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Heamatological and Histopathological Assay of Red Sokoto Bucks Fed Varying Levels of Energy and Protein Feeds

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Abstract
An experiment was conducted to determine the haematological, biochemical and histopathological indices of goats fed energy (molasses) and protein (Groundnut cake) in a mixed ration. The dietary treatments compared were T_1 (0% molasses and 40% GNC), T_2 (10% molasses and 30% GNC), T_3 (20% molasses and 20% GNC), T_4 (30% molasses and 10% GNC), and T_5 (50% molasses and 0% GNC). The animals were allotted to five (5) dietary treatments in a complete randomized block design with four animals per treatment. The results reveal significantly ($p<0.05$) higher values for Neutral Detergent Fibre (NDF), Non-fibre carbohydrates and Energy content of the diets (394.00 g kg^{-1} DM, 341.00 g kg^{-1} DM and 2668.70 kcal/kg). Packed cell volume (PCV), Haemoglobin (Hb) and Red blood cell count (RBC) were significantly ($P<0.05$) higher for T_4. White blood cell differentials and lymphocytes significantly higher ($P>0.05$) among treatments. Neutrophils was observed to be highest for T_5 compared to other treatment groups. All the parameters studied for serum biochemical indices were significantly ($P<0.05$) different among treatments except for Sodium (Na^{2+}, K^{2+}, Total Bilirubin, Triglycerol and High Density lipoprotein). Histopathology of the kidney revealed that T_1 shows no damage, T_2 showed mild necrosis while T_3 showed moderate necrosis, atrophy congestion and degeneration of the convoluted tubules. T_4 showed severe necrosis, congestion, atrophy degeneration of the convoluted tubules. The result of the micrograph also showed severe congestion, necrosis and degeneration of convoluted tubules. The histopathology of the liver for T_1 reveals no expanded portal zones with portal fibrosis with fewer pyknotic nuclei in hepatocytes and lymphocytes infiltration while T_2 and T_3 were characterized with infiltration by inflammatory cells with multifocal areas of necrosis. The photomicrograph of the liver also reveals severe vescular degeneration of the hepatocytes for T_4 and T_5 The effect of molasses was also observed on spleen as the level of molasses increase from T_1 to T_5. Based on these findings, it can be concluded that feeding high energy (40% molasses) and protein (0% GNC) level of inclusion has negative effect on the kidney, liver and spleen.

Keywords: Haematology, Serum, Biochemical indices, bucks, molasses, histopathology

Introduction

Diet plays a pivotal role in the blood and serum chemistry of animal. Energy and protein form a major constituent of diet, hence the need for due consideration and analysis of energy and protein contents of animal feed. Energy requirements vary for different physiological stages which includes; maintenance, pregnancy, lactation and growth. The maintenance requirement for energy remains the same for most goats except dairy kids; they require 21% energy higher than the average. It is important to feed high-energy rations at the time of breeding, late gestation and lactation. Lactating does have the highest energy demand. Molasses is the major by-product of sugar production, coming mainly from sugar cane but also from sugar beets. Most molasses in commercial use is adjusted to contain 25% water. While molasses is a good source of trace minerals, the protein and vitamin level is quite low. It is used often to stimulate eating, to reduce dustiness in feeds, as a pellet binder, and when fortified with a nitrogen source, as a ruminant feed known as a liquid protein supplement (Figueroa *et al.*, 1990). It nutritionally contains 83.5% DM, nitrogen 0.44%, ash 9.8%, total sugar 58.3%, sucrose 40.2%, glucose 8.9%, fructose 9.2%, nitrogen free extract 87.4%, non-identified organic matter 29.1% and metabolizable energy 13.5% all these in % of the DM. FAO (1997).

Proteins are digested and broken down into amino acids and are eventually absorbed in the small intestine. Those

amino acids are building blocks for body proteins (muscles). The rumen plays a major role in breaking down consumed protein into bacterial protein through bacterial fermentation. Feeds like forages, hays, pellets (alfalfa), barley, peas (screenings, whole, split), corn, oats, distilled grains and meals (soybean, canola, cottonseed meals) are common sources of protein for goat rationing. Groundnut cake is a by-product obtained after extraction of oil. The cake contains 45–60% protein, 22–30% carbohydrate, 3.8–7.5% crude fibre and 4–6% minerals (Desai *et al*., 1999). Utilization of meal or defatted meal into food products could be an excellent vehicle for enhancing the utilization of groundnut protein in the diets of malnourished people in developing countries. Groundnut flour produced from cake blends easily and enhances or enriches the nutritive value of wheat and other flour. It has potential to be used as low fat groundnut concentrate, composite flour, in bakery products, breakfast cereal flakes, snack foods, multipurpose supplement, infant and weaning foods, extruded foods or fabricated food (Venkataraghavan, 1998; Gopala Krishna, 2007). Utilization of defatted groundnut meal with mild processing treatment is becoming increasingly popular in other countries.

Haematological parameter is an important and reliable medium used to monitor and evaluate health and nutritional status of animals. The various functions of the blood are carried out by the individual and collective actions of its constituents-the haemotological and biochemical components. Beside nutrition, the health condition of an animal is a function of the blood and serum constituents as these determines its ability to transport oxygen and nutrients to tissues and to defend itself against infections. Madan *et al*., (2016) buttress the above assertion by stating that blood is used in nutritional evaluation and health survey of animals as the blood profile of animals often reflects their nutritional adequacy or otherwise. It can therefore, be suggested that conducting blood analysis on animals after feeding trials is a readily available and quick means for evaluating clinical and nutritional status. The nutritional and health status of animals are monitored and assessed by carrying out haematology and blood chemistry which give reliable results. Few pathomorphological studies are available on molasses feeding to small ruminants. Histopathological examination is a valid laboratory technique in cases where other diagnostic methods fail. On the other hand, this technique is indispensable in pathomorphological evaluation of side effects of vaccines, drugs, and chemical compounds. The aim of the experiment is to study in a more detailed way the eventual harmful effects of molasses and ground present in the animal feed. This research is aimed at investigating the effect of high energy and protein feeds in the diets of red sokoto bucks.

Materials and Methods

Experimental Site

This study was conducted at the Teaching and Research Farm University of Abuja, Federal Capital Territory, Nigeria. It lies between latitude $8^0$55′N and 90^0E and longitude $7^0$00′E and $7^0$05′E and, land mass of 655sqkm (6,500 hectares). The annual mean temperature ranges between 25.8 and 30.2°C (Adakayi, 2000 and Balogun, 2001). Rainfall is moderate with annual total rain approximately between 1,100 mm to 1,650 mm with about 60% of the annual rainfall during the months of July, August and September (Adakayi, 2000 and Balogun, 2001).

