

Evaluation of the serum biochemistry and haematology of rabbits fed straws and haulms diets

Awang, Z. E.¹; Shaahu, T. D.¹, Tuleun, D. C.¹, Okpanachi, U.² and Okwori¹, I. A.

Department of Animal Production, Joseph Sarwuan Tarka University, Makurdi Nigeria¹ and
Department of Animal Production, Faculty of Agriculture, University of Jos, Nigeria².

Corresponding Author: doekoos.em@gmail.com

Target Audience: Farmers, animal producers, extension workers, researchers and students

Abstract

With the current unavailability and competition for crop products in the country, there is a need to conserve crop residues, which are found here in Jos, Plateau State, and supplement them in feeding animals, especially during the dry season when fresh forages are not readily available or obtainable. The serum biochemistry and haematology of exotic breeds of rabbits were evaluated. Forty-two (42) weaner rabbits with an average weight of 922.08 g were utilized for the investigation. The haematological and serum biochemical indices were monitored after twelve (12) weeks of feeding. Six (6) rabbits with three (3) males and three (3) females were grouped into seven (7) treatments with individual rabbits as a replicate in a completely randomized design (CRD). Control groups were fed with feeds containing rice offal; while the six (6) groups from diet 2 (D2) to diet 6 (D3) in which D2 contained 20% acha straw; D3 contained 20% rice straw; D4 contained groundnut haulms; D5 contained cowpea haulms, D6 contained 20% (50% groundnut and 50% groundnut haulms) D7 contained 20% of (50% rice straw and 50% cowpea haulms). After the feeding trial, the blood samples were collected from the ear veins for serum biochemical and Hematology study. The result showed that alanine aminotransferase (ALT), aspartate transaminase (AST), total bilirubin, and glucose were significantly different between the treatments; while the total albumin, total protein, urea and creatinine had no significant difference. For haematology there were no significant differences between treatments for PCV, HB, RBC, L, M, E, B, PEP, and POS except for RBC and WBC which had a significant difference of 5% between the treatments. This study indicated that the use of 20 % straw and haulms in diets alongside other feedstuff will meet the nutritional needs of rabbits and aid adequate healthy blood formation and circulation at a similar level to the control diet. It is therefore recommended for rabbit farmers and feed manufacturers.

Keywords: haematology, serum biochemistry, rabbits, straw and haulms.

Description of Problem

The system of food globally is experiencing the pressure of conflict in how to deliver the demanded food to the increasing population while achieving sustainability in the environment (1). Along with the rising population, higher consumption rates for commodities such as meat and milk, are due to rising incomes (2, 3).

Straws are particularly stalks of grasses, mostly of cereal such as rice, oats, acha, wheat, oats and barley. When collectively used it's referred to the stalks that are left after the grains are dried and threshed. Ancient people especially in Africa have used straws as fodder and litter for ruminants (4).

Haulms are collective stems or stalks of especially legumes such as beans, peas or

tubers such as potatoes after the pods and tubers of various plants are left after harvesting the crops which are used as animal food or litter, or for thatching (5), 2023).

Haematological parameters are pointers and reflect dietary treatments effect on the experimental animals in terms of the quantity of feed consumed and the type that was given to the animal to meet all its nutrient requirements (6). The constituents and metabolites contained in the does provide an important channel for clinical study and the nutritional footing for both animals and human beings (6). Components of diets have quantifiable outcomes outcome on blood constituents, consequently, the blood components are extensively utilized in the evaluation of nutrients and animal surveys (7). Laboratory assessment can be carried out to gauge effective status of different body organs like kidneys, pancreas, and liver of animals. Therefore, the haematological and biochemical serum reaction of rabbits fed straws and haulms diets were studied.

With the current unavailability and competition on crop products in the country, there is a need to conserve crop residues which are found here in Jos, Plateau state into hay, and supplement it in feeding animals, especially in drought where fresh pasturage is not available or obtainable. Therefore, it would be very beneficial if they could be nutritionally evaluated and used in the livestock feed industry. This would solve the challenges of availability and cost of feeding and thus, meeting up protein intake of the growing population.

