

Assessing the haematology and serum chemistry of *Uda* rams fed different *Kanwa* based mineral licks

Abdulkarim, A.* and Aljameel, K. M.

Department of Animal Science, Federal University Dutse, Nigeria.

*Corresponding author. Email: muhdkjameel@gmail.com

Copyright © 2021 Abdulkarim and Aljameel. This article remains permanently open access under the terms of the [Creative Commons Attribution License 4.0](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received 1st November, 2021; Accepted 29th November, 2021

ABSTRACT: This study was conducted at the Department of Animal Science's Teaching and Research farm of Usmanu Danfodiyo University, Sokoto to evaluate the effect of feeding different *kanwa* based mineral licks on blood profile of *Uda* rams. Blood of twenty (20) yearlings *Uda* rams aged by dentition were used to evaluate the effect of *Kanwa*-based mineral blocks. Four (4) animals were allotted to each treatment (*Kanwa* block) with each animal serving as a replicate. The *Kanwa* used were *Kanwan Bai-Bai*, *Kanwan Kolo*, *Hogga*, *Balma* and conventional mineral lick to represent treatment 1, 2, 3, 4 and 5 respectively. Data was collected at the end of the experiment. The result of haematological analysis showed significant ($p < 0.05$) differences in all the parameters analysed except PCV, MCH, WBC and eosinophil; the result indicated that all the values were within the normal reference range except in MCHC where animals placed in T₂ and T₃ shows values slightly above the normal range. The result of serum biochemistry showed that all the values measured were within the normal reference range for sheep except the albumin of animals placed in T₃ which had values slightly above the normal range. The serum mineral composition showed that Potassium levels were higher in T₂ and lower in T₄; however, there was no difference between animals placed in treatments 1, 2 and 3, so also between treatments 1, 3 and 4. The study concluded that *Kanwa* positively affected sheep production with no adverse effect on both haematological and serum chemistry, hence little health hazard is associated with feeding *Kanwa*-based blocks on growing *Uda* rams.

Keywords: Haematology, *Kanwa*, serum biochemistry, *Uda* rams.

INTRODUCTION

Nigeria's ruminant animal population comprises of about 16.2 million Cattle, 33.1 million Sheep and 52.5 million Goats (FAO, 2017). Several reports (FDLPCS, 1992; Umunna and Iji, 1993; Adegbola, 2004; Malami, 2005; Aregheore, 2009) have indicated that over 90% of the ruminant animals in Nigeria are produced under various traditional extensive systems (pastoral, agro-pastoral and village herding). Northern Nigeria is home to over 80% of the ruminant population in Nigeria with significant percentage of small ruminants found with the small holder farmers under subsistence production (Edemayo, 2013). These animals rely on grazing of natural forages found in native range lands and fallows, crop residues and agricultural by-products as the main sources of their feed. The inadequacy of nutrients from these sources of feed

result in low productivity of the animals.

Up to eighteen (18) mineral elements have been found to play essential functions in the plants and animals' metabolism. They include Calcium (Ca), Phosphorus (P), Sodium (Na), Chlorine (Cl), Potassium (K), Magnesium (Mg), Sulphur (S) (designated as major or Macro-minerals, required by animals at more than 100ppm). Others are Iron (Fe), Zinc (Zn), Copper (Cu), Cobalt (Co), Manganese (Mn), Iodine (I), Selenium (Se), Chromium (Cr), Molybdenum (Mb), Silicon (Si), Nickel (Ne), Arsenic (Ar) (designated as trace elements or Micro-minerals, required by animal at less than 100 ppm). Other elements whose essentiality is inconclusive include Vanadium (Vd), Boron (B), Lithium (Li), Lead (Pb), Fluorine (F), Cadmium (Cd) and Tin (Sn) (ACIAR, 1996). McDonald et al. (2011)

restricted essentiality to a mineral element that has been proven to have a metabolic role in the animal body. However, Marcy and Grey (2005) asserted that an element is generally considered essential if it is proven that the purified diets lacking the element cause deficiency symptoms in animal and that those symptoms can be eradicated or prevented by adding the element to the diet. Although mineral elements make up a small portion of an animal's diet, they play important roles not only in their metabolism of the food substances, but also in their health, growth and reproduction. Numerous mineral deficiencies, imbalances and toxicities have been reported as economically important in livestock production throughout the world (McDonald et al., 2011).

