HAEMATOLOGICAL AND SERUM BIOCHEMISTRY OF RABBITS FED TOASTED ROSELLE (*Hibiscus sabdariffa*) SEED MEAL AS PARTIAL REPLACEMENT FOR TOASTED SOYBEANS

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ABSTRACT
The study evaluated the haematological and serum biochemistry of rabbits fed toasted roselle seed meal (TRSM) as a partial replacement for toasted soybean meal (TSM). Thirty mixed-breed grower rabbits were randomly assigned to five dietary treatments with TRSM inclusion levels of 0, 10, 20, 30, and 40%. The study lasted six weeks, with three replicates per treatment. Blood samples were collected via the ear vein for haematological and serum biochemical analyses. Haematological parameters such as packed cell volume (PCV), hemoglobin (HGB), white blood cell count (WBC), and red blood cell count (RBC), as well as serum biochemistry parameters including total protein, albumin, glucose, and enzymes (AST, ALT, urea, creatinine), were measured. Results showed significant variations (P<0.05) in several parameters with increasing TRSM levels. PCV, HGB, WBC, and RBC were highest in the 10% TRSM group (T2) and lowest in the 30% TRSM group (T4). Serum total protein, albumin, and glucose concentrations were also influenced by TRSM inclusion. The 10% and 20% TRSM groups had the highest values for most of the measured parameters. Conversely, 30% and 40% TRSM inclusion led to a decline in serum total protein, albumin, and glucose concentrations, while ALT and urea levels increased. In conclusion, moderate levels (10%-20%) of TRSM in rabbit diets can support good health and performance. it is recommended that TRSM be included in grower rabbit diets at 20% level. Further studies on the long-term effects and anti-nutritional factors in TRSM are recommended for optimizing its use in rabbit nutrition.
Keywords: Haematology, Rabbits, Toasted Roselle Seed Meal, Serum Biochemistry, Soybeans

INTRODUCTION
The growing interest in alternative feed ingredients for livestock, particularly in livestock production, has spurred research into plant-based protein sources as partial replacements for conventional feed components, such as soybean meal (Aliyu *et al*., 2020). Roselle seed meal (*Hibiscus sabdariffa*) has emerged as a promising alternative, with studies indicating potential nutritional benefits and positive health outcomes for rabbits (Awodola-Peters *et al*., 2019). Research conducted by Onunkwo et al. (2018), Awodola-Peters et al. (2019), Aliyu et al. (2020), and Obadire et al. (2022) suggested that plant-based protein diets, including those containing roselle seed meal, can influence haematological and serum biochemical parameters. However, the specific effects of roselle seed meal on rabbit health, particularly its impact on blood parameters and organ function, remain inadequately understood (Awodola-Peters *et al*., 2019). While the high protein content of roselle is well-documented, comprehensive studies are necessary to evaluate its effects on haematological indices and serum biochemistry to assess its potential as a sustainable feed ingredient (Awodola-Peters *et al*., 2019).
This study aimed to address this gap by examining the effects of varying inclusion levels of toasted roselle seed meal as a partial substitute for toasted soybean meal in rabbit diets.

MATERIALS AND METHODS
Experimental site: The experiment was conducted at the Teaching and Research Farm of Abubakar Tafawa Balewa University, Bauchi, State.
Sources of toasted roselle seed meal: Roselle seeds were obtained from Muda-lawal Market in Bauchi, Bauchi State. The seeds were thoroughly cleaned to remove any dirt, debris, or foreign materials. The raw seeds were then placed on a roasting pan and heated to a temperature of approximately 140°C to 160°C (284°F to 320°F) for about 15 to 30 minutes. During the toasting process, the seeds were periodically stirred to ensure uniform heat distribution and prevent burning. After toasting, the Roselle seeds were allowed to cool to room temperature for further processing. Once cooled, the toasted seeds were ground into a fine powder using a grinding machine, which facilitates easier incorporation into rabbit feed. The ground toasted Roselle seed meal was then packaged in airtight containers to preserve its quality and prevent moisture absorption. The toasted seed meal was stored in a cool, dry place to prevent spoilage and maintain its nutritional value until it was used in animal feed formulations. This process ensures that the anti-nutritional factors in Roselle seeds are minimized or eliminated, making the seed meal a more suitable ingredient for inclusion in rabbit feed.

