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GROWTH PERFORMANCE, BODY WEIGHT PREDICTION AND HAEMOTOLOGICAL INDICES OF RABBITS FED RUMEN LIQUOR FERMENTED SUGARCANE SCRAPPING MEAL

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ABSTRACT

The study aimed to assess the impact of incorporating rumen liquor sugar cane scrapping meal (RLFSCSM) into rabbit diets on growth performance, body weight and haemotological indices. A total of 24 mixed breed grower rabbits of similar live weight (700 – 832g) were used and subjected to a Completely Randomized Designed (CRD) with 4 treatments, 3 replicate having 2 rabbits each. The rabbit diets were formulated to replace maize at different percentages 0, 10, 20 and 30% representing T1, T2, T3, and T4 respectively. Feeding and other routine management practices were strictly adhered to according to standard practices throughout the experimental period. The results showed a $p<0.05$ increase in the total weight gain (676.83g/rabbit), average daily gain (19.34 g/rabbit) and average daily feed intake (73.29g/rabbit). Additionally, Logistics 3P and Gompertz 3P predicted the highest growth rate of rabbits 935.599 and 935.582 g/rabbits at the age of 3 weeks. However, haematological parameters showed mixed effects, with a decrease in hemoglobin (10.77 to 10.50g/dL) and packed cell volume (35.50 to 33.66%) at certain inclusion levels of RLFSCSM but increases at higher levels. Red blood cell count remained relatively stable across treatments, while mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration improved (21.67 pg and 31.67 g/L) with increasing RLFSCSM levels. White blood cell counts and mean corpuscular volume were unaffected by RLFSCSM inclusion. It was concluded that diet containing 30% RLFSCSM could improve general performance and health without detrimental effects when fed to grower rabbit.

Keywords: Body weight, Growth, Haematology, Prediction, Rabbits

INTRODUCTION

The distinctive qualities of the rabbit (*Oryctolagus cuniculus*) make it suitable for production on both a small and large scale. These qualities may offer a quicker solution to the low animal protein issues in developing nations such as Nigeria (Oloruntola *et al.*, 2015). These characteristics include, among others, small size, quick growth, high potential for reproduction, short generation interval, ability to use non-competitive diets, production of meat that is relatively high quality, and good genetic improvement potential (Oloruntola *et al.*, 2015).

Studies have shown that feeds account for about 70% of the production cost in livestock animal of which 40% comes from maize as source of energy (Ari *et al*., 2012; Ari *et al.*, 2016). Maize as an energy source has direct competition with humans in terms of food, arising from a variety of uses in both industrial and human nutrition. This makes it necessary to look for widely available and reasonably priced alternatives (Ari *et al.*, 2016). Agro-industrial waste products, including sugarcane scrappings, are easily found as unconventional feed ingredients that can be used in place of monogastric diets' energy sources, like maize, wheat, rice offal, and cassava peels (Kanyinji and Moonga, 2014).

Scrappings from sugarcane are leftover materials after processing sugarcane for chewing to extract juices, the rind of the stem is scraped off with a sharp knife to make it simpler to access the soft parenchyma tissue beneath (Ayoade *et al.*, 2007). Most of the time, these scraps and peels are piled, occasionally burned, or left in places where they release gases into the atmosphere, which pollutes the environment and dramatically increases global warming. Report from Alu, (2012) state that sugarcane scrappings have low level of crude protein but significant level of energy and crude fibre.

Ari *et al*. (2012) stated that high fibre content of agro-industrial waste products needs to be broken down and their nutritional composition altered via processing to maximize their utilization in monogastric diets. Improvements in nutrition and lower fibre content of substitute feedstuffs have been documented using a variety of methods including fermentation, the use of exogenous enzymess, mechanical and chemical treatments

It has been stated by Priego *et al.* (1977) that rumen liquor can be used for both in-vitro and in-vivo fermentation of sugarcane and other agro-industrial waste in ruminant and monogastric animals. Research has shown that fermentation process stimulates growth, and the immune system in hens (El-Abasy *et al.,* 2002). Furthermore, several authors reported different feeding mechanism to rabbits with a mixture of forages, pelleted and concentrate diets with better rate of growth, high digestibility and good health (Acho *et al.*, 2014; Yao *et al.*, 2015). It is against this background that conversion and inclusion of rumen liquor fermented sugarcane scrappings to replace maize in rabbit diets becomes important.