Materials and Methods

This study was conducted at Furaka community, Lamingo, Jos North Local Government of Plateau State. Lamingo lies within latitude N9° 53' 25.4574 and longitude E8° 55' 27.7818 located in Jos

North, Plateau State, with an average temperature which ranges from 21-25°C in November through January. The temperatures at night can be as low as 7°C. Hailstorms at times fall in the rainy periods due to the cool temperatures. The city of Jos, Plateau state receives about 1, 400 mm (55 inches) of rainfall annually (8).

Test Materials

Acha, rice, peanut and cowpea straws were obtained from farmers in Plateau State.

Experimental Diets

Seven experimental diets encrypted as diet one (D₁), diet two D₂, diet three (D₃), diet four (D₄), diet five (D₅), diet six (D₆) and diet (D₇) were formulated with D1 having rice offal as the control, while D2, D3, D4, D5, D6 and D7 contained acha straw (A S), rice straw (R S), peanut straw (P S), cowpea straw (C S), acha straw and peanut straw (50% A S and 50% P S) rice straw and cowpea straw (50% R S and 50% C S) which replaced rice offal respectively. The ingredients, calculated nutrients and energy in the diets are presented in Table 1.

Experimental Animals, Design and Management

Forty-two, (42) exotic breeds of weaner rabbits, 21 males and 21 females, 7-8 weeks of age, their weight ranging from 859.63 and 871.36 g were bought from a disease-free rabbit farm for the experiment. The rabbits were kept in sole cages made of iron/wire nets. They were allowed seven days (7) acclimatization to the new environment after which six (6) rabbits each were randomly allocated balancing for sex (3 males and 3 females) to seven treatment groups, with each rabbit serving as a replicate. Completely Randomized Design, (CRD) was used. Standard rabbit husbandry practices including, medications against common

external and internal parasites, recommended sanitary measures and other health practices were strictly observed during the study. The experimental diets and water were provided *ad libitum*. The experiment trial lasted for 84 days.

Collection of blood

Each rabbit was bled via the ear vein and two vacutainer bottles were used for each of them; with the first bottle containing (EDTA) a calculated amount of ethylene diamine tetraacetic acid for haematological test and the other sterile vacutainer tubes without EDTA were covered and centrifuged, the serum was separated, poured out, deep-frozen for serum biochemical analyses.

Hematological variables

Packed cell volume (PCV) was evaluated from the samples of blood collected in tubes containing EDTA by mixing gradually and titrating in a micro hematocrit capillary tube to $\frac{3}{4}$ lengths. The capillary bottle was kept in a micro-hematocrit centrifuge to ensure the plasticine edge was outward. Subsequently closing the bottle, it was kept centrifuged for 4 minutes at 12,000 rpm. The bottles were read in the haematocrit reader; which expressed the PCV as a percentage (%) of the blood total volume. The concentration of haemoglobin was ascertained using the method of cyanmethaemoglobin by Drabkin's solution as diluent. The corpuscular constants, blood indices, MCV (mean cell volume), MCHC (haemoglobin concentration mean cell), MCH (hemoglobin) and mean cell were analyzed with the formulae described by (9). The RBC (Red blood cells) were determined by using 0.02 ml of the sample blood from the tube with EDTA and mixed with 4 ml of diluting fluid (3 g sodium citrate, 1 ml formaldehyde in 100 ml distilled water) by

shaking for 30 seconds. A quarter of the mixture was thrown out before filling the haemocytometer counting chamber and it was allowed to settle for a minute by standing it after filling. The red cells were counted utilizing the x 40 objective lens and x 8 eyepiece of the microscope using a counter. The total of RBC counted was determined using the below formula:

$$\text{RBC Total count} = \text{RBC counts} \times 10 \times 5 \times \text{dilution factor (200)} = \text{RBC counts} \times 10,000$$

Leukocyte total counts were estimated with a neubauer haemocytometer after dilution appropriately, and leukocyte differential counts were performed using the oil - immersion objective examination of blood films stained using feedstuff modified Romanovsky's Giemsa stain.