Experimental design: This study was conducted using a completely randomized design (CRD) to evaluate the effect of toasted roselle seed meal (TRSM) as a partial replacement for toasted soybean meal in rabbit diets. Thirty mixed-breed grower rabbits were randomly assigned to five experimental groups, with three replicates per treatment (two rabbits per replicate), resulting in a total observation period of six weeks. The experimental diets included varying levels of TRSM (0, 10, 20, 30, and 40%). The ingredients and percentage composition of the dietary levels of roselle seed cake fed to weaner rabbits are presented in Table 1.

Table 1: Composition of Experimental Diets Containing Varying Levels of Toasted Roselle Seed Meal (TRSM) as partial replacement for soybean meal (SBM)

Ingredients	Diets				
	1 TRSM (0%)	**2 TRSM (10%)**	**3 TRSM (20%)**	**4 TRSM (30%)**	**5 TRSM (40%)**
Maize	27.00	27.00	29.00	30.00	30.00
Soybean Meal	15.00	13.50	12.00	10.50	9.00
Toasted Roselle Seed	0.00	1.50	3.00	4.50	6.00
Maize offal	11.00	11.00	11.00	11.00	10.00
Wheat offal	21.80	21.80	21.80	21.80	22.80
Groundnut Haulm	22.00	22.00	20.00	19.00	19.00
Bone meal	2.50	2.50	2.50	2.50	2.50
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Total	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
Crude protein (%)	16.00	16.00	16.00	16.00	16.00
Crude fiber (%)	12.30	12.46	12.27	12.25	12.15
Metabolizable energy ME kcal/kg	2469.40	2429.65	2409.90	2380.15	2328.40

Blood sampling and analysis: Blood samples (5 mL) were collected from the marginal ear vein of each rabbit at the end of the feeding trial. For haematological analysis, a portion of the blood was collected into ethylenediaminetetraacetic acid (EDTA) tubes to prevent clotting, while the remaining blood was placed in plain tubes and allowed to coagulate. The coagulated blood was centrifuged at 3,000 rpm for 10 minutes to obtain serum. Blood samples were immediately placed in iced sachet water to maintain a chilled temperature during transportation to Abubakar Tatari Ali Polytechnic Medical Center Laboratory (ATAB). Haematological parameters, including packed cell volume (PCV), haemoglobin (HGB), white blood cell count (WBC), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC), were determined using standard methods (Jain, 1993). Serum biochemistry was analyzed for total protein, albumin, globulin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), urea, creatinine, and glucose using an automated biochemistry analyzer (Roche Diagnostics).

Statistical analysis: Data collected were analyzed using a one-way analysis of variance (ANOVA) in a completely randomized design. Significant differences between treatment means were assessed using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.05$. All statistical analyses were conducted using SPSS version 22.

RESULTS

The results of haematological parameters of rabbits fed with varying levels of TRSM are presented in Table 2 Significant variations ($p< 0.05$) were observed across the measured parameters. The Packed Cell Volume (PCV) values for rabbits in treatments 1, 2, 3, and T5 were 35.50%, 38.50%, 36.00%, and 35.50%, respectively, differing statistically from 29.00% in T4 (30% TRSM). T2 (10% TRSM) exhibited the highest PCV at 38.50%, followed by T3 (20% TRSM) at 36.00%. The lowest PCV was observed in T4 (30% TRSM) at 29.00%. The haemoglobin concentrations (Hgb) for rabbits in treatments 1, 2, 3, and 5 were statistically similar but numerically distinct. T1 and T4 (9.40 and 8.65 g/dL) also showed statistical similarity. T2 (10% TRSM) had the highest haemoglobin concentration at 10.20 g/dL, followed by T3 (20% TRSM) at 10.05 g/dL, while the lowest concentration was found in T4 (30% TRSM) at 8.65 g/dL. The White Blood Cell Count (WBC) in T1 ($6.57 \times 10^3/\mu L$) was similar to those in T3 ($6.92 \times 10^3/\mu L$) and T5 ($6.83 \times 10^3/\mu L$). Statistically, T2 had the highest WBC count at $8.59 \times 10^3/\mu L$, whereas T4 had the lowest at $5.67 \times 10^3/\mu L$. The Red Blood Cell Count (RBC) showed significant differences ($p<0.05$). T1, T3, and T4 ($4.15 \times 10^6/\mu L$, $4.01 \times 10^6/\mu L$, and $3.94 \times 10^6/\mu L$) were