Offering of *Kanwa* either on free-access or incorporated in the diet of animals to supplement mineral needs has been in used for long, however, there is little or no scientifically-published work on the effect of feeding *Kanwa*-based mineral block to ruminant animals in this ecological zone. The study also evaluated the effect of feeding *Kanwa* on haematological and serum biochemistry of sheep.

MATERIALS AND METHODS

Description of the experimental site

This study was conducted at the Livestock Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria. Sokoto is located at latitudes 13° 0' 21.1428" N and longitudes 5° 14' 51.1872" E (LatLong.net, 2018). Sokoto state is within the Sudan Savannah vegetation zone and on 350 m altitude. The climate is characterised by two distinct seasons (wet and dry). The wet season starts in May/June and end in September/October while the dry season covers from October to April/May. Mean annual rainfall varies from 500 to 700 mm with a wider inter annual variations. Relative humidity is moderate to high (51 to 79%) during the rainy season and very low (10 to 25%) during the dry season. Mean monthly temperatures vary widely; from 14°C in December/January to about 41°C in April with annual mean of 29°C (Mamman et al., 2000).

Kanwa-based mineral block formulations

Varieties of *Kanwa* and binding agents (gum Arabic and locust bean powder) used in this research were sourced from *Kara* market, Sokoto (Table 1a and b).

Formation of *Kanwa*-based mineral lick blocks

A rubber pan (*mudu*) was used to form the *Kanwa* blocks.

Five hundred gram (500 g) of gum Arabic was dissolved in 2 litres of water and was later mixed with the remaining ingredients as shown in Table 1. The ingredients were homogeneously mixed. The mixture was then poured into the wooden frame lined with polythene bag and allowed to dry at room temperature to form the block.

Experimental animals and their management

Twenty (20) yearlings *Uda* rams aged by dentition (Dyce et al., 2002) and apparently healthy were purchased and used for this experiment. The rams were quarantined for two weeks and dewormed with Banmith II @12.5 mg/kg body weight. They were also treated against ecto and endo parasite using Ivermectin @1 ml per 10 kg body weight. The rams were also treated with oxytetracycline HCl (a broad-spectrum antibiotic) at dosage of 2 ml/10kg body weight against any possible bacterial infection. Prior to the commencement of the experiment, the animals were managed intensively and group-fed with cowpea hay and wheat offal for two weeks adaptation period. Experimental animals were balanced for weight before allotting to treatments and fed basal diet containing 2180 kcal energy, 12% crude protein and 19.4% crude fibre. Gross composition of the basal diet is shown in Table 2. The feeding trial lasted for twelve (12) weeks during which experimental mineral blocks were offered.

Treatments and experimental design

Completely Randomised Design was used in allotting the experimental animals to treatment. *Kanwan-Baibai*-mixed Lick (KBM), *Kanwan-Kolo*-mixed Lick (KKBM) *Balma*-mixed Lick (BMK) and *Hogga*-mixed Lick (HMK) represented treatments 1, 2, 3 and 4 respectively, while Conventional Mineral Lick (CML) was used as treatment 5 (control).

Blood sample collection

At the end of the feeding experiment, three animals per treatment were selected for blood sampling. The animals were fasted overnight and blood was collected the following morning. The blood samples were aseptically collected via jugular vein using 10 ml sterilized disposable syringe and 21 Gauge-needle from each animal. Ten (10 ml) was collected in which about 3 ml was put in Ethylene Diamine Tetra-acetic Acid (EDTA) bottle while 7 ml in plain bottle. The samples in the EDTA bottles were used for haematological analysis, while the samples in the plain tubes was centrifuged at 1400 rpm for five minutes to separate the serum from the whole blood at room temperature. The serum was used for serum biochemical analysis.

Table 1a. Formulation of the *Kanwa*-based mineral lick.

Ingredient (%)	Treatments				
	1	2	3	4	5
<i>Kanwanbaibai</i>	75	-	-	-	-
<i>Kanwankolo</i>	-	75	-	-	-
<i>Balma</i>	-	-	75	-	-
Hogga	-	-	-	75	-
Gum Arabic	10	10	10	10	-
Locust bean powder	15	15	15	15	-
Total	100	100	100	100	-

Note: Treatment 5 (control) represent conventional mineral lick.

Table 1b. Composition of a conventional mineral lick.