Experimental Animals and their Management

A total number of twenty (20) Red Sokoto goats were purchased from Anagada market, Gwagwalada Area Council, FCT-Abuja, with a pre-trial body weight of 8.7 kg ± 0.6 and were housed intensively in an individual well ventilated pen. The pens were thoroughly washed and fumigated using (DD force) prior the arrival of the animals. On arrival, the goats were quarantined for 30 days and during this period; they were given prophylactic treatments consisting of intramuscular injection of *oxytetracycline* long acting (1mL/10 kg BW) and vitamin B complex to ensure good condition of the animals. They were also routinely dewormed with *Albendazole* and injected with *ivermectin* to eliminate both endo and ecto parasites respectively. Furthermore, the animals were vaccinated against PPR infection (*Pestis des petit ruminant*) and they were maintained on a feed and fresh cool clean water *ad libitum*. After the adaptation period, twenty (20) Red Sokoto goats were balanced on weight equalization and allotted into five (5) dietary treatments consisting of four (4) goats per treatment. The diets as contained in Table 1 for each treatment were fed with molasses and groundnut cake in a mixed ration.

Experimental Design

Twenty (20) red sokoto goats were allotted to five (5) dietary treatments with four animals per treatment in a complete randomized block design. The dietary treatments compared were T_1 (0% molasses and 40% GNC), T_2 (10% molasses and 30% GNC), T_3 (20% molasses and 20% GNC), T_4 (30% molasses and 10% GNC), T_5 (50% molasses and 0% GNC) respectively.

Haematological and Biochemical Studies

The goats (bucks) were bled through jugular vein and 10 ml of blood collected; 3ml of the blood samples was collected into plastic tube containing Ethylenediamine tetraacetic acid (EDTA) for haematological studies. The remaining 7ml of blood samples was deposited in anticoagulant-free plastic tube and allowed to clot at room temperature within 3 hours of collection. The serum samples were stored at -20^0C for biochemical studies Total erythrocytic count and total leukocytic counts were determined with the aid of Haemocytometer (Neubauer counting chamber) and Hb concentration was determined by Sahl's (acid haematin) method (Benjamin 1978). Mean corpuscular Haemoglobin Concentration (MCHC), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Volume (MCV) values were calculated (Jain, 1986) Serum Aspartate Aminotransferase, serum Alanine

Aminotransferase and Alkaline Phospatase were analyzed spectrophotometric-linked reaction method (Henry *et al*., 1960). Total protein was by the Biuret method according to the procedure of Oser (1976), Albumin by Bromocresol green (BCG) method, serum glucose and creatinine by Peters *et al*. (1982), Sodium ion and potassium ions by flame photometric method. Other biochemical analysis was done using the method described by (Ogunsanmi *et al*., 2002).

Histopathological Sampling procedure and analysis

Two (2) goats were selected from each treatment for histopathological evaluation. Immediately after slaughter of the animals, their liver, kidneys and spleen was collected and fixed in 10% neutral buffered formalin. After fixation the tissue sections was processed by routine histopathological methods. Paraffin sections (5 µm) was stained with haematoxylin and eosin (HE) and examined under a Zeiss Axioskop 2 light microscope to identify and evaluate anamopathological alterations (Prophet *et al*., 1992).

Chemical analysis

The feed samples were analysed for crude fibre (CF), ether extract (EE), crude protein (CP) and ash according to AOAC (2002). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and 2acid detergent lignin (ADL) were determined according to the procedures of Van Soest *et al.* (1991).

Statistical analysis

SAS (2009) Data were subjected to one–way analysis of variance (ANOVA) in a completely randomised design using SAS) software. Where differences among means were significant, the Duncan's multiple range test was used to separate them at $p< 0.05$ level of probability.
The statistical model is shown below

$$Yij = \mu + ti + ei$$

Where:
Yij = the general response to the specific parameter under investigation,
μ, the general mean peculiar to each observation,
ti = the fixed effect of the dietary treatment on the observed parameters, and
ei = the random error term for each estimate

Results and Discussion

Results

Chemical composition of experimental diets

The results of the chemical composition are presented in Table 2. The results showed significant difference ($p<0.05$) for all the parameters studied except for ash which was not significant ($p>0.05$). The values for DM, CP, CF, EE, NDF, ADF tend to decrease with increase in the level of molasses while the Energy content of the diet increase with increase in the level of molasses. The ADL content of the experimental diet is moderately high (102.20 to 116.20 g kg^{-1} DM), while the ash content is moderate (81.00 to 86.40 g kg^{-1} DM).

Haematology

Haematological values for bucks is shown in Table 3. There was significant difference ($P<0.05$) among treatments for PCV, Hb, RBC, WBC, lymphocytes and Neutrophils while eosinophils, monocytes, Basophils, MCV, MCH, MCHC showed no significant difference ($p>0.05$). Mean corpuscular haemoglobin, 9.10 pg (T_3) – 9.64 pg (T_1) also did not differ among diets. More so, mean values for MCHC which ranged from 32.10 g/dl on T_5 to 34.80 (%) for T_1, were also not significantly ($p>0.05$) affected. The PCV range from 19.00 to 26.00% with T_4 having the highest, while, T_5 had the lowest. The haemoglobin (Hb) values ranged from (6.10 to 8.70 g/dl). The results of the red blood cell count (RBC) showed significant effect ($p<0.05$) among treatments. There was no significant effect ($p>0.05$) for white blood cells differentials (eosinophils and monocytes and basophils), while neutrophils, lymphocytes, showed significant ($p<0.05$) effect of diets.

Serum biochemical indices

The results of the serum biochemical indices of red sokoto goats are shown in Table 4. The serum sodium, potassium showed no significant effect ($p>0.05$), while chloride and HCO^{-3} showed significant difference ($p<0.05$) among treatment. Creatinine, blood urea, Cholesterol, glucose, total protein, Albumin and Globulin were all significantly ($p<0.05$) different. Alanine Aminotransferase (ALT) and Alkaline phosphate (ALP) and Aspatate Aminotransferase (AST) were significantly different ($p<0.05$) among treatments.