MATERIALS AND METHODS

Location of the study

The study was carried out at the Federal University of Lafia, State, in the Research and Teaching Farm of the Department of Animal Science, Faculty of Agriculture. The Farm is situated in the Southern Guinea Savannah Zone of Nigeria, Gandu Lafia Campus, and is located on atitude 8028.78N and Longitude 8033.11E. The typical monthly relative humidity is 74%, with an average lowest temperature of 23^{o}C and a maximum temperature of 36.90^{o}C. At the time of the experiment, the mean monthly temperature was 35.06^{o}C and the mean yearly rainfall was 823mm (NIMET, 2024).

Source of experimental rabbits

The experimental rabbits were acquired from National Veterinary Research Institute (NVRI) Vom, Plateau State, Nigeria. Rabbits were placed on 28cm by 19cm size plastic basket and transported to the experiment farm as stated above using commercial vehicle from plateau State to Lafia, Nasarawa state from 6am to 10am.

Experimental feed ingredients

The test ingredient (sugarcane scrappings) was obtained at the market where sellers of sugarcane were much concentrated,who processed sugar cane for consumption in Lafia metropolis of Nasarawa State, Nigeria. Other ingredients such as methionine, lysine, bone meal, blood meal, GNC, maize, maize bran, rice offal, palm oil, salt and premix were obtained from Global feed industry, which is located in Maraba along Keffi – Abuja road, Nasarawa State.

Rumen Liquor

The Lafia Municipal Abattoir gathered the bovine rumen content as a slaughter waste produced during slaughtering of White Fulani cattle. A 100-mm nylon mesh filter was used to filter the rumen content to obtain the fluid (liqour). The liquor portion of the contents was transferred into insulated flasks and kept for 5-10 minutes prior to inoculation. the solid components were disposed. The rumen fluid was later used as source of inoculums.

Rumen liquor inoculation with sugarcane scrapping

Six litres of rumen liquor were sprayed using a plastic container for every kilogram of sugarcane inoculate them the stored rumen liquor. After properly mixing the sprayed sugarcane scrappings, they were placed in an airtight plastic container to start the fermentation process, which took place for 72 hours. The fermented sample was sundry, hammer-milled to produce rumen liquor fermented sugarcane scrapping meal (RLFSCSM) and sub-sample was sent for the analysis of nutrient composition according to AOAC (2010) methods.

Experimental Diets

The experimental diet was 15% isonitrogenous crude protein and 2500 kcal/kg ME with test ingredients. Four (4) experiment diets were tag T1, T2, T3 and T4 respectively. T1 contained (0%RLFSCSM) which serves as the control diet, T2 contained (10% RLFSCSM), T3 contained (20% RLFSCSM), and T4 contained (30% RLFSCSM).

Experiment Design

Twenty-four (24) rabbits were distributed to the test diets T1, T2, T3 and T4 respectively. Completely Randomized Design (CRD) was used for four treatments with 3 replicates and each having 2 rabbits. $Yij = \mu + ti + eij$ is the statistical model that was employed, in which eij represents the random error, ti denotes the treatment effect i, μ is the population mean, and Yij represents jth observation of treatment ith.

Management of experimental animals

Five (5) weeks old composite grower rabbits of equal sex (12 male and 12 female) and average live weight (700-832g) were purchased and reared in an open-sided mesh hutch. Throughout the trial, electric lights were used to provide nighttime lighting so that the rabbits could eat throughout the day. Experimental diets were supplied to the rabbits, and they were given unlimited access to water. Standard management procedures were implemented in accordance with Kpehe *et al*. (2020).

Collection of data and processing

Feed intake

Every day, the necessary amount of feed was weighed before being fed to the animals. To determine the real feed consumption for that day, leftovers were weighed and deducted from the feed that was supplied. Feed intake (g) = feed given (g) – feed left out (g). The entire sum of the daily feed intake was divided into seven (7) to determine the weekly feed consumption. Total daily feed intake / 7 equals weekly feed consumption. The total weekly feed intake for the duration of the experiment was divided by the number of days to get the average daily feed intake.

Weight gain

To determine the true weight disparities, rabbits were weighed on a scale at the start and conclusion of each week. By deducting the initial weight from the end weight, weight gain is calculated by the foll owing equation: Final body weight (g) - initial body weight (g).

Feed Conversion Ratio

The Feed Conversion Ratio (FCR) was used to measure the animal's efficiency in converting feed mass into body mass. It is defined as the ratio of the amount of feed consumed by the animal to the amount of weight gained by the animal over a specific period. FCR is given by the following calculation FCR = feed intake/weight gain.