Contents	Quantity (mg)
Manganese oxide	145
Cobalt	15
Zinc	230
Copper	162
Iron	800
Selenium	5
Iodine	10
Analytic constituents	Percentage (%)
Sodium as Sodium chloride	37.6
Magnesium as Magnesium oxide	0.32
Ash	85

Source: Hebei New Century Pharmaceutical Co. Ltd.

Table 2. Gross composition of the experimental basal diet.

Ingredient	Composition (%)
Maize	14.00
Soybean meal	15.00
Cowpea husk	30.00
Wheat offal	25.00
Rice Milling Waste	15.00
Salt	1.00
Total	100

Energy 2181 kcal/kg; crude protein 12%; crude fibre 19.4%.

Haematological and serum biochemical analysis

Haematological analysis

The haematological parameters determined were packed cell volume (PCV), red blood cells (RBC) count, total white blood cells (WBC) count, leucocytes differential count and haemoglobin concentration (Hb) using the methods described by Bush (1991). Erythrocyte indices [mean

corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC)] were computed using standard formula outlined by Schalm et al. (1975) as shown below:

$$\text{MCV (fl)} = \frac{\text{PCV}}{\text{RBC Count (In } 10^6/\text{Mn}^3)} \times 100$$

$$\text{MCH (pg)} = \frac{\text{Hb (G/Dl)}}{\text{RBC (In } 10^6/\text{Mn}^3)} \times 100$$

$$\text{MCHC} = \frac{\text{Hb (G/Dl)}}{\text{PCV (\%)}} \times 100$$

Where: MCV = mean corpuscular volume, PCV = packed cell volume, RBC = red blood cell, MCH = mean corpuscular haemoglobin, Hb = haemoglobin, MCHC = mean corpuscular haemoglobin concentration.

Serum biochemical analysis

The serum biochemical parameters evaluated were total protein, albumin and globulin concentrations, urea and serum cholesterol.

Serum protein: The plasma total protein was measured using biuret reaction according to the procedure of Savory et al. (1968).

Albumin concentration: Albumin protein in the serum was measured by colorimetric estimation using sigma assay kits as outlined by Baker and Silverston (1985).

Globulin concentration: This was calculated by subtracting albumin value from total protein value (Baker and Silverston, 1985).

Serum urea: The serum urea concentration estimation was carried out by the diacetyl monoxime (Bush, 1991). The protein was first precipitated by trichloroacetic acid. The urea in the filtrate was then reacted with diacetyl monoxime in the presence of acid, oxidizing reagent and thiosemicarbazide to give a coloured solution. This was then measured in a photoelectric colorimeter at a wavelength of 520 nm (Bush, 1991).

$$\text{Urea concentration (mmol/l)} = \frac{\text{at}}{\text{ar}} \times 100$$

Where: At = Absorbance of the test sample and Ar = Absorbance of the reference sample

Serum cholesterol: Serum cholesterol concentration was determined by colorimetric enzyme method as outlined by Bush (1991). The method involved enzymatic hydrolysis

and oxidation which terminates in the production of a red coloured solution. The concentration was determined after reading the colorimetric at 546 nm.

Serum electrolytes: Serum sodium and potassium were determined using Flame Spectrophotometric method as described by Varley et al. (1980), while Calcium was determined by Flame Spectrophotometric method as described by Trudean and Freier (1967).

Statistical analysis

Data generated was subjected to analysis of variance using completely randomized design (Steel and Torrie, 1980). Least significant difference (LSD) was used to separate the means. The data were analysed using SAS (2002).

RESULTS

Haematology of growing *Uda* rams offered different *Kanwa*-based mineral blocks

The result of the haematological analysis was presented in Table 3. The result shows significant ($p < 0.05$) difference in all the parameters analysed except PCV, MCH, WBC and eosinophil. The only significant difference ($p < 0.05$) observed with regards to RBC was between animals placed in treatment 1 and 2. MCV values were significantly higher in treatment 2 and 3, while lower ($p < 0.05$) in treatment 1 and 4. Significantly higher ($p < 0.05$) levels of MCHC were also recorded in treatment 2 and 3 while the lowest ($p < 0.05$) was in treatment 5. The result shows no significant difference ($p > 0.05$) between all the treatments regards to MCH levels. Higher ($p < 0.05$) levels of monocytes were recorded in animals placed in treatment 5, there was no difference between treatment 2 and 5, likewise between treatment 1, 2, 3 and 4. The result shows that the only observed difference with regards to lymphocytes was between treatment 3 and those in treatment 1 and 5.