Serum parameters

Biuret method in total serum protein ascertainment was used as reported by (10). The determination of albumin was done using the Bromocresol Green (BCG) method described by (11). The concentration of globulin was carried out by deducting albumin from total protein. The albumin/globulin proportion was obtained by dividing the albumin calculated value by the globulin calculated value. Aspartate amino transferase (AST) and alanine aminotransferase (ALT) were ascertained by spectrophotometric methods reported by (12) and (13), respectively.

Data analysis

Data gathered were all analyzed statistically using (ANOVA) analysis of variance software program (14)

Results

Serum biochemistry

Blood serum biochemistry of the experimental rabbits is presented in Table 2 and were all significantly ($P < 0.05$) affected

by the diets. The ALT ranged from (3.40 umol /L – 17.85 umol /L), glucose 6.85 umol IU/L – 20.88 IU/L), AST (10.78 IU/L – /L – 11.25 umol /L), urea (7.35 umol /L – 26.00 IU/L), albumin (20.68 g/L – 24.10 8.90 umol /L and creatinine (62.23 umol /L – g/L), TP (77.03 g/L – 83.08 g/L), TB (10.33 68.80 umol /L).

Table 1: The Ingredients and Calculated Rabbit Nutrient Required Composition of Experimental Diets

Ingredients (%)	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
	Control	20.00% AS	20.00% RS	20.00% PS	20.00% CS	20.00% ASPS	20.00% RSCS
Maize	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Brewers dried grain	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Soya beans meal	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Rice offal	20.00	-	-	-	-	-	-
Acha straw	-	20.00	-	-	-	-	-
Rice straw	-	-	20.00	-	-	-	-
Peanut haulm	-	-	-	-20.00	-	-	-
Cowpea haulm	-	-	-	-	20.00	-	-
Acha straw +	-	-	-	-	-	20.00	-
Peanut haulm	-	-	-	-	-	-	-
Rice straw +	-	-	-	-	-	-	20.00
Cowpea haulm	-	-	-	-	-	-	-
Palm kernel cake	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Table salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit./Min.	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients							
Crude Protein (%)	18.58	18.22	18.50	19.60	20.34	19.05	19.28
Energy (kcal/kg)	2528.02	3005.93	3135.50	3115.88	3101.54	3125.44	3053.73
Crude Fibre (%)	13.01	12.71	12.23	12.43	12.21	11.81	12.46
Ether extract (%)	4.61	3.37	3.37	3.43	3.43	3.40	3.40
Calcium (%)	0.82	1.36	1.36	2.98	3.4	2.17	2.38
Phosphorus (%)	0.65	0.73	0.69	0.85	1.33	0.77	1.03

Table 2: The effect of feeding straws and haulms diets on the blood serum biochemistry of the experimental rabbits

Parameter	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇	SEM	LOS
ALT IU/L	3.82 ^b	6.50 ^b	6.25 ^b	5.15 ^b	3.40 ^b	20.88 ^a	20.20 ^a	1.58	Ns
AST IU/L	26.00 ^a	21.30 ^{ab}	20.13 ^{ab}	21.35 ^{ab}	14.20 ^{ab}	14.23 ^{ab}	10.78 ^b	1.78	Ns
Albumin (g/L)	21.63 ^a	23.08 ^a	20.68 ^a	22.05 ^a	23.10 ^a	24.10 ^a	23.38 ^a	0.46	Ns
Total Protein (g/L)	77.03 ^a	80.55 ^a	83.08 ^a	82.15 ^a	78.80 ^a	81.75 ^a	82.53 ^a	2.77	Ns
Total Bilirubin (umol /L)	14.58 ^{ab}	17.85 ^a	14.38 ^{ab}	13.60 ^{ab}	13.75 ^{ab}	10.33 ^b	11.68 ^b	0.75	Ns
Glucose(mmol /L)	6.85 ^b	9.28 ^{ab}	9.48 ^{ab}	9.58 ^{ab}	10.53 ^a	11.25 ^a	11.05 ^a	0.42	Ns
Urea (umol /L)	7.83 ^a	7.35 ^a	8.88 ^a	8.90 ^a	7.58 ^b	7.53 ^a	7.98 ^a	0.29	Ns
Creatinine L	62.23 ^a	66.95 ^a	64.68 ^a	66.00 ^a	68.80 ^a	67.53 ^a	65.60 ^a	0.81	Ns