Discussion

Chemical composition of experimental diets

The chemical composition of the experimental diets is shown in Table 2. The Dry matter (DM) content of the experimental diets showed significant difference ($p>0.05$) among treatment groups. The DM (g kg^{-1} DM) was observed to decrease with increase in the level of molasses. Similar trend was reported by Njidda (2019) who reported a decrease in dry matter content of the experimental diets as the level of molasses increases. Crude protein decrease with decrease in the level of GNC (162.20 to 140.10 g Kg^{-1} DM) from T_1 to T_5. The cake contains 45–60% protein, 22–30% carbohydrate, 3.8–7.5% crude fibre and 4–6% minerals (Desai *et al* 1999a). The cake which is a rich source of protein is indigenously used as cattle feed or manure. The crude protein content in the present study is above 7% CP recommended for rumen microbes of tropical livestock by Minson (1990) below which there will be a deficiency in performance. The high crude protein content of the feed makes it suitable substitute for goats. The crude fibre content was observed to decrease with increasing level of molasses, this implies that increasing the level of molasses decreases the crude fibre in the diet. This trend is similar to the report of Njidda (2019) who reported that molasses has 0% fibre. The NDF and ADF level was moderate T_5 (40% molasses) to T_5 (40% GNC). Meissner *et al.* (1991) observed that NDF level of forage above 65% can limit feed intake. The lignin content of the diets is moderate and it's within the range

reported by Njidda *et al.* (2016a) and Njidda *et al.* (2016b) for browse forages. Ash content was highest for the 30% level of inclusion which agrees with the findings reported by Amata and Lebari (2011) and Njidda (2019). The mineral content of molasses is very variable depending on the species and stage of growth of the sugar cane (Deaville, 1994 and Njidda, 2019). According to Wang *et al.* (2011), rich mineral content of molasses has been widely advertised for its therapeutic properties.

Haematological parameters of Red Sokoto Bucks Fed High Energy and Protein Diets

Result for haematological parameters of Red Sokoto bucks fed high energy and protein diets is presented in Table 3. Some of the parameters showed a significant ($P<0.05$) effect of diets. Goats on diet T_4 (26.00%) had higher packed cell volume (PCV) compared to other treatment groups. Those on T_5 had the least PCV (19.00%). The values obtained in this study are comparable with 19.90 – 25.25 reported by Aye (2013) in African Dwarf goats fed *Cnidosculus aconitifolius*, but lower than 32.75 ± 2.4% reported by Okunlola *et al.* (2015) in Red Sokoto goats fed baobab fruit meal. Furthermore, except for T_5, all values were within the range of 22 – 38% reported for normal and healthy goats (Feldman *et al.* 2002). The low PCV values obtained in goats fed diet T_5 may be attributed to low RBCs in their circulatory systems. This could lead to anaemia. However, considering the fact both energy and protein levels in the diet are well above the minimum recommended levels, the cause of this low PCV is not very much clear. Similar trend was also recorded for haemoglobin concentration, with goats on T_4 (8.70 g/dl) having the highest value and T_5 (6.10 g/dl) having the lowest. Hb concentration in this study fell within the range of high values (80 – 140 g/L obtained for Red Sokoto goats (Sirosis, 1995). In general increase in Hb concentration is associated with greater ability to resist disease infection, and low level is an indication of disease infection and poor nutrition (Cheesbrough, 2004; Njidda *et al.* 2013; Njidda and Enoch, 2020). Most of the values in this study are slightly lower than 8 - 12 g/dl reported in literature for healthy goats (Feldman, 2002). The lower RBC count in T_5 is further reflection of lower levels of PCV and Hb in goats in that treatment group. The value is also slightly lower 8.00 – 18 x 10^6µ/l for normal and healthy goats reported by Feldman *et al.* (2002). Conversely, WBC count was statistically higher ($P<0.05$) for T_3 (25.60 x 10^9/L) compared to other treatment groups. Most of the values in this study are higher than the reference values of 3 – 13 x 10^3µ/l (Feldman *et al*., 2002) and 14.6 x 10^3µ/l (Al-Bulushi *et al.* 2017) in Omani breeds of goats. Purwar *et al.* (2019) reported that variations in WBC could be attributed to seasonal and environmental differences. A significant ($P<0.05$) effect of diet was observed on percent lymphocytes and neutrophils. Goats on T_5 (58.00%) had higher neutrophils than the other treatment groups while lymphocytes was higher in T_3. There was no significant ($P<0.05$) effect of diet on eosinophils, monocytes and basophils. However, all the values obtained in this study are within the ranges of 0 – 4% for monocytes and 1 - 8% for eosinophils and 0 – 4% for basophils reported by Feldman *et al.* (2002) for healthy goats. Similarly, no significant differences were observed for red blood cell indices. Numerical values for MCV were between 26.10 – 27.70 fl on T_2 and T_1 respectively.

Biochemical Indices of Red Sokoto Bucks Fed High Energy and Protein Diets

Serum electrolyte of sodium, potassium, chloride and bicarbonate acid in this study are above the normal range reported by Banerjee (2007) but within the range reported by Njidda *et al.* (2013) and Njidda and Enoch (2020). The electrolytes are known to regulate osmotic pressure, maintain membrane potentials and acid base balance and transmit nerves impulses. For instances sodium and potassium deficiencies affect the tubes of kidney resulting in inability to concentrate urine (Latimer *et al*., 2004). The creatinine values in the present study were within normal range reported by Njidda and Enoch (2020). High creatinine is indicative of poor protein and amino acid metabolism that can lead to impaired renal function and cardiac infarction (Gray and Howarth, 1980). The blood urea final values obtained was lower than values 12.00 to 28.00 mg/dl reported by Kaneko (1989) for goats. Generally, Low blood urea levels can result from a low protein diet or liver disease (Kaneko, 1989; Turnera *et al*., 2005). Ruminants are not efficient utilizers of dietary protein (Beever, 1982). A positive correlation exists between level of protein (N) intake and blood urea concentration (Karnezos *et al*., 1994). In ruminants, blood urea can be influenced by dietary N-to energy ratio, level of forage intake, and protein degradability in the rumen (Turnera *et al*., 2005). Hart and Sahlu (1993) reported a breed × forage quality interaction for plasma urea nitrogen levels. The cholesterol values are higher than the values reported by Olafadehan *et al.* (2018). High level of blood cholesterol may result in its deposition on the walls of the blood vessels and these deposits may eventually harden to atherosclerotic plaque, this may block important blood vessels and result in a myocardial infraction. The glucose levels show inconsistency for the dietary treatments. Serum glucose is an indicator of cito metabolism, in high energy diets (Coles, 1986). When glucose is lower than the normal range is an indication of hypoglycemia while higher levels are indication of hyperglycemia (Olorunnisomo, 2012). The results for the total protein agree with the findings of Njidda *et al.* (2013) and Njidda and Enoch (2020). Kamalu *et al.* (1988) reported that plasma protein helps to transport calcium and phosphorus and other substances in the blood by attachment to the albumin. The albumin level is lower than the values reported by Olafadehan *et al.* (2018). The normal Serum enzymes (ALT, AST and ALP) values among the diets imply no damage to the liver and kidney and no negative influence on the functions of organs associated with blood metabolism (Vakili *et al*., 2013). Serum enzyme activities above the normal ranges are abnormal and indicate that animals might have suffered liver and/or kidney damage (Njidda and Enoch, 2020). Albumin

values less than normal usually indicates hypoalbuminemia (Altman, 1979). The urea level in this study shows significant difference ($P<0.05$) with higher value in T_3 Generally, the values compared favourably with the values 1.5 mmol/L reported by Oduye and Adedevon (1976) and 5.6 to 8.1 mmol/L reported by Njidda *et al.* (2013) and Njidda and Enoch (2020). High level of serum urea has been attributed to excessive tissues protein catabolism associated with protein deficiency (Oduye and Adedevon, 1976).