Growth rate model

The individual animals were weighed every week to obtain the weekly body weight thereafter for 35 days across all the treatment. Weights were recorded as weekly body weight and were analysed for growth model predictions.

Haematological parameters

At the end of the 35 days experiment, blood samples were collected via the ear veins of three (3) selected rabbits from each treatment group and 5ml syringe was used for the collection and samples of blood were analyzed using haemocytometer while Hb and PCV were determined using methods adopted by Ari *et al*. (2016).

Statistical analysis

All data collected were analysed using SPSS MODEL 22 while SAS JMP statistical package was used to predict growth rate model. Means were separated using Ducan Multiple Range Test (DMRT) at ($P<0.05$).

RESULTS AND DISCUSSION

Table 1 indicates the proximate composition of raw and fermented sugarcane scrappings meal. The result showed reduction in dry matter in the RLFSCM (96.34%), ether extract (2.26%), crude fibre (16.86%), ash (2.30%) but improved crude protein (11.02%), NFE (62.99%) and metabolizable energy (2828.75 kcal/ME) compared to the raw sugarcane scrapping composition (97.41, 7.47, 3.10, 27.25, 4.44 and 55.14% and 2487.07 kcal/ME). Table 2 showed the experimental diets for grower rabbits for the four (4) treatments with percent inclusion of RLFSCSM at 0, 10, 20 and 30%. The metabolizable energy ranges from 2506.05 to 2507.02 kcal/ME while the crude protein values were between 18.01 to 18.03. this agrees with the recommended nutrient requirements of grower rabbits for optimum performance as outlined by de Blas & Wiseman, (2003). Table 3 depicts the gross response of rabbits fed RLFSCSM. Significant ($P<0.05$) effects exist in mean values for total weight gain (TWG), average daily gain (ADG) and average daily feed intake (ADFI) but initial body weight, final body weight and feed conversion ratio (FCR) were not significant (P>0.05). Rabbits fed T2 (676.83 g) had higher TWG compared to control T1 (435.50 g) and T3 (428.83 g) but statistically similar with T4 (525.33 g). However, T2 and T3 were the same as T4 respectively. Similarly, average daily weight gain (19.34 g) at T2 followed the same trend with TWG. Average daily feed intake at T4 (73.29 g) was statistically higher than control T1 (55. 76 g) and T3 (63.59 g) but similar with T2 (66.89 g) only. The higher values obtained in T2 for TWG and ADG might be associated with inclusion of RLFSCSM in the diet. This is because fermentation has improved the nutritional status of diet thereby making the diet more palatable. This is in concordance with Kpehe *et al.* (2020) who stated that fermenting rice offal with rumen filtrate improves overall production profitability of rabbit and increases cheaper animal protein. The average daily weight gain in the present study was comparable with daily body weight gain with rabbits fed 20% rumen filtrate fermented rice husk 20.54 g by Kpehe *et al*. (2020) but feed intake was slightly lower compared with 93.88 g from Kpehe *et al*. (2020). The feed intake in this present study increased from T1 to T4. The consistent increase in feed intake in the group fed with RLFSCSM implied acceptability of the diets. This could be because of the palatability of the diet at 30% inclusion meal of RLFSCSM. This is also confirmed by Moningkey, (2022) who suggested that fermented rumen content and sludge mixture in rabbit feed increases consumption and body weight increment while reducing food conversion. Similarly, Amos *et al*. (2022) reported that dried rumen waste can replace maize up to 30% in growing rabbit diets without compromising growth performance or health status. The non-significant improvement in the FBW and feed conversion ratio implies that the diets supported the production of grower rabbits without any alteration in their performance. This agreed with Mohammed and Igwebuike (2011) who stated that 40% bovine blood-rumen content mixture can be incorporated into growing rabbit diets without adverse effects on growth performance, leading to lowered feed cost and production costs.

Table 1: Proximate analysis of RLFSCSM

Nutrients composition	Raw sugarcane scrappings	Fermented sugarcane scrappings
Dry matter %	97.41	96.34
Crude protein %	7.46	11.02
Ether extract %	3.10	2.26
Crude Fibre %	27.25	16.86
Ash %	4.44	3.20
NFE %	55.14	62.99
ME kcal/ME	2487.07	2828.75

%NFE= 100 – (%CP + %CFAT + CFIBRE + %ASH + %M); DM= 100- %MOISTURE; ME= 37x CP % +81.8 x CFAT % + 35.5 x NFE %, source: MR O.O. AFOLABI (FIPAN), ANALYST, IPAN ANALYST LICENCE NO; 00328.

