts are significantly different (P<0.05).*

Changes in linear body measurements as estimated by the Gompertz growth model are shown in Figures 1 to 4. The rabbits' growth curves showed that rabbits fed with pellets only, had the highest growth rate followed by rabbits fed with 30% and 40% SDBRC inclusion levels, respectively. According to the model, the growth rate was high in the first 9 weeks (Figure 1).

**Linear measurements of rabbits fed with different inclusion levels of SDBRC**

Figures 2 through 4 display the linear measurement findings. All linear body parameters taken into consideration in this investigation showed no significant differences between rabbits fed with varying inclusion amounts of SDBRC. Heart girth at week 16 varied between

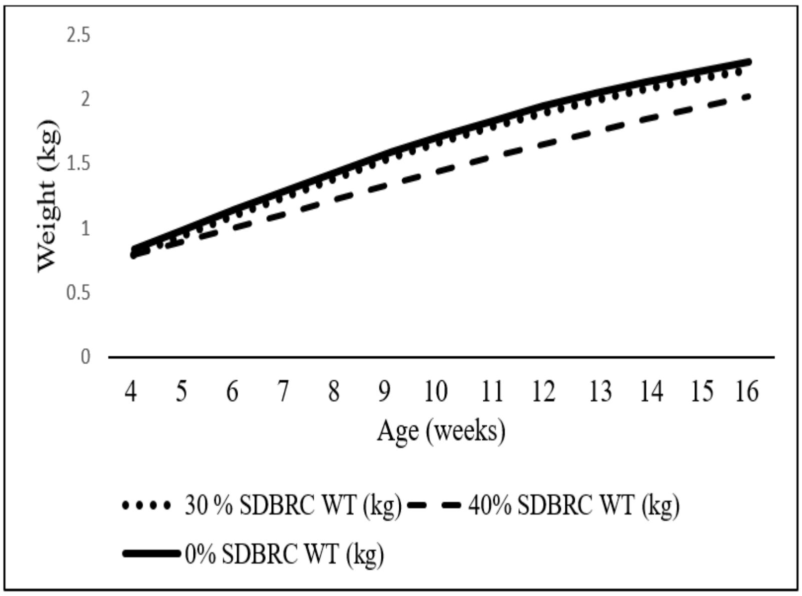


**Figure 1**. Live weights of rabbits fed with different inclusion levels of SDBRC

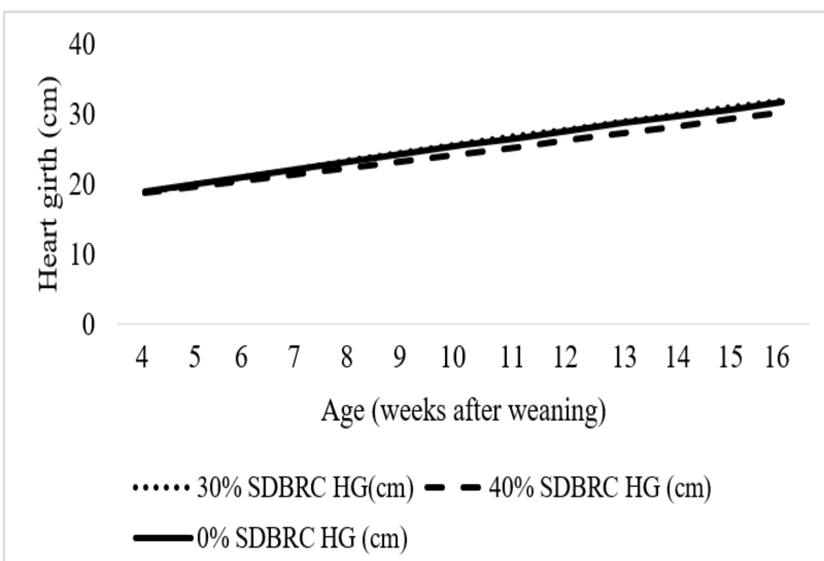


**Figure 2**. Heart girth of rabbits from 4 weeks to 16 weeks

28.1 and 30.9 cm for all dietary regimens (Figure 2).

The results for final body length ranged between 28.8cm and 29.3cm across the dietary treatments as shown in Figure 3.

Abdominal circumference ranged between 30.5cm to 31.9cm across the dietary treatments, as shown in Figure 4.