Keys: a,b,c,d,e Means in column with different superscript(s) are significantly different at the 5 % level of probability; IU/L= unit per litre; G/L= gram per litre
umol/L= one-millionth per litre

Haematology

The effect of feeding straws and haulms diets on the haematology of experimental rabbits is presented in Table 3. No significant ($P>0.05$) difference in all parameters. The PCV of the experimental rabbits varied from 38.25 % to 42.00 %, the Hb (12.80 g/dl – 14.03 g/dl), RBC (8.25

$\times 10^{12}/L$ – 9.28 $\times 10^{12}/L$), WBC (6.15 $\times 10^{12}/L$ – 11.95 $\times 10^{12}/L$), N (25.25 % – 56.75 %), L (42.25 % – 71.75 %), M (0.00 % – 0.75 %), E (0.00 % in – 1.00), B seen were 0.00 % in all the diets, BLP were 1.00 in all the diets expect in D₄ which had 1.25 and POS recorded 6.00 in all the experimental diets.

Table 3: Effect of straws and haulms diets in haematology on the experimental rabbits

Parameters	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇	SEM	LOS
PCV %	40.25	39.00	39.00	42.00	40.25	41.25	38.25	0.58	Ns
HB g/dl	13.43	12.98	13.00	14.03	13.38	13.75	12.80	0.19	Ns
RBC $\times 10^{12}/L$	8.95	8.60	8.55	9.28	8.90	9.03	8.25	0.13	Ns
WBC $\times 10^{12}/L$	7.20	7.15	8.15	11.95	8.50	7.33	6.15	0.56	Ns
N %	25.25	38.00	40.75	56.75	28.00	32.50	29.50	2.93	Ns
L %	62.50	61.75	58.75	42.25	71.75	65.25	69.25	2.89	Ns
M %	0.75	0.00	0.50	0.50	0.00	0.75	0.25	0.16	Ns
E %	0.00	0.00	0.00	0.50	0.00	0.75	1.00	0.19	Ns
B %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
PEP %	1.00	1.00	1.00	1.25	1.00	1.00	1.00	0.04	*
POS %	6.00	6.00	6.00	6.00	6.00	6.00	6.00	0.00	*

PCV= Packed Cell Volume

HB= haemoglobin

RBC= Red Blood Cell

WBC= White Blood Cell

BFP= Blood Film Picture

POS= Platelet on Smear

g/dl= Gram per Decilitre

$\times 10$

%= Percentage

Ns= none significant

*= significant

Discussion

Serum Biochemistry

The results obtained for biochemistry were all significantly affected by the dietary treatments, which implied there was abnormal protein metabolism in the rabbits. (15) stated that serum biochemistry is subject to the quality and quantity of the protein included in the diet. Total protein (Tp) (77.03 - 83.08 g/L) is higher than (68.00 – 74.00 g/L) recorded by (16) who fed weaned rabbits diets containing *Ficus sycomorus* and *Parkia biglobosa* leaf meals. Tp was also higher than 54-75 g/L and 5-8 g/L recorded by 17 and 18, respectively for rabbits; which could indicate a high content of dietary proteins since the synthesis of protein serum is subject to the quantity of protein usually available in diet (15). In those fed legumes haulms diet was extremely higher than what was reported by (19). The Total protein in the blood of rabbits is higher than what was obtained by (20) in a similar study. The TP is higher than the normal range of 50 – 75 g/L in adult rabbits as recorded by (21).