similar but varied from T2 (5.06 × 10^6/µL) and T4 (3.17 × 10^6/µL). The Mean Corpuscular Haemoglobin Concentration (MCHC) values for rabbits in T1, T2, T3, and T5 (26.46 g/dL, 26.48 g/dL, 27.54 g/dL, and 27.36 g/dL) were statistically similar but differed from T4, which had an MCHC of 30.00 g/dL. Mean Corpuscular Volume (MCV) values for rabbits in T1, T3, T4, and T5 were statistically similar but numerically different, with T1, T3, and T5 also showing similarity but varying in numerical values.
Mean Corpuscular Haemoglobin (MCH) values were the same in T3, T4, and T5 but differed statistically ($p<0.05$) from T1 and T2. T1 (22.75 pg) and T2 (20.30 pg) had different values compared to T3 and T5 (24.75 pg) each.

Table 2: Haematological Parameter of Grower Rabbits Fed Varying Levels of Toasted Roselle Seed Meal (TRSM) as Partial Replacement for Soybean Meal (SBM)

Parameters	T1 TRSM (0%)	T2 TRSM (10%)	T3 TRSM (20%)	T4 TRSM (30%)	T5 TRSM (40%)	SEM	**R/Range
PCV (%)	35.50^{a}	38.50^{a}	36.00^{a}	29.00^{b}	35.5^{a}	1.62*	33-50
HGB (g/dL)	9.4^{ab}	10.20^{a}	10.05^{a}	8.65^{b}	9.75^{a}	0.36*	8-18
WBC (10^9/L)	6.57^{bc}	8.59^{a}	6.92^{b}	5.67^{c}	6.83^{b}	0.47*	5.5-12.5
RBC (10^6/µL)	4.15^{b}	5.06^{a}	4.01^{b}	3.17^{c}	3.94^{b}	0.31*	3.94-5.06
MCHC (g/dL)	26.46^{b}	26.48^{b}	27.54^{b}	30.00^{a}	27.36^{b}	0.84*	29-37
MCV (fL)	85.20^{ab}	76.70^{b}	88.20^{ab}	91.60^{a}	88.35^{ab}	5.24*	58-67
MCH (pg)	22.75^{bc}	20.30^{c}	24.75^{ab}	27.45^{a}	24.75^{ab}	01.47*	17-23.5

^{abc} means along rows bearing different superscript are significantly different ($p<0.05$)
References range **Leineweber et al. (2018)
PCV: Packed Cell Volume, **HGB:** Haemoglobin, **RBC:** Red Blood Cell, **WBC:** White Blood Cell, **MCH:** Mean Corpuscular Haemoglobin, **MCHC:** Mean Corpuscular Haemoglobin Concentration, **MCV**: Mean Corpuscular Volume, **R/Range** = Reference range.