**Carcass parameters of rabbits fed on rabbit pellets with different inclusion levels of sundried rumen contents**

There were significant differences ($P<0.05$) in carcass weights of rabbits fed different diets with different levels of sundried rumen contents (Table 3).

There were no significant differences in the dressing percentage of slaughtered rabbits across

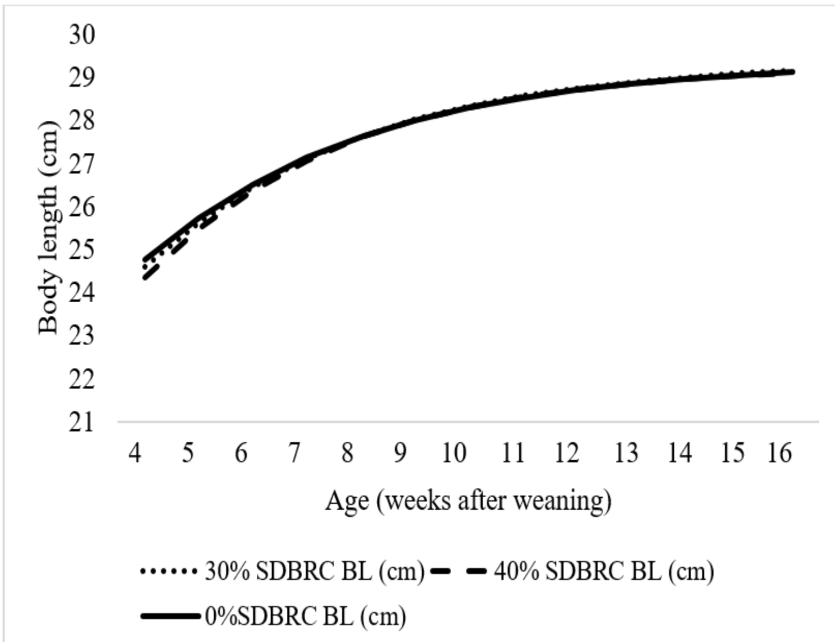


**Figure 3**. Body length of rabbits from 4 weeks to 16 weeks

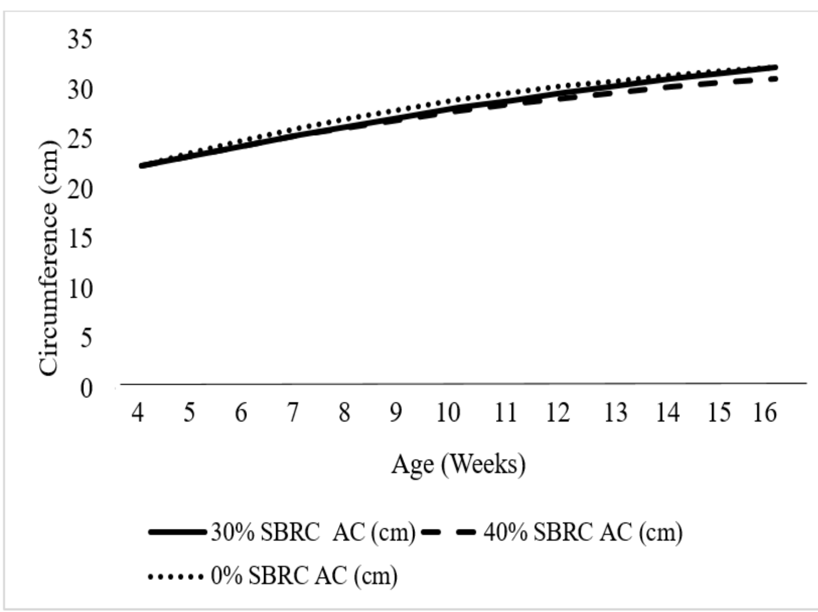


**Figure 4.** Abdominal circumference of rabbits from 4 weeks to 16 weeks

**Table 3.** Carcass quality of rabbits fed commercial pellets with different levels of sundried bovine rumen contents (SDBRC)

| Parameter | Diets | | | | |
|---|---|---|---|---|---|
| | 0%SDBRC | 30%SDBRC | 40% SDBRC | P-value | LSD |
| Carcass weight (kg) | 1.30[a] | 1.24[a] | 1.05[b] | 0.001 | 0.10* |
| Dressing % | 58.80 | 57.50 | 56.00 | 0.050 | 2.42 |
| Meat color | White | White | White | - | - |
| Meat pH | 5.70 | 5.60 | 5.60 | 0.983 | 0.62 |

*SDBRC= Sundried Bovine Rumen Content. LSD = Least Significant Difference. * = Significant (P<0.05). ab = Means on the same row with different superscripts are significantly different (P<0.05).*

the three dietary treatments. Rabbit meat had a uniform white meat color across the three dietary treatments. There were also no significant differences in the meat pH of rabbits across the three dietary treatments.