Range values obtained for albumin (20.68 - 24.10 g/L) which is lower than that of (16) who recorded (34.00 - 48.33 g/L) for healthy rabbits and a properly functioning liver (22). The albumin in the rabbits fed legumes haulms diet (groundnut and beans) was significant at 5% level of probability and in contrast to the findings of (19) in similar research. Albumin in these studies is lower than what was reported by (20). The albumin in their blood is below the normal range of 2.7 – 5.0 mg/dL for adult rabbits according to (23). Likewise lower than 25 – 40 g/L was reported by (21). A range of 44.1 -53.4 g/L urea was recorded which is higher than 30.96 - 35.40 g/L urea which was reported by (22) for weaned rabbits fed with varying levels of dried *Gmelina arborea* leaf meal. Urea values observed in this experiment were lower than reported values

in vet times. The low content of urea in the serum of the rabbits in this experiment indicates that the diets were rich in protein and the protein was of high quality, as high content of urea in the blood usually indicates a low amount of protein in the diet (24). A lower level of urea in the blood also insinuates that the protein rich diet enhanced the proper functioning of the kidneys (Henry *et al.*, 2017). (19) recorded 31.37 - 38.00 g/dL urea in their studies on the effect of processing methods of *Leptadenia hastata* leaves. The level of urea found in rabbits fed legumes haulms diet (groundnut and beans) is lower than what was obtained in the studies done by (19) which reported 33.27 (umol/L) in those of rice straw diet and 33.65 umol/L in the diet. The urea in this study is higher than 20.50 – 22.50 mg/dl as recorded by (20). Urea is below the normal range of 20 -45 mg/dl for adult rabbits according to (23) and 9.1 – 25.5 mmol/l reported by (21). The low level of urea in this study indicated that the diet contained rich-quality protein. ALT found in their blood is lower than what was reported by (20) in a similar study. The ALT is below the normal range of 45-80 IU/L and 55-260 IU/L for adult rabbits according to (23) and (21). The amount of AST IU/L (10.78 - 26.00) is higher than 11.09 – 12.52 reported by (20). The AST is within the normal range of 10 – 96 IU/L recorded by (21). Creatinine values are in contrast to the works of (20) but it is within the normal range of 53 – 124 mmol/l (21). These results indicate that the straws and haulms in diets at 20 % are healthy for the rabbits. This contradicts the findings of (25) who reported that the levels of albumin and globulin are normally low in the blood but when the liver is damaged by toxic substances it becomes high.

Haematology

Haematological parameters ascertained

were within the normal physiological ranges for rabbits (26) except for monocyte and were all not significantly different at ($p>0.05$) except for lymphocyte which was affected by the dietary treatments. PCV values (38.25 - 42.00 %) in this study are within the range of (31.93 - 41.90 %) reported by (16) in their studies with diets containing *Ficus sycomorus* and *Parkia biglobosa* leaf meals. This study is greater than the range of 32.31 – 36.89 %, 31.33 - 36.83 % and 31.62 - 36.59 % recorded by (27; 28 and 22) respectively. However, it is lower than 49.17 – 53.83 reported by (7). The 42.00 % PCV in groundnut haulms diet is slightly higher compared to (19) which reported 40.08 %. In the beans haulms diet the value of 40.25 % in this study is lower than 42.07 recorded by (19). The PCV is within the normal range of 33.50 – 50 % in adult rabbits (21). Haemoglobin (Hb) (12.80 - 14.03 g/dL) values obtained were in agreement with the reports of 12.90 – 14.00 g/dl by (29; 30 and 28) on different levels of neem (*Azadirachta indica*) leaf meal but higher than reported values of (10.20 – 11.64); (9.50-12.10g/dl) and (3.60-5.20) $\times 10^6/\text{mm}^3$ reported by 27; 29 and 16 respectively. Groundnut haulms diet recorded 14.03 g/dl higher than 10.15 g/dl by (19). 13.38 g/dl in beans haulms diet is higher than 10.09 g/dl as reported (19). The amount of Hb in their blood is within the normal range of 9.4 – 17.4 g/dl recorded by (21). The values in this research indicated that the diet do not result in mineral deficiency, especially magnesium and iron which were able to synthesis haemoglobin made red blood cells transport oxygen effectively. The RBC (red blood cells) in groundnut haulms diet $9.28 \times 10^{12}/\text{L}$ which is higher than the values reported in the findings of (19). While in the beans haulms diet the value of 8.90 is similar to what was reported by (19). The entire values in the