Table 3 showed the serum biochemistry of rabbits fed varying levels of toasted roselle seed meal (TRSM). The highest total protein value was observed in T2 (10% TRSM) at 6.80 g/dL, which was statistically similar to T1 (0% TRSM) at 6.70 g/dL. This was followed by T3 (20% TRSM) at 6.50 g/dL, which was also similar to T4 (30% TRSM) at 6.40 g/dL. The lowest total protein value was recorded in T5 (40% TRSM) at 6.10 g/dL. The highest albumin values were in T2 (10% TRSM) and T3 (20% TRSM), both at 3.60 g/dL, which were statistically similar to T1 (0% TRSM) at 3.40 g/dL and T4 (30% TRSM) at 3.50 g/dL. The lowest albumin value was in T5 (40% TRSM) at 3.10 g/dL. There was no statistically significant difference in globulin values across treatments. The values ranged from 3.10 to 3.40 g/dL, with T3 (20% TRSM) and T5 (40% TRSM) recording the highest values of 3.40 g/dL.
The highest AST values were observed in T4 (30% TRSM) at 33.86 IU/L and T5 (40% TRSM) at 34.21 IU/L, which were statistically similar. Lower values were recorded in T1 (0% TRSM), T2 (10% TRSM), and T3 (20% TRSM), all around 32.03 to 32.40 IU/L and statistically similar. The highest ALT value was found in T5 (40% TRSM) at 22.60 IU/L, followed by T4 (30% TRSM) at 21.50 IU/L. T2 (10% TRSM) and T3 (20% TRSM) had similar values, at approximately 19.33 to 19.37 IU/L. The lowest ALT value was in T1 (0% TRSM) at 18.41 IU/L. The highest urea value was recorded in T5 (40% TRSM) at 28.63 mg/dL, followed by T4 (30% TRSM) at 27.50 mg/dL, T3 (20% TRSM) at 26.80 mg/dL, and T2 (10% TRSM) at 26.27 mg/dL. The lowest value was in T1 (0% TRSM) at 25.43 mg/dL. The highest creatinine values were observed in T2 (10% TRSM), T3 (20% TRSM), T4 (30% TRSM), and T5 (40% TRSM), all around 0.92 to 0.97 mg/dL, with no significant difference among them. T1 (0% TRSM) had a lower value of 0.81 mg/dL. The highest glucose value was recorded in T5 (40% TRSM) at 76.50 mg/dL, which was statistically different from other groups. T1 (0% TRSM) and T2 (10% TRSM) had similar values, at 65.50 and 65.00 mg/dL, respectively. T3 (20% TRSM) and T4 (30% TRSM) had the lowest glucose values, at 53.0 and 54.5 mg/dL, respectively, and were statistically similar.

Table 3: Serum Biochemistry of Rabbits Fed Varying Levels of Toasted Roselle Seed Meal

Parameters	T1 (0%) RSM	T2 (10%) RSM	T3 (20%) RSM	T4 (30%) RSM	T5 (40%) RSM	SEM	*R/Range
Total protein (g/dl)	6.70^{a}	6.80^{a}	6.50^{b}	6.40^{b}	6.10^{c}	0.08*	5.4-7.5
Albumin (g/dL)	3.40^{ab}	3.60^{a}	3.60^{a}	3.50ab	3.10^{b}	0.17*	2.7-5.0
Globulin (g/dL)	3.10	3.20	3.40	3.10	3.40	0.18^{ns}	1.5-2.7
AST (IU/L)	32.40^{b}	32.03^{b}	32.03^{b}	33.86^{a}	34.21^{a}	0.57*	35-130
ALT (IU/L)	18.41^{d}	19.33^{c}	19.37^{c}	21.50^{b}	22.60^{a}	0.23*	19-73
Urea (mg/dL)	25.43^{e}	26.27^{d}	26.80^{c}	27.50^{b}	28.63^{a}	0.23*	20-45
Creatinine (mg/dL)	0.81^{b}	0.92^{a}	0.97^{a}	0.97^{a}	0.97^{a}	0.02*	0.50-2.50
Glucose (mg/dL)	65.50^{ab}	65.00^{ab}	53.0^{b}	54.5^{b}	76.50^{a}	0.57*	75-155

^{abc} means along rows bearing different superscript are significantly different ($p<0.05$)
R/Range: Reference range* Melillo (2007); Fielder (2022) AST: Aspartate Aminotransferase, ALT: Alanine Aminotransferase