Serum biochemistry levels of growing *Uda* rams offered different *Kanwa*-based mineral block

Result of blood serum biochemistry of *Uda* rams fed different types of *Kanwa*-based mineral block was presented in Table 4. The result shows significant ($p < 0.05$) difference in serum albumin levels only. All the values measured were within the normal reference range for sheep except in albumin where animals placed on treatment 3 had values slightly above the normal range. The only observed significant ($p < 0.05$) difference in terms

of albumin was between animals placed on treatment 1 and 3.

Serum electrolytes levels and enzymes activity of growing *Uda* rams offered different *Kanwa*-based mineral blocks

The result of serum electrolytes and enzymes of *Uda* rams offered different *Kanwa*-based mineral blocks was presented in Table 5. The result showed significant ($p < 0.05$) difference in total bilirubin, bicarbonate, potassium and sodium levels. The only significant ($p < 0.05$) difference with regards to total bilirubin was between treatment 2 and 4 while in terms of bicarbonate it was between treatment 2 and those in treatments 4 and 5. The result showed that potassium levels were higher in treatment 2 and lower in treatment 4; there was no difference between animals placed in treatments 1, 2 and 3, so also between treatments 1, 3 and 4, likewise between treatments 4 and 5. Sodium levels were significantly ($p < 0.05$) higher in treatment 2; there was no significant ($p > 0.05$) difference between animals placed in treatments 2 and 3, so also between treatments 1 and 3, and likewise between treatments 1, 4 and 5.

DISCUSSION

Haematology of growing *Uda* rams offered different types of *Kanwa*-based blocks

Haematological components which consist of red blood cells, white blood cells or leucocytes, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration are valuable in monitoring feed toxicity especially with feed constituents that affect the blood as well as the health status of farm animals (Oyawoye and Ogunkunle, 2004). The haematological results of this study suggest that *Kanwa*-based block does not pose any threat with regards to health status of sheep. The haematological changes indicate insignificance difference between animals fed different types of *Kanwa*-based mineral blocks and those fed conventional mineral lick in terms of PCV, WBC, and eosinophil counts, though there were higher values of MCHC in treatment 2 and 3 which may lead to a condition known as polycythemia. The result shows that the animals have high level of WBC counts indicating that they are capable of generating antibodies in the process of phagocytosis and have high degree of resistance to diseases (Soetan and Oyewole, 2009) and enhance adaptability to local environmental and disease prevalent conditions (Issac et al., 2013; Iwuji and Herbert, 2012; Kabir et al., 2011; Okunlola et al., 2012). The variation in lymphocytes and monocytes may be as a result of other

Table 3. Haematological parameters of growing *Uda* rams offered different *Kanwa*-based mineral block.

Parameter	Treatment					SEM	*Reference values
	1	2	3	4	5		
Haemoglobin (g/dL)	8.5 ^b	9.17 ^{ab}	8.73 ^{ab}	9.3 ^{ab}	9.63 ^a	0.32	9-15
PCV (%)	25.33	28	27.33	25.67	27.67	1.35	27-45
RBC (x10 ⁶ /ul)	7.33 ^b	10.34 ^a	9 ^{ab}	8.67 ^{ab}	9 ^{ab}	0.71	9-15
MCH (pg)	8.68	8.83	9.17	8.88	9.07	0.29	8-12
MCV (fl)	33.34 ^b	34.67 ^a	35 ^a	33.67 ^b	34.33 ^{ab}	0.38	28-40
MCHC (g/dL)	34 ^b	34.67 ^a	35.67 ^a	34 ^b	31.67 ^c	0.50	31-34
WBC (x 10 ⁹ /L)	4.43	4.93	4.57	4.47	4.63	0.28	4-12
Monocytes (x 10 ⁹ /L)	0.6 ^b	0.77 ^{ab}	0.63 ^b	0.63 ^b	0.9 ^a	0.06	0-0.8
Lymphocytes (x 10 ⁹ /L)	2.36 ^b	3.33 ^{ab}	4.0 ^a	3.67 ^{ab}	2.33 ^b	0.45	2-9
Eosinophil (x 10 ⁹ /L)	0.6	0.7	0.87	0.93	0.7	0.20	0-1.0

^{a,b,c} means in the same row with different superscripts are significant ($p < 0.05$) different. 1= *KanwanBai Bai* block, 2= *KanwanKolo* block, 3= *Balma* block, 4= *Hogga* block, 5 = Conventional Lick (**Source:** Elmhurst et al., 2002).