Table 2: Experimental diets for grower rabbits with percent inclusion of RLFSCSM

Ingredients	T1 (0% RLFSCSM)	T2 (10% RLFSCSM)	T3 (20% RLFSCSM)	T4 (30% RLFSCSM)
Blood meal	0.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25
Maize bran	21.00	24.00	24.00	26.00
Groundnut cake	25.00	23.00	23.00	24.00
Rice offal	20.00	18.00	18.00	15.00
Premix	0.25	0.25	0.25	0.25
Maize	30.00	27.00	24.00	21.00
***RLFSCSM**	0.00	3.00	6.00	9.00
Bone meal	2.00	1.50	1.50	1.50
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Palm oil	0.50	1.00	1.00	1.00
TOTAL	100.00	100.00	100.00	100.00
Calculated analysis				
Energy kcal/kg ME	2506.05	2506.39	2505.34	2507.02
Protein %	18.01	18.03	18.01	18.03
Crude fibre %	4.63	5.37	5.92	6.62
Ether Extract %	5.46	5.77	5.82	5.82
Ash %	5.78	5.44	5.52	5.11
Calcium %	0.84	0.71	0.73	0.75
Phosphorus %	0.67	0.68	0.78	0.88
Lysine %	0.82	0.85	0.87	0.90
Methionine %	0.44	0.45	0.45	0.46

*RLFSCSM = rumen liquor fermented sugarcane scrapping meal; The vitamin- mineral premix supplied the following per 100kg of diet: vitamin A15,000 I.U, vitamin D3 300,000 I.U.,vitamin E 3,000 I.U., vitamin K 2.50mg, vitamin B1 (thiamin) 200mg, Riboflavin (B2) 600mg, pyridoxine (B6), Niacin 40.0mg, vitamin B12 2mg, Pantothenic acid 10.0mg, folic acid 100mg, Biotin 8mg, choline chloride 50mg, anti-oxidant 12.5mg, manganese 96mg, zinc 6mg, Iron 24mg, Copper 0.6mg, Iodine 0.14mg, Selenium 24mg, cobalt 214mg. Using Feedwin software version 1.01.

Table 3: Rumen liquor fermentation on growth performance of grower rabbits fed sugarcane scrapping meal for 35 days

Parameters	Percent inclusion level of fermented SCSM					
	T1 (0%)	T2 (10%)	T3 (20%)	T4 (30%)	SEM	LOS
Initial body weight (g/rabbit)	792.67	792.67	832.00	810.67	36.89	ns
Final body weight (g/rabbit)	1228.17	1469.50	1260.83	1336.00	43.57	ns
Total weight gain (g/rabbit)	435.50^{b}	676.83^{a}	428.83^{b}	525.33^{ab}	37.48	*
Average daily gain (g/rabbit)	12.44^{b}	19.34^{a}	12.25^{b}	15.01^{ab}	1.07	*
Average daily feed intake (g/rabbit)	55.76^{c}	66.89^{ab}	63.59^{b}	73.29^{a}	2.15	*
Feed conversion ratio	4.82	3.49	5.29	4.88	0.32	ns

^{abc*} Means on the same row having similar superscripts were not significant (P>0.05), ns=not significant, * = significant at (P<0.05), SEM= standard error of mean, LOS= level of significance.

The predicted growth rate model is presented in Table 4. Best growth was predicted by Logistic 3P model for rabbits fed RLFSCSM, AIC and BIC descend the models in order, in the following rank Logistic 3P, Gompertz 3P, Gompertz 4P, Logistics 4P and Logistics 5P. The Coefficient of determination ranged from 0.0789 and 0.0961 for the models, representing superior fit and high ability to predict weight during the production. The age at inflection point was 3 weeks while weights were 935.599, 935.582, 879.292, 879.159 and 879.033 g/rabbit for Logistic 3P, Gompertz 3P, Gompertz 4P, Logistics 4P and Logistics 5P. The graph of the actual and predicted body weight is shown in Figure 1. Logistics 3P and Gompertz 3P predicted the highest growth rate of rabbits fed RLFSCSM from 10-30% (935.599 and 935.582 g/rabbits) at the age of 3 weeks with the subsequent coefficient value of determination of 0.0789 and 0.0961 respectively. Age (3 weeks) and weight (935.599 and 935.582 g/rabbits) at point of inflection are indices which indicated the optimal age and weight of rabbits fed RLFSCSM where the best weight is predicted and realized by the models. The curve averagely matched the growth with optimal efficiency 0.0789 in Logistic 3P and 0.0961 in Gompertz 3P which considers both fits and parsimony. This is in conformity with Anna *et al.* (2022) that investigated two growth patterns of Popielno White and New Zealand White rabbits and concluded that for practical prediction of rabbit growth, the Gompertz function was a superior choice. This was confirmed in an earlier study by Jacob *et al.* (2015), who conducted a study on white giant rabbits and noted that the fastest growth occurred during the 5th to 6th week. However, this is slightly above the prediction of the present study.