Histopathology

Kidney

From the results, T_1 did not display any histopathological changes in the kidney (Figure 1), while T_2 and T_3 showed mild to moderate atrophy of the glomentics with increased Bowen's space and lesions which increased across the experimental treatment. T_4 and T_5 showed moderate to severe necrosis and degenerative changes, hydropic degeneration of tubular epithelia and especially of proximal tubules, proteinaceous casts as evidenced by purple color masses in the tubules, and pyknotic nuclei of the tubular epithelia in T_5 were noticed. In acute molasses toxicity (Rodrigues *et al*., 2014) reported, the kidney showed hyper anemia, enlarged sinusoids within an apparently decreased amount of hematopoietic tissue, edema on tubular cells and tubular necrosis, and an enlarged Bowman's capsule. The epithelial cells around the renal blood vessels showed necrosis and damage, indicated by the presence of fibrosis replacing the damaged areas. Bowman's capsular spaces were expanded due to the shrinkage of the glomerular cells. There were profuse hemorrhages in the medulla, indicative of glomerular damage. The result from this experiment shows that goats fed high level of molasses and groundnut cake T_4 and T_5 have adverse effect on the vital organs such as kidney. The kidneys of the control goats did not display any histopathological changes. The kidneys are highly vascular organs and they receive approximately 25% of the cardiac output (Michael and Wojciech, 2006).

Liver

Light microscopic examination of the livers of the control T_1 goats did not show any pathological changes. T_2 goats showed non cirrhotic portal fibrosis characterized by expansion of portal zones with streaky fibrous tissue proliferation. Goats fed the T_3 showed moderate expanded portal zones with portal fibrosis, with fewer pyknotic nuclei in hepatocytes and lymphocyte infiltration at the periphery of portal zone, and, in a few cases endothelial cell degeneration. Increased pyknotic nuclei of hepatocytes and drop-out necrosis were visible in focal areas and there was formation of syncytia in T_4 and T_5. The presence of congestion of liver with some damage matched with findings of Sharma, *et al.* (2004) who reported liver congestion and pericarditis when fed diets containing high amount of urea and molasses. It is generally agreed that urea molasses toxicity is equivalent to ammonia poisoning (Shirley, 1986). Toxicity problems are usually associated with the ingestion of excess levels of urea and molasses. The liver presented dilatation of hepatic sinusoids, fatty deposition in hepatocytes and Mallory bodies.

Spleen

Histopatological presentations of the spleen shows no observable changes in T_1, there is yaline degeneration in the small artery wall with middle wall ruptured and intercalation in T_2 and T_3 T_4 and T_5 recorded massive hemorrhage and necrosis in the parenchyma with several lymphocytes and neutrophils infiltrations in the splenic membrane. Focal infiltrations of lymphocytes and neutrophils are observed in some vessel walls with intimal thickening. The spleen contains hematopoietic and lymphoid elements; it is a primary site of extra medullary hematopoiesis, and removes degenerate and aged red blood cells as well as particulate materials and circulating bacteria from the blood supply (Anosa and Isoun, 1980).

Conclusion

Based on the results obtained in this study, it can be concluded that feeding high energy (40% molasses) and protein (GNC 0%) level of inclusion had negative effect on the kidney, liver and spleen. A blend of 40% molasses as energy source and 0% groundnut cake gave a serum cholesterol level lower than all other combinations (treatments). The moderate level of inclusion of molasses and GNC in a mixed ration is 20%.

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Table 1: Composition of Experimental Diet (%)

	T_1	T_2	T_3	T_4	T_5
Molasses	0	10	20	30	40
GNC	40	30	20	10	0
Wheat Offal	10	10	10	20	20
Sorghum Stover	20	20	20	20	20
Cowpea husk	25	25	25	25	25
Premix	3	3	3	3	3
Salt	2	2	2	2	2
Total	**100**	**100**	**100**	**100**	**100**

Table 2: Proximate Composition of Experimental Diets (g kg^{-1} DM)

	Treatment					
Parameter	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**SEM**
Dry matter	919.00^{a}	917.80^{b}	915.00^{c}	913.60^{d}	914.80^{e}	1.33^{*}
Crude protein	162.20^{a}	150.80^{b}	145.70^{c}	143.00^{d}	140.10^{e}	2.15^{*}
Crude fibre	138.00^{a}	129.20^{b}	128.50^{b}	128.00^{b}	127.20^{bc}	1.92^{*}
Ether extract	67.90^{a}	59.20^{b}	58.80^{c}	57.10^{d}	56.00^{e}	0.98^{*}
Acid Detergent Fibre	239.10^{a}	229.70^{b}	227.00^{c}	225.60^{d}	224.10^{e}	1.23^{*}
Neutral Detergent Fibre	394.00^{a}	384.20^{a}	378.20^{ab}	365.00^{c}	352.00^{d}	0.04*
Non-fibre Carbohydrates	301.90^{c}	329.00^{ab}	325.50^{ab}	335.00^{a}	341.00^{a}	1.79*
Ash	81.00	82.20	85.00	86.40	85.20	0.92^{NS}
Lignin	102.20^{e}	114.00^{b}	116.20^{a}	110.60^{c}	109.20^{d}	1.21^{*}
Energy (kcal/kg)	2550.20^{e}	2591.00^{d}	2601.40^{c}	2665.30^{b}	2668.70^{a}	0.28*

a, b, c, d, e = Means within the same row with different superscripts differed significantly; * = (P<0.05), SEM = Standard Error of the Mean, NS = Not significant

Table 3: Haematological parameters

	Treatment					
Parameter	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**SEM**
PCV (%)	23.00^{b}	23.00^{b}	22.00	26.00^{a}	19.00^{c}	1.31*
Hb (g/dl)	8.00^{a}	7.50^{b}	7.60^{b}	8.70^{a}	6.10^{c}	0.92*
RBC (x 10^{9}/L)	8.30^{b}	8.80^{b}	8.30^{b}	9.60^{a}	7.22^{c}	0.67*
WBC (%)	20.50^{b}	15.70^{cd}	25.60^{a}	16.60^{c}	17.10^{c}	2.33*
Lymphocytes (%)	54.00^{b}	43.00^{c}	56.00^{a}	53.00^{b}	40.00^{d}	2.21*
Neutrophils (%)	42.00^{d}	51.00^{b}	42.00^{d}	45.00^{c}	58.00^{a}	1.56*
Eosinophil (%)	1.00	2.00	0.00	1.00	0.00	0.06^{NS}
Monocytes (%)	4.00	2.00	2.00	1.00	2.00	0.96^{NS}
Basophils (%)	2.00	2.00	2.00	1.00	2.00	0.04^{NS}
MCV (fl)	27.70	26.10	26.40	27.00	26.30	1.56^{NS}
MCH (pg)	9.64	8.50	9.10	9.10	8.40	1.77^{NS}
MCHC (%)	34.80	32.60	34.50	33.50	32.10	2.38^{NS}