Table 4. Serum biochemistry levels of growing *Uda* rams offered different *Kanwa*-based mineral blocks.

Parameters	Treatment					SEM	*Reference values
	1	2	3	4	5		
Albumin (g/dl)	2.37 ^b	2.83 ^{ab}	3.07 ^a	2.67 ^{ab}	2.8 ^{ab}	0.15	2.4-3
Globulin (g/dl)	3.93	4	3.93	3.8	3.73	0.12	3.6-4.9
Total protein (g/dl)	6.3	6.83	7.00	6.47	6.53	0.22	6-7.9
HDL (Mmol/L)	0.51	0.86	0.94	0.57	0.62	0.19	0.8-2.6
LDL (Mmol/L)	1.86	1.74	1.97	1.83	1.72	0.15	0.5-4.3
Creatinine (umol/L)	79.67	72.33	74.67	78.83	71.00	2.97	70-105
Cholesterol (mmol/L)	0.58	0.65	0.65	0.63	0.65	0.05	1.05-1.5
Urea (mmol/L)	5.15	4.57	4.80	4.63	4.53	0.38	3-10

^{a,b,c} means in the same row with different superscripts are significant ($p < 0.05$) different. 1= *KanwanBai Bai* block, 2= *KanwanKolo* block, 3= *Balma* block, 4= *Hogga* block, 5 = Conventional Lick (**Source:** Elmhurst et al., 2002).

Table 5. Serum enzymes activity and electrolytes levels of growing *Uda* rams offered different *Kanwa* blocks.

Parameter	Treatments					SEM	*Reference values
	1	2	3	4	5		
AST (u/L)	64.67	62	70.68	62	67	2.98	60-280
ALT (u/L)	23	24.17	23.6	24	25.17	0.7	22-38
ALP (u/L)	104	103	113	117.3	114.3	20.86	70-390
Direct bilirubin (umol/L)	0.76	1.01	1.32	0.93	1.33	0.25	0-4.61
Total bilirubin (umol/L)	1.12 ^{ab}	1.82 ^a	1.03 ^{ab}	0.57 ^b	1.3 ^{ab}	0.22	1.71-8.55
Chloride (Mmol/L)	96.32	96.67	97	100.3	98.62	2.02	95-103
Bicarbonate (Mmol/L)	26.3 ^{ab}	27.67 ^a	27 ^{ab}	25.67 ^b	26 ^b	0.43	21-28
Potassium (Mmol/L)	5.27 ^{ab}	5.67 ^a	5.2 ^{ab}	4.2 ^c	4.63 ^{bc}	0.24	3.9-5.4
Sodium (Mmol/L)	143.33 ^{bc}	151.33 ^a	148 ^{ab}	139.67 ^c	141.67 ^c	1.58	142-152

^{a,b,c} means in the same row with different superscripts are significant ($P < 0.05$) different. 1= *Kanwanbaibai* block, 2= *KanwanKolo* block, 3= *Balma* block, 4= *Hogga* block, 5 = Conventional Lick (**Source:** Elmhurst et al., 2002).

factors that can affect or alter the animal welfare index not necessarily as a result of the *Kanwa* or conventional mineral block intake. Animals place in treatment 1 show

reduced RBC which implies reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs (Issac et al.,

2013; Soetan and Oyewole, 2009) leading to decrease rate of metabolism; this is further explained by the result of digestibility in this study especially with regards to crude fibre and dry matter digestibility in general.

