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THE PERFORMANCE AND HEMATOLOGICAL INDICES OF GROWING RABBIT FED SESSILIS JOYWEED (*Alternanthera sessilis*) AND TRIDAX DAISY (*Tridax procumbens*)

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ABSTRACT: The performance and blood constituents of growing rabbits fed varying ratios of *Alternanthera sessilis* (Sessilis joyweed; AS) and Tridax procumbens (Tridax Daisy; TP) were evaluated. Thirty growing male rabbits with initial body weight ranging from 617.50g to 657.50g were randomly allotted to five dietary treatments, each comprising six animals housed individually in a completely randomized design. The experimental diets were as follows: T1 (100%AS), T2 (75%AS+25%TP), T3 (50%AS+50%TP), T4 (25% AS+75%TP) and T5 (100%TP). The experiment lasted for seven weeks, during which data on feed intake, body weight gain, hematological indices and serum biochemical parameters were collected and analyzed using one-way analysis of variance. The results indicated that dietary treatments had no significant effect ($P>0.05$) on performance parameters, except for average daily feed intake (ADFI). Rabbits fed T1 and T4 recorded the highest ADFI (96.49 and 96.01 g/day respectively), whereas those on T3 and T5 showed the lowest values. The best (lowest) feed conversion ratio (5.79) was observed in rabbits fed T4. Rabbits on T4 exhibited the highest packed cell volume (32.00%), hemoglobin concentration (10.20 g/dL), red blood cell count (5.64×10^6/μL), platelet count (140.00×10^3/μL), and white blood cell count (32.50×10^2/μL). In addition, significantly higher ($P<0.05$) serum total protein (7.00 g/dL), albumin (2.90 g/dL) and globulin (4.10 g/dL) levels were recorded in rabbits fed T4 compared with other treatments. It can be concluded that the dietary combination of 25%AS+75%TP produced the most favorable performance and blood profile in growing rabbits. This suggests that *Alternanthera sessilis* can serve as a viable alternative forage resource *Tridax procumbens* in rabbit nutrition.

Keywords: Blood, Forage, Rabbit, Performance, Sessilis joyweed, Tridax daisy.

INTRODUCTION

The growing global population suggests the necessity of food security and a sustainable supply of dietary protein. According to FAOSTAT (2022), a substantial reduction in protein consumption has been observed in parts of Africa and Asia. In Nigeria, the average daily protein intake is estimated at 45.40 g per capita which is below the recommended level of 53.80 g per day set by the Food and Agriculture Organization (FAO) and also lower than the global average of 64.00 g (Akerele et al., 2017; Protein Challenge, 2020). Furthermore, Adetunji and Adepoju (2011) emphasized that approximately 35.00 g of daily protein intake should be derived from animal sources. However, a declining trend in animal protein consumption has been reported in Nigeria, despite the country's population being projected to increase from about 201 million in 2019 to approximately 401 million by 2050.

This rapid population growth, coupled with the increasing demand for animal protein highlights the urgent need to explore unconventional livestock species characterized by fast growth rates and short gestation periods (Sonea et al., 2023; Miassi and Dossa, 2023). Rabbit (*Oryctolagus caniculus*) production represents a promising option, as rabbits are relatively inexpensive to raise and exhibit high meat production efficiency. Rabbits possess several advantageous characteristics, including rapid growth rate, early attainment of puberty, short gestation period, high reproductive potential, efficient feed conversion, ability to utilize forages, and ease of housing and handling (Arijeaniwa et al., 2002; Chipo et al., 2019; Khalid et al., 2020; Oladimeji et al., 2021). Despite these favorable attributes, rabbit production remains underutilized in tropical regions. This is largely due to the scarcity and high cost of conventional feed ingredients, which constrain large-scale rabbit production, particularly in Nigeria.

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In order to tackle these challenges, research efforts have increasingly focused on identifying feed ingredients and additives that are readily available and relatively inexpensive (Oluremi et al., 2018; Aderemi and Alabi, 2023). Agro-industrial by-products, forages, and meals derived from various plant leaves and seeds represent promising alternatives to conventional feed resources (Aderemi et al., 2015; Alabi et al., 2017; Vastolo et al., 2022; Amos et al., 2025). Among the available forages, *Alternanthera sessilis* and *Tridax procumbens* are particularly noteworthy because of their nutritional and medicinal properties (Fahey, 2005). These plants therefore have the potential to partially or completely replace conventional protein sources in rabbit diets, thereby improving feed efficiency and growth performance.