DISCUSSION

Haematological Parameters of Grower Rabbits Fed Varying Levels of Toasted Roselle Seed Meal (TRSM) as Partial Replacement for Soybean Meal (SBM)

Packed Cell Volume (PCV), also known as hematocrit, measures the proportion of blood volume occupied by red blood cells. It is a critical indicator of the overall health and physiological status of animals, including rabbits, as presented in Table 2. Normal PCV values for rabbits typically range from 33% to 50%. Deviations from this range can indicate various health issues, such as anemia (low PCV) or dehydration/polycythemia (high PCV). The PCV values in this study (Table 2) fall within the range recommended by Fielder (2022), with the exception of the significantly low value of 29% observed in T4 (30% TRSM), which may indicate reduced red blood cell production or increased destruction. A PCV value of 29% is slightly below the normal range for rabbits and could suggest anemia, potentially caused by factors such as parasitic infections or diseases (Fielder, 2022). The PCV range of 29% to 38.50% in this study contrasts with the findings of Evans *et al*. (2021) regarding the hematological characteristics and serum biochemical indices of rabbits fed *Hibiscus sabdariffa* residue, but aligns with the range of 29% to 39.33% reported by Aliyu *et al*. (2020) on the hematological profile of weaner rabbits fed diets containing raw and boiled Roselle Seed (*Hibiscus sabdariffa* L.) meal. Haemoglobin concentration refers to the amount of hemoglobin present in a given volume of blood, measured in grams per deciliter (g/dL). Haemoglobin is a protein found in red blood cells that is responsible for transporting oxygen from the lungs to the rest of the body and returning carbon dioxide from the tissues back to the lungs. According to Fielder (2022), normal hemoglobin values for rabbits typically range from 8 to 15 g/dL. The variation observed in this study, ranging from 8.65 to 10.20 g/dL (Table 2), could be attributed to natural biological variations, dehydration, or iron deficiency (Boule, 2022). The haemoglobin concentration range in this study aligns with the values reported by Awodola-Peters *et al*. (2019) regarding the hematological indices of grower rabbits fed roselle calyx residue.

White blood cells (WBCs), also known as leukocytes, are a crucial component of the immune system, responsible for defending the body against infectious diseases and foreign invaders. WBCs circulate in the blood and lymphatic system and are derived from multipotent cells in the bone marrow known as hematopoietic stem cells. According to Leineweber *et al*. (2018), normal WBC values for rabbits typically range from 5.5 to 12.5 × 10^9/L, which encompasses the values obtained in the current study. The significant variations observed across the treatments in this study (Table 2) may be attributed to normal physiological fluctuations, stress, differences in breeds (as the experiment involved a mix of rabbits), and dehydration resulting from high heat stress during the study. The range of 5.67 to 8.59 × 10^9/L obtained in this study is lower than the range reported by Evans *et al*. (2021) and Aliyu *et al*. (2020), but higher than the findings of Awodola-Peters *et al*. (2019) regarding the hematology of rabbits fed diets with varying levels of Rubber Seed Meal (RSM). Red blood cells (RBCs), also known as erythrocytes, are the most prevalent type of blood cell and serve as the primary means of delivering oxygen to the body's tissues through blood circulation. RBCs absorb oxygen in the lungs or gills and release it into tissues as they navigate through the body's capillaries. The quantity of RBCs is a critical indicator of an animal's health status and can be influenced by various dietary interventions. Normal RBC values for rabbits typically range from 4 to 7 × 10^6/µL, according to Fielder (2022). The range of 3.94 to 5.06 × 10^6/µL observed in this study is consistent with the findings of Istifanus *et al*. (2022) but is higher than those reported by Mafimidiwo *et al*. (2023).