Serum biochemistry of growing *Uda* rams offered different *Kanwa*-based blocks

All the values measured were within the normal reference range for sheep except in albumin where animals placed in treatment 3 have values slightly above the normal range. The result of this study found that albumin, which is the main protein in blood that binds water cations (such as Ca^{2+} , Na^{+} and K^{+}) (Harper et al., 1977), are lower in animals fed treatment 1 (2.37 g/dl) compared to treatment 3 (3.07 g/dl). The decrease in concentration may suggest that haemo-concentration of plasma electrolytes are low or it may be due to the fact that treatment 3 have high MCV compared to treatment 1 which may lead to hypertonicity as a result of which plasma electrolytes levels increase. Similar findings was also reported by Jibike and Igbokwe (1993) who worked with *Mangul* (another variety of *Kanwa*) on sheep suggest that with concomitant loss of intracellular fluids by RBC because of osmotic diffusion, increase in MCV is an indication of increase in erythropoiesis (Schalm et al., 1975) and the absence of such suggest *Mangul* does not induce such effect (Harper et al., 1977). The result shows that all other parameters are within the normal range.

Serum electrolytes and enzymes of growing *Uda* rams offered different *Kanwa*-based mineral blocks

The result of the serum electrolytes and enzymes shows that the values are within the normal range (1.71 to 8.55) for all the treatments except in total bilirubin where it is below T_4 (0.57); also, in treatment 2, value of potassium (5.67) is above the normal range. The result shows that all parameters remain same across the treatments except in bicarbonate, sodium, potassium and total bilirubin. This trend was also reported by Jibike and Igbokwe (1993) with an increase in plasma potassium and bicarbonate but no variation in sodium, chloride, calcium and inorganic phosphate when sheep are fed high level of *Mangul* (a variety of *Kanwa*). The higher level of potassium, sodium, and bicarbonate may be as a result of the *Kanwa* intake which are known to be high in those minerals. The electrolyte levels evaluated is within the normal range, this is an indication that *Kanwa* blocks may not interfere with the normal renal function of the animals. High ALP could indicate liver flukes and pyrrolizidine alkaloid toxicity (Infovets, 2015). However, high levels of ALP can be normal in growing animals due to growth of bones (Infovets, 2015). However, high ALP values are indication

of high quality protein in the diet, however, values from this study are just above average. The bilirubin and AST values are within the normal range.

Conclusion

The study concluded that offering *Kanwa* especially *Kanwan Kolo* positively affect sheep production with no adverse effect as result of both haematological and serum chemistry shown, hence little health hazard is associated with feeding *Kanwa*-based blocks on growing *Uda* rams.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- Adegbola, T. A. (2004). Utilizaing Proven Alternative Feed Ingredients in Livestock Industry. In: Tukur, H. M., Hassan, W. A., Maigandi, S. A., Ipinjolu, J. K., Daneji A. I., Baba, K. M. and Oloredo, B. R. (eds.). Sustainable livestock production under changing economic fortunes. *Proceedings of the 29th NSAP Conference, held at Usmanu Danfodiyo University, Sokoto, Nigeria*. March 21st – 25th, 2004. Pp. 370-373.
- Aregheore, E. M. (2009). Nigeria: Country pasture/forage resource profiles. Retrieved June 9, 2010 from <http://www.fao.org/AGP/agpc/doc/Counprof/region/index.htm>.
- Australian Centre for International Agricultural Research (ACIAR) (1996). Animal Operational Plan, Annual Report. 1995 – 1996. ACIAR Canberra.
- Baker, F. J., & Silverston, R. E. (1985). *Introduction to medical laboratory Technology* (6th edition.). London: Butterworth.
- Bush, B. M. (1991). *Interpretation of laboratory results from small animal clinician*. United Kindom: Black Well Scientific Publication.
- Dyce, K. M., Sack, W. O., & Wensing, C. J. G. (2002). *Textbook of Veterinary anatomy*. 3rd edition. Philadelphia: Saunders Company.
- Edemayo, A. E. (2013). Utilization of dietary mineral salt in the feeding of sheep in semi-arid environment of Northern Nigeria. MSc. Dissertation, Department of Animal Science, Usmanu Danfodiyo University, Sokoto.
- Elmhurst, S., Hons, B. A., & Pearson, M. (2002). *Clinical examination of farm animals* (1st ed., p. 456). Osney Mead, Oxford OX2 0EL, UK: BlackWell Scientific Publication.
- FDLPCS (1992). Nigerian Livestock Resources. Federal Department of Livestock and Pest Control Services (FDLPCS), National Synthesis Vol. II. Resource Inventory and Management Ltd. Jersey, UK. 287pp.
- Food and Agriculture Organization of the United Nations (FAO) (2017). FAO statistics database (FAOSTAT): Agricultural production and production indices data (Nigeria). Food and Agriculture Organization of the United Nations (FAO).
- Harper, P. S., Williams, E. M., & Sunderland, E. (1977). Genetic markers in Welsh gypsies. *Journal of Medical Genetics*, 14(3), 177-182.