*Alternanthera sessilis (*Sessilis Joyweed) is perennial forage belonging to the family *Amaranthaceae* and is commonly utilized fin ruminant nutrition (Singla et al., 2022). In addition to its use as a leafy vegetable and edible herb, it possesses a pleasantaroma and contains a desirable levels of dietary fibre, vitamins, flavonoids, minerals and carotenoids (Michael, 2011; Shehzad et al., 2018; Alabi et al., 2024a). According to Shehzad et al, (2018), *Alternanthera sessilis* provides approximately 251.00 KJ/mol of energy and 4.70 g/100 g of crude protein, indicating its potential value as a feed resource.

Similarly, *Tridax procumbens* (Tridax daisy) is characterized by excellent regrowth ability, resilient, and suitability as a forage crop for livestock. Its nutritional profile, including levels of protein, minerals, vitamins, tocopherols, phenolic compounds and β-carotene, has been well documented (Anwar et al., 2007; Samantha et al., 2018; Sarkar et al., 2022). These nutrients play vital roles in growth and reproductive development of the animals, making *T. procumbens* useful substitute for conventional protein sources such as soybean meal and fish meal in monogastric animal nutrition.

Given these nutritional qualities, *Alternathera sessilis* and *Tridax procumbens* may enhance feed utilization and growth performance in growing rabbits. Therefore, the objective of this study was to evaluate the effect of graded dietary inclusion levels of these two forages on the performance of growing rabbits. Specifically, the study assessed feed intake, body weight gain, and feed conversion efficiency, as well as the effects of the diets on haematological and serum biochemical indices. The overall aim was to determine the suitability of these forages as alternative feed resources for rabbits and to identify the optimal combination level for maximizing growth performance and physiological health.

MATERIALS AND METHODS

Ethical consideration

Ethical approval for the study was obtained from the Institutional Research Ethics Committee.

Study location and duration

The experiment was carried out at the rabbit Unit of the Animal Production Research Faculty National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Nigeria.

Forage sourcing and processing

The two experimental forages used in the feeding trial were *Alternanthera sessilis* (AS) and *Tridax procumbens* (TP), both harvested locally. Fresh samples of the forages were collected from areas within the vicinity of the study site. Whole plants, including stems and leaves, were harvested at approximately 3 cm above ground level during the mid-vegetative to early flowering phase. The harvested material were rinsed with clean water to remove soil and debris, drained, and air-dried for 24 hours on a concrete surface while ensuring retention of green coloration. The air-dried forages were weighed using a Salter electronic scale and subsequently offered to the rabbits according to the assigned dietary treatments.

Experimental diets

Five dietary treatments were formulated based on varying proportions of AS (*Alternanthera sessilis*) and and TP (*Tridax procumbens*) as follows:

T1: 100% AS; T2: 75% AS + 25% TP; T3: 50% AS + 50% TP; T4: 25% AS + 75% TP; T5: 100% TP

Animal selection and husbandry

Thirty weaned male Large White rabbits, aged eight weeks and weighing between 617 and 657 g, were sourced from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. Prior to the arrival of animals, all housing units, feeders, drinkers, and the hutch area were thoroughly cleaned and disinfected. Upon arrival, the rabbits were allowed a seven-day acclimatization period, during which they were managed under conditions similar to those of the experimental period. Each rabbit was individually housed in a metal battery cage measuring 23 × 18 × 15 inches. Feed and clean drinking water were provided *ad libitum* throughout the experiment.

The rabbits were allowed to stabilize on the experimental diets for four days before the data collection commenced. Feeding was carried out twice daily at 08:00 and 16:00 h and maintained consistently throughout the study. Equal quantities of moistened concentrate feed were provided daily as supplements. The proximate composition of the concentrate diet is presented in Table 1.

Table 1 - Proximate composition of the experimental diets.

Parameters (%)	T_1 (100%AS)	T_2 (75%AS+25%TP)	T_3 (50%AS+50%TP)	T4 (25%AS+75%TP)	T5 (100%TP)
Dry matter	72.40	73.05	73.7	73.88	75
Crude Protein	26.16	24.47	22.78	21.25	19.4
Crude fibre	8.8	8.03	7.25	6.8	5.7
Ether extract	3.87	6.03	8.185	10.05	12.5
Ash	8.5	7.45	6.4	5.75	4.3
NFE	45.07	47.08	49.09	56.15	53.1

NFE: Nitrogen free extract; *Metabolizable energy of the experimental diets: T1 = 2862.24, T2= 3046.44, T3 = 3250.54, T4 = 3573.59, T5 = 3598.80 KCal/Kg.