experimental diets were higher than 7.33 – 8.64 and 4.90 – 5.38 $\times 10^{12}/\text{L}$ reported by (7 and 27). It is higher than the normal range of 3.8 – 7.9 $\times 10^{12}/\text{L}$ reported by (21). The PCV, Hb and RBC are within the normal physiological range in rabbits (31 and 19). White blood cell (WBC) within in groundnut haulms diet is higher than $8.14 \times 10^{12}/\text{L}$ reported by (19). In beans haulms diet is lower than what was recorded by (19). WBC (6.15 - 11.95 $\times 10^{12}/\text{L}$) in these studies are higher than (27 and 16) who got the values of 5.22 – 6.13 $\times 10^{12}/\text{L}$ and (1.71-5.80) respectively. However, the result obtained was lower than 9.21 -13.90 $\times 10^{12}/\text{L}$ reported by (7). WBC is within the normal range (7-15 $\times 10^6/\text{mm}^3$) reported by (31 and 19). There was no illness experienced during the study because the white blood cells were not affected by the dietary treatment. The main functions of WBC are preventing and fighting any occurrence of disease infection. It is also within the normal range of 5 – 13 $\times 10^9$ reported by (21). Neutrophils which was between 25.25 – 56.75 % higher than 37.17 – 40.00 % obtained by (7). The Neutrophils percent in the blood of the rabbits fed groundnut haulms diet (56.75 %) is higher than the 40.99 % reported by (19) in similar research. While in the blood of the rabbits fed beans haulms diet the neutrophils were lower than 42.90 % reported by (19). It was within the normal range of 34 – 70 % for adult rabbits (21) except for diet four (4). Lymphocyte values were (42.25 - 71.75 %). A lower lymphocyte count signifies the inability of the rabbits to produce and release sufficient antibodies when an infection occurs (32). The result obtained in this study was similar with the values observed by (7) which recorded 47.83 – 60.50 %. Lymphocytes present in the rabbits fed groundnut haulms diet are similar with (19). In those fed beans haulms diet the percentage found in this study is higher than

46.09 % reported by (19). Lymphocytes in the blood are within the normal range of 43 – 80 % (21). Lymphocytes are a great protection against local diseases and are involved in the formation of antibodies. Monocyte (0.00 – 0.75 %) which are lower than the values of 1.17 – 2.33 % recorded by (7). It is within the normal range of 0 – 4 % as reported by (21). Eosinophil 0.00 – 1.00 % which is lower than 0.67 – 2.00 % reported by (7). Eosinophils percentage present in rabbits fed legumes haulms is not significant and contrast to 19 which reported 2.20 % in rabbits fed groundnut haulms diet and 2.03 in beans haulms diet respectively and is within the normal range of 0 – 2 % for adult rabbits (21). Likewise, the Basophil is within the normal range (21). The results of these findings imply that the rice offal, straws, and haulms included at 20 % in the diet of the rabbits were adequate and had no adverse effect on all haematological components, which are basic indicators of health status in animals since the values recorded were within the normal range documented for healthy rabbits. This also signified the performance of the rabbits concerning with their health status, which provided a strong and well-developed immunity against local diseases that could have resulted in illness or death during the studies. Also, the haematological parameter variation recorded in this study could be due to feed differences, blood collection methods, handling of the samples collected, environmental factors, etc.

Conclusion and Applications

1. In this investigation study on rabbits fed diets containing 20 % straws and haulms in diets showed that serum biochemical and haematology were not affected.
2. This study indicated that the use of 20 % straw and haulms in diets alongside

other will meet the nutritional needs of rabbits and aid adequate healthy blood formation and circulation at a similar level to the control diet.