Mean Corpuscular Haemoglobin Concentration (MCHC) is a measure of the average concentration of hemoglobin in a specified volume of packed red blood cells, expressed in grams per deciliter (g/dL). For rabbits, normal MCHC values typically range from 29 to 37 g/dL, according to Fielder (2022). However, these values may vary slightly depending on specific laboratory standards and the health status of the rabbits. The significant variations and lower values of 26.46, 26.48, 27.54, 30.00, and 27.36 g/dL (T1, T2, T3, T4, and T5, respectively) observed in this study (Table 2) may be attributed to iron deficiency or inadequate dietary intake of essential nutrients necessary for hemoglobin synthesis. These results are lower than the range of 32.00 to 33.95 g/dL recorded by Mafimidiwo *et al*. (2023) (Table 2), which importantly fall within the normal range. Mean Corpuscular Volume (MCV) is a measure of the average volume of a red blood cell (RBC), expressed in femtoliters (fL). For rabbits, normal MCV values typically range from 58 to 67 fL, according to Fielder (2022). All MCV values from the five treatments in this study are significantly above the normal range of 58 to 67 fL, indicating that the rabbits in these treatments are experiencing macrocytosis, a condition characterized by larger-than-normal red blood cells. This condition may be attributed to deficiencies in vitamin B12 or folate (Boule, 2022). The observed range of 76.7 to 91.60 fL in this study (Table 2) exceeds the range of 64.10 to 66.30 fL reported by Istifanus *et al*. (2022).

Mean Corpuscular Haemoglobin (MCH) is a measure of the average amount of haemoglobin contained in a single red blood cell, expressed in picograms (pg). According to Fielder (2022), the typical range for MCH in rabbits is between 17 and 23.5 pg. All observed values in this study (Table 2) fall within this range, indicating no significant abnormalities in the haemoglobin content of the red blood cells across these treatments. The range of

20.30 to 27.45 pg is generally consistent with the range of 19.57 to 25.47 pg reported by Mafimidiwo *et al*. (2023), although it is slightly higher than the range of 19.30 to 21.09 pg observed by Evans *et al*. (2021).

Serum Biochemistry of Rabbits Fed Varying Levels of Toasted Roselle Seed Meal as Partial Replacement for Soybean Meal (SBM)

The total protein levels of rabbits fed toasted roselle seed meal (TRSM) in this study ranged from 6.10 g/dL in treatment group T5 to 6.80 g/dL in treatment group T2, falling within the reference range of 5.4–7.5 g/dL (Melillo, 2007). Total protein (TP) reflects the combined concentrations of albumin and globulin, providing insights into the animal's nutritional status, liver function, and immune response. The values obtained are consistent with those reported by Aliyu *et al*. (2024), who found similar total protein levels in rabbits fed a sunflower seed cake (SFSC) diet. This suggests that TRSM diets adequately support protein levels comparable to other seed-based diets. Variations in TP across treatment groups may result from differences in protein content in the diets or the digestibility of TRSM at higher inclusion levels (see Table 3). Albumin levels were highest in T2 and T3, measuring 3.60 g/dL, which falls within the reference range of 2.7–5.0 g/dL (Melillo, 2007). Albumin, a key blood protein synthesized by the liver, plays a vital role in maintaining blood osmotic pressure and facilitating the transport of nutrients and hormones. These values are comparable to those reported by Aliyu *et al*. (2024) for rabbits fed a diet of SFSC. However, rabbits on TRSM diets exhibited slightly lower albumin levels than those observed by Evans *et al*. (2022), who reported values ranging from 4.20 to 4.90 g/dL in rabbits fed *Delonix regia* seed meal. This discrepancy may indicate that TRSM offers moderate support for albumin levels compared to other high-protein sources, such as Delonix, potentially due to variations in amino acid profiles or the bioavailability of protein in TRSM.