Experimental design

The experiment was arranged in a completely randomized design. Thirty rabbits were randomly allocated to five dietary treatments, with six replicates per treatment and one rabbit constituting each replicate.

Nutrient composition analysis

The chemical composition of the experimental diets was determined using standard procedures of the Association of Official Analytical Chemists (AOAC, 2000). Parameters analyzed included dry matter, crude protein, crude fiber, ether extract and ash content while nitrogen-free extract (NFE) was calculated by difference. The Metabolizable Energy ($KcalKg^{-1}$) content of the experimental diets was estimated using the following formula:

ME ($KcalKg^{-1}$) = 3.50 x crude protein + 8.46 x acid ether extract + 3.50 x NFE as recommended by the National Research Council-NRC (Ohshima et al., 1995).

Performance metrics

Feed intake and growth performance

The experimental diets were offered to the rabbits in known quantities at designated feeding times. Feed refusals were collected and weighed after 24 hours to determine actual feed intake. Initial live body weights were recorded at the commencement of data collection, prior to feeding, and subsequently measured on a weekly basis throughout the experimental period. Average daily weight gain (ADG) was calculated by dividing the total weight gain by the duration of the experiment (49 days). Average daily feed intake (ADFI) and Feed Conversion Ratio (FCR) were computed using standard procedures.

$$\text{Feed intake (kg)} = \text{Feed offered-Remnant}$$

$$\text{Average daily feed intake (kg)} = \frac{\text{Feed intake (g)}}{\text{Number of days of the experiment}}$$

$$\text{Weight Gain (kg)} = \text{Final Weight Gain - Initial Weight Gain}$$

$$\text{Average daily Weight gain (kg)} = \frac{\text{Weight Gain (g)}}{\text{Number of days of the experiment}}$$

$$\text{FCR} = \frac{\text{Average daily feed intake}}{\text{Avearage daily weight gain}}$$

Blood sample collection and analysis

On the 49^{th} day of the experiment, blood samples (5 ml) were collected from three rabbits randomly selected from each treatment group via the lateral saphenous vein of the hind limb, as described by Parasuraman et al. (2017). The collection site was shaved and sterilized prior to sampling. Of the 5 ml collected from each rabbit, 3 ml was dispensed into tubes containing ethylenediaminetetraacetic acid (EDTA) for hematological analysis. The samples were gently mixed to prevent clot formation and analyzed within one hour of collection. Hematological parameters determined included red blood cell (RBC) count, white blood cell (WBC) count, hemoglobin (Hb) concentration, and packed cell volume (PCV), following the methods described by Davice and Lewis (1991). The remaining 2 mL of blood was transferred into plain tubes without anticoagulant and centrifuged at 500 rpm for 3 minutes to obtain clear serum. Serum samples were analyzed using a spectrophotometry at a wavelength of 500 nm with commercial assay kits (Sentinel, Italy). Serum biochemical indices, including total cholesterol, aspartate aminotransferase (AST), alkaline phosphatase (ALP), and albumin were determined using diagnostic kits supplied by Randox Laboratories Ltd. (U.K).

Statistical analysis

All data generated were subjected to statistical analysis using one-way analysis of variance (ANOVA) in SAS software version 9.1 (SAS, 2005). Where significant differences were detected, treatment means were separated using Duncan's Multiple Range Test at a 5% level of significance (P<0.05).