3. The results also revealed that the diets did not modify or resulted in any disease condition.

References

1. Tilman, D. and Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature*, 515 (2014), pp. 518-522, 10.1038/nature13959CrossRefView Record in ScopusGoogle Scholar.
2. Kearney, J (2010). Food consumption trends and drivers. *Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci.*, 365 (2010), pp. 2793-2807, 10.1098/rstb.2010.0149CrossRefView Record in ScopusGoogle Scholar.
3. Tilman, D., Balzer, C., Hill, J. and B.L. Befort, L. B (2011). Global food demand and the sustainable intensification of agriculture. *Proceeding. National. Academy Sciences U. S. A.*, 108 (2011): 20260-20264, 10.1073/pnas.1116437108.cassava diets for pigs. *Tropical Veterinary*, 16:57-67.
4. Britannica, The Editors of Encyclopaedia. "straw". *Encyclopedia Britannica*, Invalid Date, <https://www.britannica.com/topic/straw>. Accessed 27 January 2022.
5. Gartner, L. B. (1995). *Plant stems Physiology and functional morphology*. Academic press. San Diego. New York London Sydney Tokyo Toronto. ISBN 0-12-276460-9.
6. Ewuola, E.O, Folayan, O. A, Gbore, F.A, Adebunmi, A.I, Akanji, R.A, Ogunlade, J.T and Adeneye, J.A (2004). *Physiological response of*

- growing West African Dwarf goats fed groundnut shell-based diets as the concentrate supplements. *BOWEN Journal of Agriculture*. 1(1): 61-69.
7. Ewuola, E. O. and Egbunike, G. N. 2008. Haematological and serum biochemical response of growing rabbit bucks fed dietary fumonisin B1. *African Journal of Biotechnology* Vol. 7 (23), pp. 4304-4309,
 8. Gps (2021). Global positioning system. .
 9. Jain N. C. (1986). Scanning electron micrograph of blood cells. In: Schalm's Veterinary haematology. 4th ed. P Lea & Febiger. Philadelphia: 4: 63-70.
 10. Kohn, R. A. and Allen, M. S. (1995). Enrichment of proteolytic activity relative to Nitrogen in preparation from the rumen for in vitro studies. *Animal Feed Science and. Technology*, 52(1/2): 1-14.
 11. Peter T, Biamonte, G.T, Doumas, B.T. (1982). Protein (Total protein) in serum, urine and cerebrospinal fluids; Albumin in serum. In: Selected method of clinical chemistry. Volume 9 (Paulkner WR, Meites S Eds) American Association for Clinical Chemistry, Washington, D.C.
 12. Rej R, Hoder M (1983). Aspartate transaminase. In: Methods of Enzymatic Analysis. 3rd ed. (H.U.Bergmeyer, J. Bergmeyer and M. Grassl, Eds). Weinhein Verlag-Chemie, 3: 416-433.
 13. Hoder, M and Rej R. (1983). Alanine transaminase. In: Methods of Enzymatic Analysis. 3rd ed. (H.U.Bergmeyer, J. Bergmeyer and M. Grassl, Eds). Weinhein Verlag-Chemie, 3: 416-433.
 14. SAS (1999). SAS/STAT User's Guide. Version 8 for windows. SAS Institute Inc., SAS Campus Drive, Cary, North Carolina, USA.
 15. Iyayi, E. A and Tewe, O. O (1998). Serum total protein, urea, creatinine levels indices of quality Tilman, D. and Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature*, 515 (2014), pp. 518-522, 10.1038/nature13959CrossRefView Record in ScopusGoogle Scholar.
 16. Audu, R., Tijjani, A., Ibrahim, A. A., Amin, A. B., Gumel A. I. and Suleiman. A. T. (2018).Evaluation of haematology and serum biochemistry of weaner rabbits fed diets containing Ficus sycomorus and Parkia biglobosa leaf meals. *Nigerian Journal of Animal Production*; 45(5):30 - 38.
 17. Jenkins, J. R. 2006. Clinical Pathology. BSAVA, Manual of Rabbit Medicine and Surgery 2nd Edition. Gloucester, GL2 2AB, UK. ISBN: 1090521496X.
 18. Mitruka, B. M. and Rawnsley, H. M. 1977. Clinical, biochemical and haematological reference values in normal experimental animal.Mason Publishing, New York. Pp 86.
 19. Wafar, R. J., Yakubu, B. and Obun, C. O. 2014. Effect of processing methods of Leptadenia hastata leaves on haematology and serum biochemistry of weaner rabbits. *International Journal of Applied Science s and Engineering Research*, 3(2):94-103.
 20. Suliman, M. A. E., Saber, D. M, El-Manylawi, M. A and Ibrahim M. R. (2022). Profitability of diets, nutritive value, performance and cecal activity of growing rabbits fed bean vein hay. *Online Journal of Animal and Feed Research*, 12(5): 284-291. Melillo, A. (2007) 'Rabbit clinical pathology' *Journal of Exotic Pet Medicine* 16(3)