Table 4: Predicted growth rate on weekly body weight of Rabbits fed fermented RLSCSM for 35 days

Body weight/ Model	A	B	C	d	e	Age and weight at inflection point	AIC	BIC	RMSE	R^2
Logistic 3P	0.061	47.873		15131.629		3; 935.599	1677.701	1688.503	257.072	0.0789
Logistic 4P	3.8589	3.950	874.006	1081.346		3; 879.159	1677.622	1691.033	255.761	0.0961
Logistic 5P	12.316	4.177	874.013	1077.793	0.255	3; 879.033	1679.839	1695.821	257.072	0.0789
Gompertz 3P	0.004	783.979		8.4484e+9		3; 935.582	1677.700	1688.502	257.071	0.0789
Gompertz 4P	1.655	3.805	874.00	1108.024		3; 879.292	1677.622	1691.033	255.761	0.0961

AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSE = Root mean square error; R^2 =Coefficient of determination; a = maturity index; b = scale parameter; c = asymptotic weight; d = upper asymptote; e= power or asymmetry parameter.

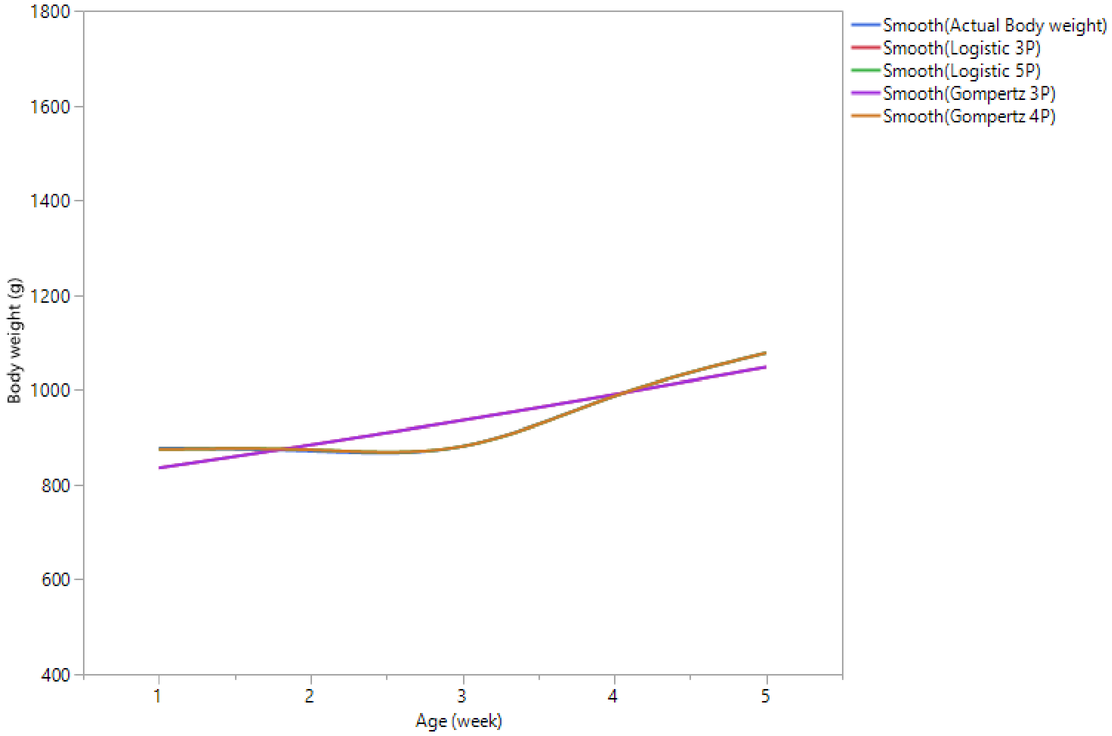

Figure 1: Estimated growth rate of rabbit fed fermented RLSCSM

Table 5 Present haematological parameters of grower rabbits fed RLFSCSM. Haemoglobin (Hb) reduced at T2 but increased at T3 and T4 (10.50 and 10.07 g/dL) as RLFSCSM progresses compared to T1 with the highest Hb (10.77 g/dL). Similarly, packed cell volume (PCV) reduced as the level of RLFSCSM increased from 0 - 10% (35.50 – 23.33%). However, T3 and T4 had increased PCV (33.66 and 32.00%). The similarity in the RBC between T1, T3 and T4 were due to the palatability of T3 and T4 diets that was improved by RLFSCSM. However, T2 (3.47×10^{12}/l) had lower RBC compared with others. There was improved MCH and MCHC when RLFSCSM also improved. T2 had higher MCH (21.67 pg) than T3 and T4 but similar with T1 (20.00 pg). MCHC was higher at T4 and T3 (31.67 and 30.33g/L) compared with T2 and T1 (23.33 and 10.50 g/L) respectively. White blood cells and mean corpuscular volume were not altered by RLFSCSM. The reduction in Hb and PCV of 10% did not cause any anemic condition. However, 20 and 30% inclusion of RLFSCSM improved the Hb and PCV (10.07 and 10.50 g/dL). This might be associated with RLFSCSM percent inclusion which is probably due to the fermentation at 72 hours. Fermentation is believed to have a positive relation with rabbit's blood haemoglobin and packed cell volume. This assertion agreed with the previous work by Onifade *et al*. (1998) who said that rabbits fed fermented feeds had improved hemoglobin levels and PCV compared to those on non-fermented diets, indicating better overall health and nutrient utilization. Again, research has shown that fermented soybean meal increases iron bioavailability, which can improve haemoglobin