RESULTS AND DISCUSSION

Growth performance of the experimental rabbits

Table 2 presents the growth performance indices of the rabbits fed graded levels of *Alternanthera sessilis* and *Tridax procumbens.* The results indicated that the dietary treatments had no significant effect (P<0.05) on most performance parameters, except for average daily feed intake (ADFI), which differed significantly among the treatment groups. Rabbits fed diets containing 100%AS and 75%AS+25%TP recorded the highest ADFI values of 96.49 g/day and 96.01 g/day, respectively, with no significant difference between the two treatments. In contrast, rabbits fed 50%AS+50%TP (79.35 g/day) and 25%AS+75%TP (66.14 g/day) exhibited statistically similar ADFI values, which were significantly lower than those observed in the other treatment groups. The feed intake values recorded in the present study were higher than the 41.20 g/day previously reported by Adeniji and Ehiemerem (2003). Similarly, average daily weight gain observed in this experiment exceeded the range of 6.78 - 8.64 g/day earlier reported by Omoikhoje et al. (2006) and Odeyinka et al. (2008) for rabbits raised under tropical climates. Furthermore, the feed conversion ratios (FCR) values obtained in this study were higher than those previously documented by Mufwa et al. (2011) and Okorie (2003) for growing rabbit.

Table 2 - Performance characteristics of the experimental rabbits.

Parameters \ Treatments	T_1 (100%AS)	T_2 (75%AS+25%TP)	T_3 (50%AS+50%TP)	T_4 (25%AS+75%TP)	T_5 (100%TP)	SEM	P-value
Initial weight (g)	620.33^b	617.5^b	657^a	625.33^b	618^b	18.61	.001
Final weight (g)	1247.3^b	1232^c	1225.7^c	1194.7^d	1286.3^a	30.45	.002
Weight gain (g)	626.97^b	614.5^c	568.7^d	569.37^d	668.3^a	32.18	.001
ADWG (g/d)	12.8^b	12.54^c	11.61^d	11.62^d	13.64^a	0.66	.004
TFI (g)	4728^a	4704.3^a	3888^b	3241^b	3966.3^{ab}	173.94	.002
ADFI (g/d)	96.49^a	96.01^a	79.35^b	66.14^b	80.95^{ab}	3.55	.001
FCR	7.86^a	7.84^a	6.83^b	5.79^c	6.11^b	0.36	.0001

^{a,b} Means along the same row with different superscripts are significantly different (P<0.05). SEM: The standard error of the mean. ADWG: Average daily weight gain, TFI: Total feed intake, ADFI: Average daily feed intake, FCR: feed conversion ratio. T1: 100% *Alternanteria sessil*, T2: 75% *Alternanteria sessil* and 25% *Tridax procumbens*, T3: 50% *Alternanteria sessil* and 50% *Tridax procumbens*, T4: 25% *Alternanteria sessil* and 75% *Tridax procumbens* and T5: 100% *Tridax procumbens*

Hematological parameters

Blood analysis is a reliable tool for assessing the health status as well as the nutritional, physiological, and pathological conditions of animals (Alabi et al., 2024b). Hematological indices are particularly valuable for detecting potential dietary toxicity and evaluating the physiological responses of animals to experimental diets (Oyawoye and Ogunkunle, 1998). Table 3 presents the effects of the dietary treatments on the hematological parameters of the experimental rabbits. These indices serve as critical indicators of the animals' physiological and immunological status and provide insight into how dietary interventions influence systemic function and overall welfare.

Packed cell volume (PCV), heamoglobin concentration (Hb) and red blood cell (RBC) count

Rabbits fed diet in T4 (25%AS+75%TP) recorded the highest packed cell volume (32.00%), heamoglobin concentration (10.20 g/dl), and red blood cell count (5.26×10^6/µL), values that were significantly (P<0.05) higher than those observed in the other treatment groups. These findings suggest that this dietary combination supported enhanced erythropoiesis, possibly due to a balanced supply of essential micronutrients such as iron, folic acid, and vitamin B_{12}, which are required for red blood cell synthesis (Jain, 1993). In contrast, rabbits fed T5 (100% TP) exhibited the lowest PCV (21.00%), Hb concentration (6.90 g/dL), and RBC count (3.41×10^6/µL), indicating a possible reduction in haematopoietic efficiency or a tendency toward anaemia when *Tridax procumbens* was offered as the sole forage source. Although *T. procumbens* possesses documented phytotherapeutic properties, these results suggest that it may not provide adequate nutritional support for optimal erythropoiesis when used alone, highlighting the importance of dietary complementarity with *Alternanthera sessilis*. Notwithstanding these variations, the hematological values obtained across treatments fell within the established reference ranges for healthy rabbits (Obinnea et al., 2013; Abdullahi et al., 2021), supporting earlier findings by Obinne et al. (2013), who reported improved blood indices in rabbits fed *Tridax procumbens.* The higher inclusion level of *Tridax procumbens particularly at* 75%, appeared to enhance hematological parameters, likely due to its favorable nutrient composition. The values of the packed cell volume recorded in this study were slightly lower than the range of 34.59 - 36.65% reported by Ayandiran et al. (2020) in rabbits fed sorghum brewers' dried grain.