Pack cell volume PCV Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) Mean Corpuscular Hemoglobin Concentration (MCHC) Packed Cell Volume (PCV) Hemoglobin (Hb) Red blood cell (RBC), total white blood cell count (WBC)

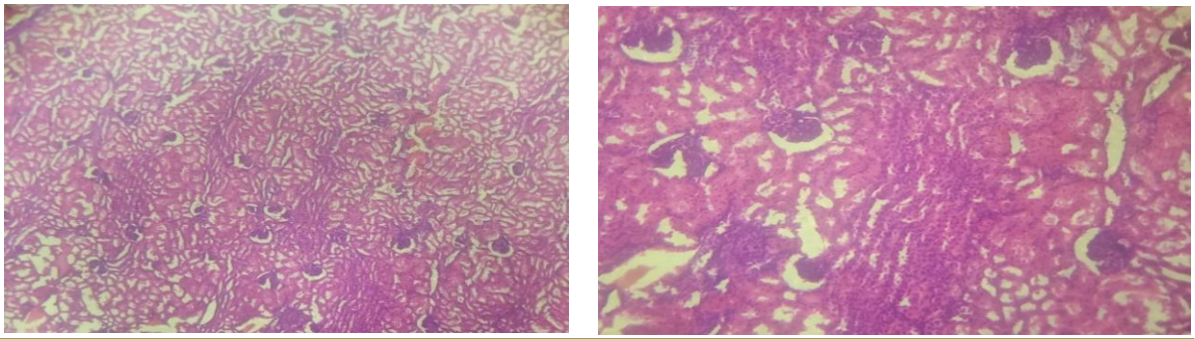
Table 4: Biochemical Indices of Red Sokoto Goats Fed High Energy and Protein Diets

Parameter	Diets					
	T_1	T_2	T_3	T_4	T_5	SEM
Sodium (mmol/l)	137.00	139.00	135.00	137.00	136.00	3.21^{NS}
Potassium (mmol/l)	4.00	3.90	4.10	3.80	4.20	1.09^{NS}
Chloride (mmol/l)	103.00^{a}	101.00^{b}	98.00^{d}	100.00^{c}	101.00^{b}	0.87*
Biocarbonate (mmol/l)	21.00^{d}	23.00^{c}	20.00^{c}	24.00^{b}	25.00^{a}	0.02*
Creatinine (mg/dl)	24.00^{d}	34.00^{c}	37.00^{a}	36.00^{ab}	38.00^{a}	1.16*
Blood Urea (mmol/l)	8.60^{a}	11.70^{c}	11.10^{e}	8.10^{b}	6.70^{d}	0.56*
Total cholesterol (mg/dl)	0.82^{c}	1.06^{ab}	1.71^{a}	1.22^{a}	0.51^{d}	0.96*
Glucose (FBS) (mg/dl)	3.90^{d}	7.00^{a}	6.10^{b}	5.50^{c}	5.30^{c}	0.56*
Total protein (g/dl)	60.00^{d}	65.00^{a}	63.00^{b}	61.00^{c}	63.00^{b}	0.27*
Albumin (g/dl)	32.00^{a}	25.00^{c}	22.00^{d}	36.00^{a}	18.00^{c}	0.40*
Globulin (g/dl)	2.80^{a}	2.40^{b}	2.30^{b}	2.70^{a}	2.70^{a}	0.03*
Total bilirubin (mmol/l)	2.00	2.00	2.00	3.00	2.00	0.18^{NS}
Triglycerol (mmol/l)	0.30	0.21	0.35	0.34	0.17	0.02^{NS}
High Density Lipoproteins (mg/dl)	0.41	0.48	0.68	0.56	0.28	0.03^{NS}
Low Density Lipoproteins (mg/dl)	0.30^{c}	0.50^{b}	0.90^{a}	0.50^{b}	0.20^{e}	0.02*
Aspartate aminotransferase (iu/l)	369.00^{a}	90.00^{c}	117.00^{b}	115.00^{b}	62.00^{d}	3.32*
Alanine aminotransferase (iu/l)	60.00^{a}	21.00^{d}	29.00^{c}	33.00^{b}	12.00^{e}	2.46*
Alkaline phosphatase (iu/l)	108.00^{b}	32.00^{e}	94.00^{d}	113.00^{c}	245.00^{a}	3.42*

abcde = Means within the same row with different superscripts differed significantly; * = (P<0.05), SEM = Standard Error of the Mean, NS = Not significant, FSB = Fasting Blood Sugar

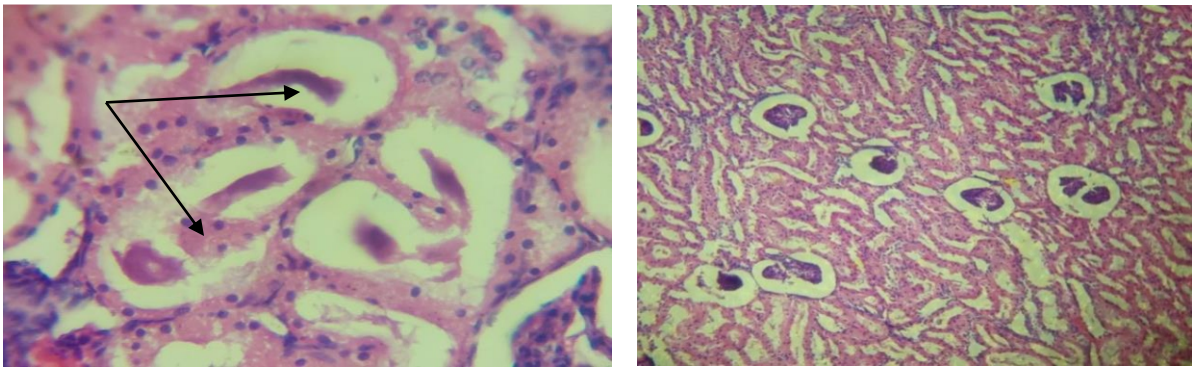
Histopathological findings of the kidney