- Infovets (2015). ALP reference values. Retrieved from infovets.com/books/smrn/D/D080.htm.
- Issac, L. J., Abah, G., Akpan, B., & Ekaette, I. U. (2013). Haematological properties of different breeds and sexes of rabbits. In: *proceeding of the 18th Annual Conference of Animal Science Association of Nigeria*, (pp. 24-27).
- Iwuji, T. C., & Herbert, U. (2012). Haematological and serum biochemical characteristics of rabbit bucks fed diets containing garcimola kola seed meal. In: *proceedings of 37th Annual Conference of Nigerian Society of Animal Production* (pp. 87-89).
- Jibike, G. I., & Igbokwe, I. O. (1993). The effects of "Mangul" overdose on plasma protein, potassium and bicarbonate levels in Yankasa rams. *Annals of Borno*, 10, 258-264.
- Kabir, M., Akpa, G. N., Nwagu, B. I., Adeyinka, I. A., & Bello, U. I. (2011). Sexual dimorphism, breed and age characteristics of rabbits in Zaria, Nigeria. In: *proceeding of the 16th Annual Conference of Animal Science Association of Nigeria* (Pp. 133-137).
- LatLong.net (2018). Sokoto, Nigeria Map. Retrieved 11th February 2018 from <https://www.latlong.net/place/sokoto-nigeria-21027.html>.
- Malami, B. S. (2005). Balancing nutrient supply and requirement of ruminants in Zamfara reserve, Northwestern Nigeria. Ph.D Thesis, Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Nigeria, 243pp.
- Mamman, A. B., Oyebanji, J. O., and Petters, W. S. (2000). *Nigeria: A people united, a future assure (survey states)* (2nd edition.). Calabar, Nigeria: Gabumo Publishing Company Limited.
- McDonald, P., Edwards, R. A., Greenhalgh, J. F., & Morgan, C. A. (2002). *Animal nutrition*. (Sixth Edit). Pearson. Prentice-Hall, Edinburgh Gate, Harlow, England.
- Marcy, W., & Greg, L. (2005). *Beef cattle mineral nutrition: A Review*. NDSU Extension Service, North Dakota State University of Agriculture and Applied Science, and U.S. Department of Agriculture cooperating. Retrieved from <https://library.ndsu.edu/ir/bitstream/handle/10365/5354/as1287.pdf>.
- Okunlola, D. O., Olorunisomo, A. O., Aderinola, A. O., Agbola, A. S., & Omole, O. G. (2012). Haematology and serum quality of red sokoto goats fed Baobab (*Adansonia digitata*) fruit meals as supplement to guinea grass (*Panicum maximum*). In: *proceedings of 17th Annual Conference of Animal science Association of Nigeria*, (Pp. 427-433).
- Oyawoye, B. M., & Ogunkunle, H. N. (2004). *Biochemical and Haematological reference values in normal experimental animals* (pp. 212-218). New York: Mason Publishing Inc.
- SAS (2002). *Statview statistical package*. SAS incorporated, New York
- Savory, J., Pu, P. H., & Sunderman Jr, F. W. (1968). A biuret method for determination of protein in normal urine. *Clinical chemistry*, 14(12), 1160-1171.
- Schalm, O. W., Jain, N. C., & Carrol, E. J. (1975). *Veterinary Haematology* (pp. 15-218). USA: Lea and Febiger publishers, Philadelphia.
- Soetan, K. O., & Oyewole, O. E. (2009). The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds: A review. *African Journal of food science*, 3(9), 223-232.
- Steel, R. G. D., & Torrie, J. A. (1980). *Principles and Procedure of Statistics*. New York: McGraw-Hill Book Company Inc.
- Umunna, N. N., & Iji, P. A. (1993). The natural feed resources in nigeria. In: Adamu, A. M., Mani, A., Osinowo, O. A., Adeoye, K. B. & Ajileye, E. O. (eds). *Forage production and utilization in Nigeria. Proceedings of National Workshop held in Kaduna, Nigeria by the National Livestock Project Division (NLPD), Kaduna, Nigeria, Federal Ministry of Agriculture and Natural Resources, Nigeria*. June, 1993. Pp. 16-31.