Table 3 - Haematological indices of the experimental rabbits.

Parameters \ Treatments	T_1 (100%AS)	T_2 (75%AS+25%TP)	T_3 (50%AS+50%TP)	T_4 (25%AS+75%TP)	T_5 (100%TP)	SEM	P-value
PCV (%)	29^b	26^c	31^a	32^a	21^d	1.06	.002
Haemoglobin (g/dL)	9.3^b	8.7^c	10.1^a	10.20^a	6.9^d	0.12	.002
Red blood cell (×10)	4.32^b	4.23^b	5.2^a	5.26^a	3.41^c	0.18	.001
Platelet ($\times 10^3$)	85^a	83^a	86^a	88^a	70^b	6.49	.002
WBC ($\times 10^2$)	23.5^c	21^d	26^b	32.5^a	15.34^e	2.90	.002
Lymphocytes (%)	39^c	35^d	46^b	51^a	3^e	2.01	.001
Neutrophils (%)	57^c	62^b	50^d	46^e	69^a	2.20	.001
Monocytes (%)	3^a	1^c	2^b	2^b	1^c	0.20	.001
Eosinophils (%)	$1.^b$	2^a	2^a	1^b	0^c	0.20	.002

^{a,b} Means along the same row with different superscripts are significantly different (P<0.05). SEM: The standard error of the mean. WBC: white blood cell. T1: 100% *Alternanteria sessil*, T2 : 75% *Alternanteria sessil* and 25% *Tridax procumbens*, T3: 50% *Alternanteria sessil* and 50% *Tridax procumbens*, T4: 25% *Alternanteria sessil* and 75% *Tridax procumbens* and T5: 100% *Tridax procumbens*

White blood cell (WBC) and platelet counts

White blood cell counts are widely use indicators of immunological competence and immune responsiveness. As presented in Table 3, rabbits in treatment T4 recorded the highest WBC count (32.50×10^2/µL), which was significantly higher (P<0.05) than the values observed in the other treatment groups. In contrast, rabbits fed T5 exhibited the lowest WBC count (15.34×10^2/µL). This pattern suggests that a mixed forage diet, particularly the T4 combination, may provide bioactive compounds capable of enhancing immune function. Similarly, platelet count was significantly higher (P<0.05) in rabbits fed T4 (140×10^3/µL) compared with those in the other treatments. This increase may indicate enhanced thrombopoiesis. Beyond their primary role in hemostasis, platelets also contribute to inflammatory processes and host immune defense mechanisms (Semple et al., 2011).

Lymphocytes and neutrophils

Lymphocyte percentages were highest in rabbits fed T4 (51.00%), further suggesting that partial substitution of AS with TP may stimulate adaptive immune responses. By comparison, rabbits fed the control diet (T1; 100%AS) recorded a lower lymphocyte proportion (39%), while the lowest value was observed in rabbits fed T5 (30%), indicating a potential compromise in immune competence under a diet composed solely of *T. procumbens*. Neutrophil percentages, which are often associated with stress and inflammatory responses, were significantly higher (P<0.05) in rabbits fed T5 (69%) and T2 (62%). This elevation may reflect increased physiological stress or subclinical inflammatory conditions in these treatment groups. Conversely, rabbits fed T4 (46%) and T3 (50%) exhibited significantly lower neutrophil counts, which may be indicative of reduced stress levels and a more balanced immune status (Minka and Ayo, 2013).

Monocytes and eosinophils

Rabbits fed T1 (100% AS) exhibited the highest monocytes percentage (30.00%) which was significantly greater (P<0.05) than those recorded in T2 (75%AS+25%TP) and T5 (100%TP). Although, monocytes play crucial roles in phagocytosis and inflammation, excessive levels may indicate the presence of chronic inflammatory processes. Eosinophil percentages were highest in T2 and T3 (2%) and lowest in T5 (0%). Elevated eosinophil levels may sometimes reflect allergic responses or parasitic infections; however, in this study, all values remained within the acceptable physiological range for healthy rabbits. Overall, the results suggest that T4 (25%AS+75%TP) optimally supports a balanced hematological profile and immune status in rabbits. Inclusion of *T. procumbens* at higher proportions appears to enhance both red and white blood cell parameters, possibly due to synergistic interactions between its bioactive compounds and the nutritional composition of *A. sessilis*. In contrast, feeding *T. procumbens* exclusively, as in T5, consistently resulted in suboptimal hematological outcomes, which may negatively affect productivity, immunity, and overall welfare.