- pp. 135-145.DOI: <https://dx.doi.org/10.51227/ojafr.2022.39>.
22. Medirabbit, 2023. Complete blood count and biochemistry reference values in rabbits. Medirabbit.com. http://www.medirabbit.com/EN/Hematology/blood_chemistry.htm. Copied on the 16/7/2023.
 23. Jiwuba, P. C., Ikwunze, K., Dauda, E. and Ugwu, D. O. 2016 .Haematological and serum biochemical indices of growing rabbits fed diets containing varying levels of Moringa oleifera leaf meal. *British Biotechnology Journal*, 15(2): 1-7.
 24. Melillo, A. (2007) ‘Rabbit clinical pathology’ *Journal of Exotic Pet Medicine* 16(3) pp. 135-145.
 25. Esonu, B. O., Emenalom, O. O., Udedibie, A. B. I., Berbert, U., Ekpok, C. F., Okoli, E. C. and Iheukwumere, F. C. 2001. Performance and chemistry of weaner pigs fed raw mucuna bean (velvet bean) meal. *Tropical Animal Production Investment*, 4: 49-54.
 26. Muhammad, N. O. and Oloyede, O. B. (2009). Haematological Parameters of Broilers Chicks Fed *Aspergillus niger* Fermented *Terminalia catappa* Seed Meal-Diet. *Global Journal of Biotechnology and Biochemistry*, 4(2): 179-183.
 27. Olaleru, I. F., Abu, O. A. and Okereke, C. O. (2019). Performance and blood profile of young doe rabbits fed diets containing two varieties of composite sweet potato (*ipomoea batatas* Lam) meal in a palm kernel based diets. *Nigerian Journal of Animal Production* 46(3):245 – 252.
 28. Oloruntola, O.D.; Daramola, O.T.; Omoniyi, S.O. (2015). Effect of forages on performance, carcass cuts and haematological profile of weaner Rabbits. *Archivos de Zootecnia*, vol. 64, núm. 245, pp. 87-92.
 29. Ibrahim, N. H., Morsy, A. S. and Ashgan, M. E. 2014. Effect of Moringa Peregrine Seeds on productive performance and hematology/biochemical parameters of growing rabbits. *Journal of American Science*, 10(6): 7-12.
 30. Ogbuewu, I. P., Uchegbu, M. C., Okoli, I. C. and Iloeje, M. U. 2010. Assessment of blood chemistry, weight gain and linear body measurements of pre-puberal buck rabbits fed different levels of neem (*Azadirachta indica* A. Juss.) leaf meals. *Chilean Journal of Agricultural Research*, 70(3):515-520.
 31. Bradley, T. A. 2001. What every Veterinary needs to know about Rabbit: Zoological Education Network, Lake Florida, USA (3) 1:42-45.
 32. Etim, N. N., Williams, E. M., Akpabio, U. and Offiong, A. E. E. (2014). Haematological Parameters and Factors Affecting their Values. *Agricultural Science*. 2(1):37-47.