synthesis and prevent anaemia in rabbits (Oliveira *et al*., 2005). The increase in the Mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) and the non-significant white blood cells suggest better utilization of RLFSCSM by rabbits. This is associated with the presence of microbes still present in the rumen liquor which helps to degrade fibre component of the diet making complex carbohydrate and protein available for the animals. This is in consonant with Zulkifli *et al*. (2000) who stated that fermented feeds containing probiotics like *Lactobacillus spp* which improved antibody production. This has been confirmed to boost gut health, leading to improved immune responses and balanced WBC counts in rabbits. Moreso, fermentation enhances the breakdown of complex carbohydrates and proteins, making nutrients more readily available for absorption. This is crucial for maintaining healthy blood parameters, as noted in the works of Esonu *et al.* (2001).

Table 5: Rumen liquor fermentation on haematological indices of grower rabbits fed sugarcane scrapping meal (35 days)

Parameters	Percent inclusion level of fermented SCSM					
	T1 (0%)	**T2 (10%)**	**T3 20%)**	**T4 (30%)**	**SEM**	**LOS**
Haemoglobin (g/dL)	10.77[a]	6.90 [b]	10.50 [a]	10.07 [ab]	0.64	*
Packed cell volume (%)	35.50[a]	23.33 [b]	33.66 [ab]	32.00 [ab]	1.97	*
Red blood cells ($\times 10^{12}$/l)	5.50 [a]	3.47[b]	5.47 [a]	5.27 [a]	0.33	*
White blood cells ($\times 10^{9}$/l)	8.87	6.30	9.00	9.07	0.75	ns
Mean corpuscular volume (fL)	63.00	66.67	62.00	61.67	1.07	ns
Mean corpuscular haemoglobin (pg)	20.00[ab]	21.67[a]	19.00[b]	19.00[b]	0.39	*
Mean corpuscular haemoglobin concentration (g/l)	10.50[c]	28.33[b]	30.33[a]	31.67[a]	0.42	*

[abc*] Means on the same row having similar superscripts were not significant (P>0.05), ns=not significant, * = significant at (P<0.05).

CONCLUSION

The results from the study provided a means of using RLFSCSM as locally available feed ingredientsfor rabbits' diet, thereby improving general performance and health without detrimental effects. The growth prediction model could also prove valuable for breeders in describing the growth rate pattern and process in selecting economically advantageous rabbit breeds. Haematological indices reveal reduction in most blood parameters at T2 (10%). However, values were within the normal blood constituents of rabbits at 20 and 30%. The study recommends up to 30% inclusion of RLFSCSM in the diets of grower rabbits for general growth performance and normal physiological function.

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