Serum biochemical parameters

The effects of the dietary treatments on serum biochemical indices are presented in Table 4. Significant differences (P<0.05) were observed among the treatment groups for several parameters. Blood urea nitrogen (BUN) values were highest in T5 (32 mg/dL) and lowest in T1 (21 mg/dL). Conversely, rabbits fed T1 exhibited the highest levels of alanine aminotransferase (ALT; 61 µ/L) and alkaline phosphatase (ALP; 14 µ/L), in agreement with Bhuyan et al. (2018), who reported that inclusion of *A. sessilis* in rat diets may influence liver function.

Variations in serum metabolites indicate that dietary composition affects metabolic activity and nutrient utilization. Unlike the findings of Omoikhoje et al. (2006), who observed no significant effects from *Syndrella nodiflora*-based diets, this study demonstrated notable dietary influence on serum total protein, albumin, and globulin levels particularly in rabbits fed T4 (25%AS+75%TP). Enhanced protein fractions likely reflect improved nutrient assimilation and protein utilization, supporting the observations of Iheukwumere and Okoli (2002) that blood chemistry is a direct indicator of an animal's physiological response to diet and environment. Notably, all protein fractions in this study aligned with the physiological reference range for normal rabbits: total protein (5.4–7.5 g/dL), albumin (2.5–4.5 g/dL), and globulin (1.9–3.5 g/dL) (Eshar et al., 2021).

Table 4 - Serum biochemical indices of the experimental rabbits

Parameters \ Treatments	T_1 (100%AS)	T_2 (75%AS+25%TP)	T_3 (50%AS+50%TP)	T_4 (25%AS+75%TP)	T_5 (100%TP)	SEM	P-value
Total protein (g/dL)	5.9^c	6.1^b	6^b	7^a	6.2^b	0.11	.002
Albumin (g/dL)	2.5^c	2.6^b	2.5^c	2.90^a	2.6^b	0.04	.001
Globulin (g/dL)	3.4^d	3.5^c	3.5^c	4.10^a	3.6^b	0.07	.001
A/G	0.74^a	0.74^a	0.71^b	0.72^b	0.71^b	0.02	.001
BUN (mg/dL)	21^e	25^c	22^d	27^b	32^a	1.05	.002
Creatinnine (mg/dL)	0.6^c	0.7^b	0.5^d	0.7^b	0.8^a	0.03	.0001
AST (µ/L)	71^a	66^b	54^c	67^b	69^a	9.41	.003
ALT (µ/L)	45^e	53^c	49^d	55^b	61^a	1.45	.003
ALP (µ/L)	12^c	13^b	13^b	12^c	14^a	0.20	.001

^{a,b} Means along the same row with different superscripts are significantly different (P<0.05). SEM: The standard error of the mean. A/G; Albumin/ Globulin ratio, BUN: Blood Urea Nitrogen, AST: Apartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline Phosphatase, T1: 100% *Alternanteria sessil*, T2 : 75% *Alternanteria sessil* and 25% *Tridax procumbens*, T3: 50% *Alternanteria sessil* and 50% *Tridax procumbens*, T4: 25% *Alternanteria sessil* and 75% *Tridax procumbens* and T5: 100% *Tridax procumbens*

CONCLUSION

The findings of this study indicate that a dietary combination of 25% *Alternanthera sessilis* and 75% *Tridax procumbens* yields the most favorable outcomes in terms of feed efficiency, hematological indices and serum biochemical parameters. This dietary blend supported optimal physiological performance without adverse effects, suggesting its suitability for inclusion in growing rabbit diets to enhance health, immunity and productivity.

DECLARATIONS

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Ethical approval

All procedures involving animals in this study were conducted in accordance with the ethical standards of the Bowen University Research Ethics Committee .All authors complied with the ARRIVE guidelines for the reporting of animal research.

Authors' contribution

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Consent to publish

All authors agreed to the publication of this manuscript.

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Competing interests

The authors declared that there is no competing interests before, during and after the data collection and preparation of the manuscript.

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