Fig. 1 Treatment 1



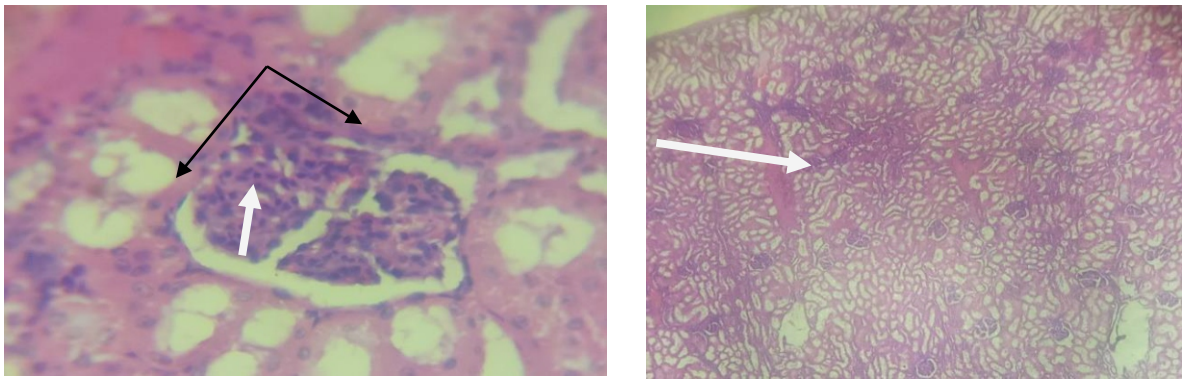
Photomicrograph of kidney of Red Sokoto goats showing no damages. H & E X 40 and H &E X 100

Fig (2) Treatment 2



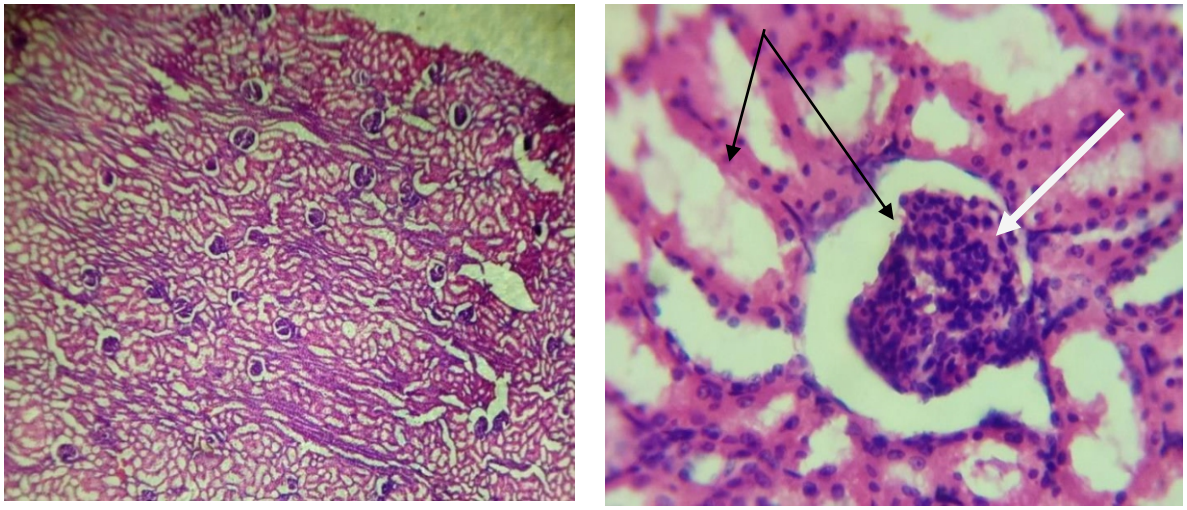
Photomicrograph of kidney of Red Sokoto goats showing mild necrosis (white arrow) congestion and degeneration of the convoluted tubules (black arrow). H &E X 400 and H &E X 100

Fig (3) Treatment 3



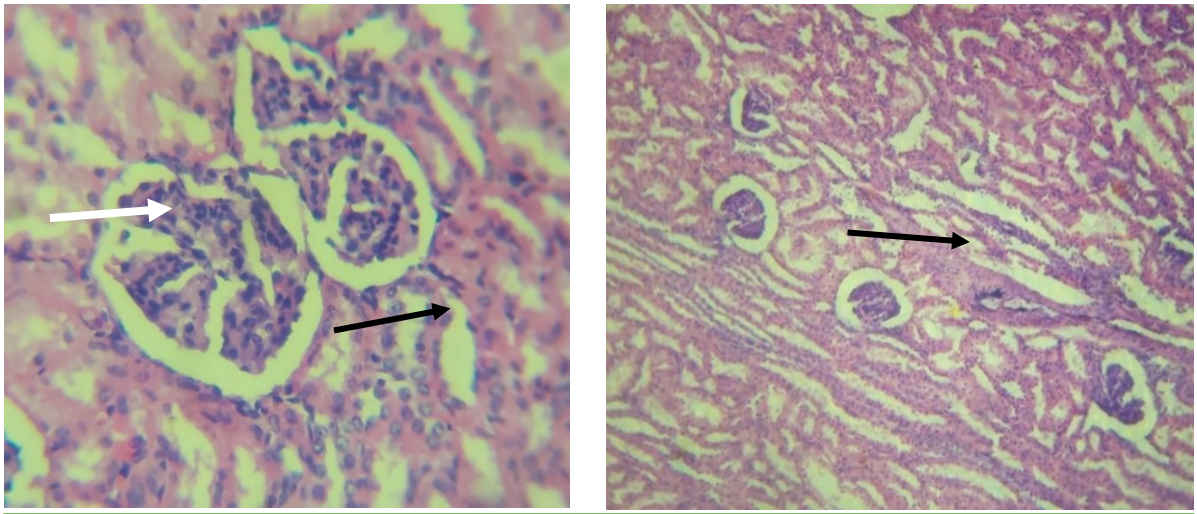
Photomicrograph of kidney of Red Sokoto goats showing moderate necrosis (white arrow), atrophy, congestion and degeneration of the convoluted tubules (black arrows). H &E X 400 and H &E X 40

Fig (4) Treatment 4



Photomic raph of kidney of Red Sokoto goats showing severe necrosis (white arrow), congestion, atrophy and degeneration of the convoluted tubules (black arrow). H &E X 100 and H &E X 400