Globulin values across TRSM treatments ranged from 3.10 to 3.40 g/dL, which is slightly above the range of 1.5–2.7 g/dL reported by Melillo (2007). Globulin proteins are essential for immunity, clotting, and transport. The slightly elevated globulin levels may indicate an enhanced immune response or increased protein synthesis capacity in rabbits fed TRSM, particularly at higher inclusion levels. These values are consistent with those reported by Aliyu *et al*. (2024) for rabbits fed SFSC, but they differ slightly from the findings of Ashom and Luka (2018), who observed lower globulin levels in rabbits fed baobab seed kernel meal. The observed variations may be attributed to the immune-stimulating effects of TRSM or differences in dietary nitrogen retention (see Table 3). Aspartate Aminotransferase (AST) levels in the study peaked at T4 and T5, measuring 33.86 and 34.21 IU/L, respectively. These values fall below the reference range of 35–130 IU/L (Melillo, 2007). AST is an enzyme that plays a crucial role in assessing liver and muscle tissue health. The lower AST levels observed suggest that toasted TRSM may promote healthy liver function with minimal metabolic stress, potentially due to the reduced presence of anti-nutritional factors in the toasted TRSM. In contrast, Aliyu *et al*. (2024) reported elevated AST levels associated with SFSC, while Awodola-Peters *et al*. (2019) noted even higher levels with roselle calyx residue. These findings indicate that TRSM may induce less liver stress compared to other seed-based diets.

Alanine aminotransferase (ALT) levels, an enzyme associated with liver function, were highest in T5 at 22.60 IU/L, showing a progressive increase with TRSM levels. These values fall within the range reported by Melillo (2007), which is 19–73 IU/L. ALT levels were lower than those documented by Awodola-Peters *et al*. (2019), who reported values of up to 53.22 IU/L with roselle calyx residue. This suggests that TRSM may contribute to lower ALT levels and reduced liver stress in rabbits. The variations in ALT levels among the treatments could be attributed to the differing concentrations of plant metabolites in the TRSM diets, which may have a mild influence on liver enzyme production. Urea levels ranged from 25.43 mg/dL in T1 to 28.63 mg/dL in T5, which aligns with the range of 20–45 mg/dL reported by Melillo (2007). Urea serves as an indicator of protein metabolism and kidney function. Elevated levels may suggest protein catabolism or renal stress; however, the stable levels observed across treatments indicate that TRSM does not significantly strain renal function. Additionally, similar urea levels reported in studies by Ashom and Luka (2018) involving baobab-fed rabbits suggest that both TRSM and baobab seed meal diets are well tolerated by rabbits concerning kidney health.

Creatinine levels ranged from 0.81 mg/dL in T1 to approximately 0.92–0.97 mg/dL in T2 through T5, all within the reference range of 0.50–2.50 mg/dL (Melillo, 2007). Creatinine is a byproduct of muscle metabolism and serves as a marker for kidney function. The consistent levels observed across treatments suggest that TRSM does not significantly impact renal health. This finding is consistent with Ashom and Luka (2018), who reported similar values in rabbits fed baobab. Therefore, it can be inferred that TRSM, like baobab seed meal, is unlikely to induce renal impairment in rabbits (see Table 3).Glucose levels were highest in T5 at 76.50 mg/dL, which is at the lower end of the reference range (75–155 mg/dL; Melillo, 2007). The lower glucose levels observed in TRSM diets may indicate reduced carbohydrate content in the TRSM feed, which can influence glucose production and utilization in the body. Awodola-Peters *et al*. (2019) reported higher glucose levels in rabbits fed roselle calyx residue, suggesting that TRSM diets may lead to different carbohydrate metabolism compared to those containing roselle calyx residue. Additionally, the decline in glucose levels with increased TRSM may reflect variations in dietary composition and differences in feed energy content (see Table 3).

CONCLUSION

In conclusion, toasted roselle seed meal (TRSM) can partially replace toasted soybean meal (TSM) in rabbit diets without compromising overall health. However, increasing TRSM levels led to significant variations in hematological and serum biochemical parameters. Notably, packed cell volume (PCV), hemoglobin (HGB), white blood cell counts (WBC), and red blood cell count (RBC) fluctuated across treatments, with T4 (30% TRSM) showing lower values. Similarly, total protein, albumin, and glucose levels were significantly influenced by TRSM inclusion. These findings suggest that TRSM can be safely incorporated at levels up to 20% while maintaining normal physiological functions in rabbits.

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