### Feed intake and growth

The total feed intake in the range of 4.72kg – 5.85kg which translate to a range of 56 to 69 g / rabbit/day are in line with values of 61-79.9g/rabbit/day of rabbits fed SDBRC in Nigeria (Okpanachi *et al.,* 2010).The significantly higher intake of the control diet and diet with 30% SDBRC inclusion levels than that of the diet with 40% SDBRC could be explained by the acid detergent fibre component of the earlier diets, which were within an acceptable range of 15 to 25 % of the feed (Tisch, 2006). The growth of the rabbits as reflected in final liveweights and liveweight gains could have been enhanced by water-soluble vitamin complement from the rumen contents as a result of their synthesis during microbial fermentation in the rumen (McDonald *et al.,* 2010).

### Linear Body Measurements (LBMs)

The range of values for heart girth (28.1cm-30.9cm) recorded in this study, is similar to 27.54 to 36cm range reported by Ajayi and Oseni (2012). Adeyemo *et al.* (2014) also reported a similar range of 25.88cm – 27.47cm. The marginal difference in values could be attributable to genetic variations and environmental differences in these studies.

The results show that body length varies between 28.8 and 29.3 cm for each dietary treatment. The range is greater than the 25.46–28.92 cm previously reported by Henry *et al.* (2013), who fed diets based on *Citrus sinensis* pulp to rabbits. Anya *et al.* (2018) showed greater body length values, ranging from 31.86cm to 33.60cm, while feeding diets based on cocoa bean shell meal to rabbits. The variations could be explained by the impact of breed and the various feed components employed in the various tests.

The values for final abdominal circumference across the three treatments were 30.5cm to 31.9cm. This range is higher than 28.42cm average reported by Kiprono *et al.* (2018) and higher than the values 26cm – 26.16cm reported by (Gouda, 2008).

### Carcass Characteristics

The white meat colour recorded in this study is similar to the findings from Fadare *et al.* (2015) and Bivolarski *et al.* (2011), who argue that the white colour is due to low levels of myoglobin in the New Zealand white rabbit breed.

The ultimate pH (pHu) of 5.6 – 5.7 are similar to the findings of Suradi *et al.* (2017) and Składanowska-Baryza *et al.* (2020), who are of the idea that, in good quality rabbit meat, the pHu value measured after 24 hours from slaughter is above 5.6. These results are within the pH range of 5.4 – 5.8 indicating meat of good quality (Kumar *et al.,* 2023). At this pH, microbial growth is slowed thereby increasing the shelf-life of meat.

The favourable meat colour and pH recorded indicate that the inclusion of SDBRC up to 30% in the diet does not negatively impact these specific aspects of meat quality. However, this study did not evaluate other important meat quality attributes, such as microbiological safety, chemical composition, texture, odour, and sensory qualities.

## CONCLUSION

This study demonstrates that sun-dried bovine rumen contents (SDBRC) can be incorporated into rabbit diets at levels up to 30% without compromising feed intake, live-weight gain, or carcass characteristics. The findings suggest that SDBRC is a viable and affordable feed ingredient for rabbit production, yielding meat of comparable quality. However, further investigation is warranted to expose the long-term effects of SDBRC inclusion on rabbit performance, health, and meat quality. Additionally, comprehensive evaluations of meat quality, encompassing microbiological safety, chemical composition, texture, odor, and sensory attributes, are essential to fully assess the suitability of SDBRC as a sustainable feed ingredient in rabbit production systems. The results of this study contribute to the development of innovative and environmentally friendly feeding strategies for rabbit farming, aligning with the principles of circular economy and sustainable agriculture.

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### *Declaration of interests*

The authors declare that there is no conflict of interest surrounding this paper.

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