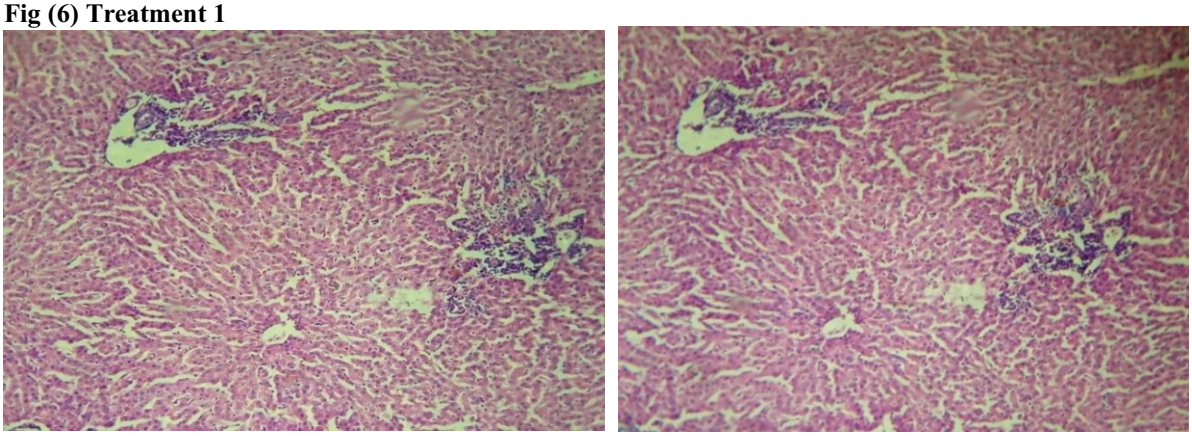
Fig (5) Treatment 5



Photomicrograph of kidney of Red Sokoto goats showing severe congestion, necrosis (white arrow) and degeneration of the convoluted tubules. H &E X 400 and H &E X 100

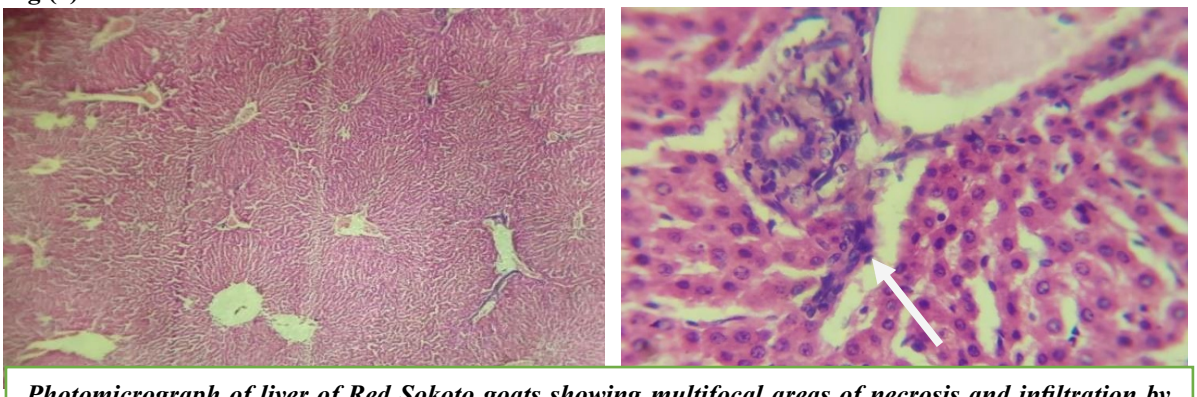
Histopathological findings of the liver

Fig (6) Treatment 1



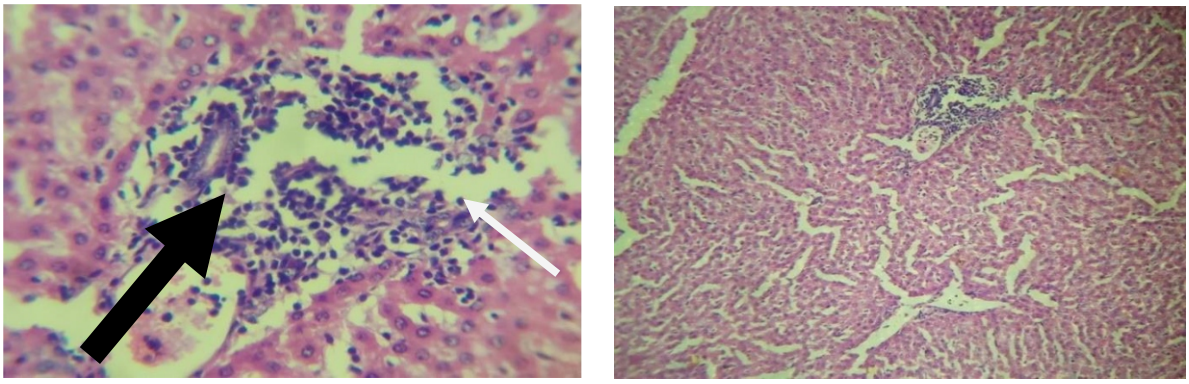
Photomicrograph of the liver of Red Sokoto goats showing no expanded portal zones with portal fibrosis, with fewer pyknotic nuclei in hepatocytes and lymphocyte infiltration H &E X 40 and H&EX 400.

Fig (7) Treatment 2



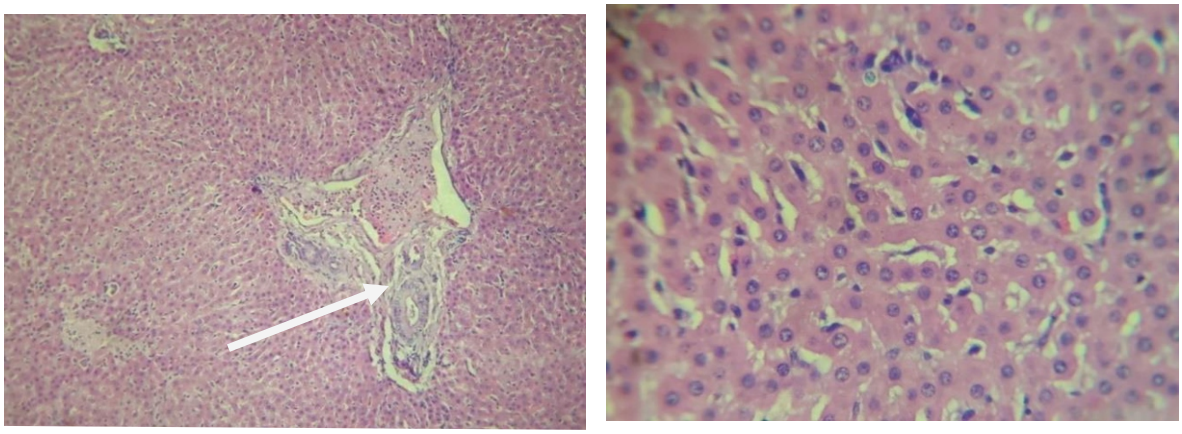
Photomicrograph of liver of Red Sokoto goats showing multifocal areas of necrosis and infiltration by inflammatory cells were observed in treatment H &E X 40 and H &E X 100

Fig (8) Treatment 3



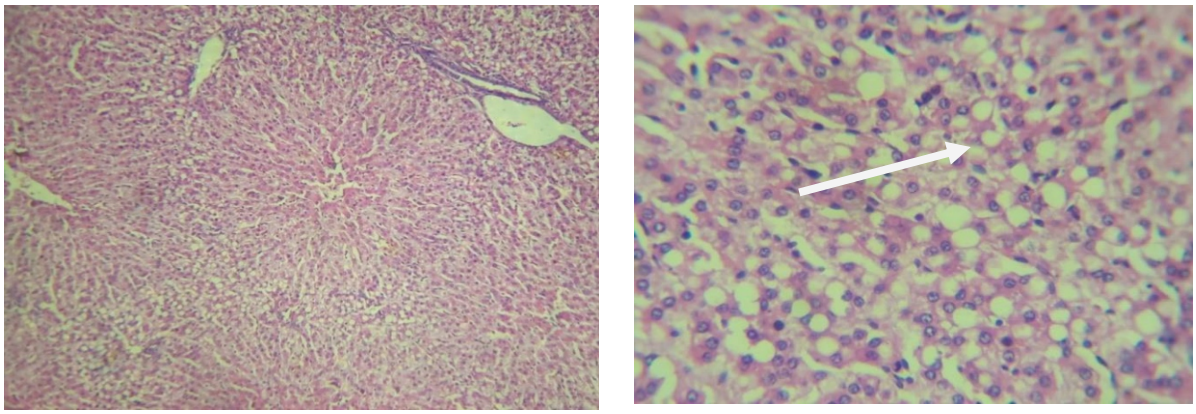
Photomicrograph of liver of Red Sokoto goats showing moderate infiltration by inflammatory cells (white arrow) multifocal areas of necrosis (black arrow) H &E X 40 and H &E X 100

Fig (9) Treatment 4



Photomicrograph of liver of Red Sokoto goats showing severe vescular degeneration of the hepatocytes. H &E X 100 and H &E X 400

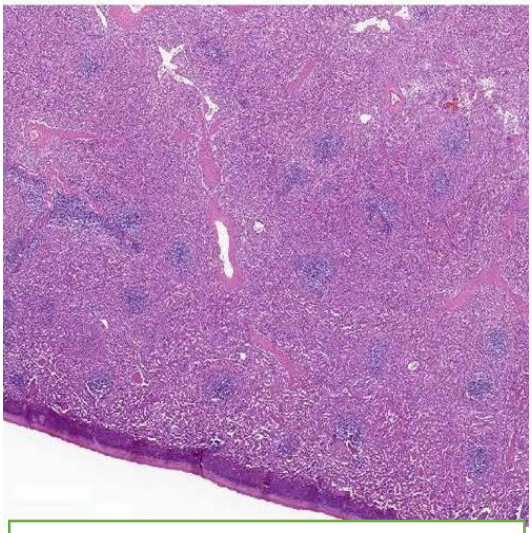
Fig (10) Treatment 5



Photomicrograph of liver of Red Sokoto goats showing severe vesicular degeneration of the hepatocytes and lymphocytic infiltration at the periphery of portal zone, and, in a few cases endothelial cell degeneration were observed. H &E X 100 and H &E X 400

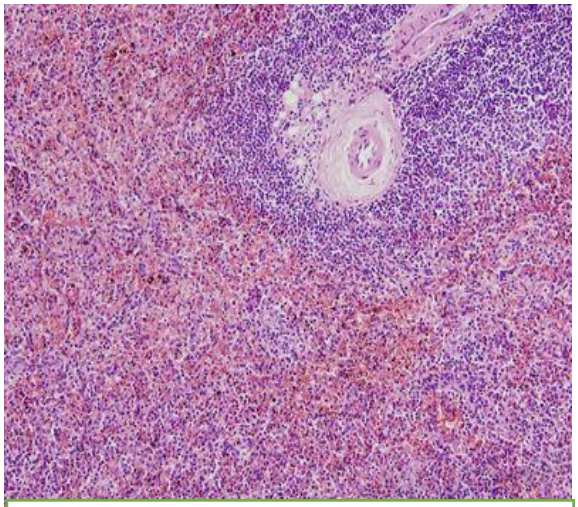
Histopathological findings of the spleen

Fig 11 Treatment 1



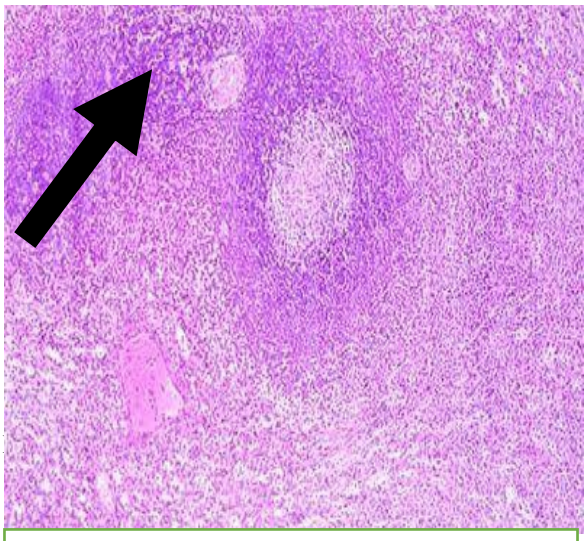
No damage to the spleen is observed (H&E X200)

Fig 12 Treatment 2



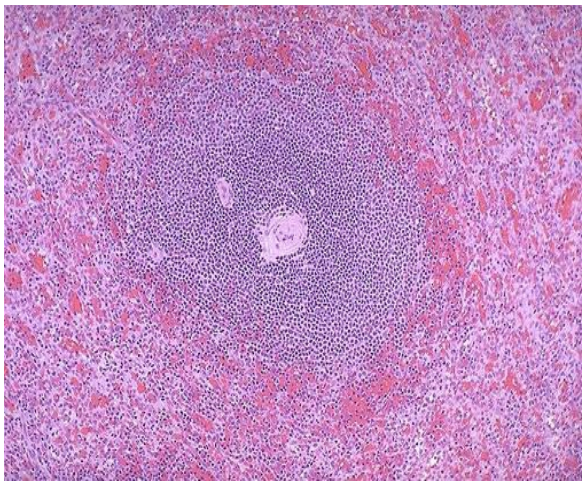
Focal infiltrations of lymphocytes and neutrophils is observed in some vessel intimal thickenin (H&E X200). is observed (H&E X200)

Fig 13 Treatment 3



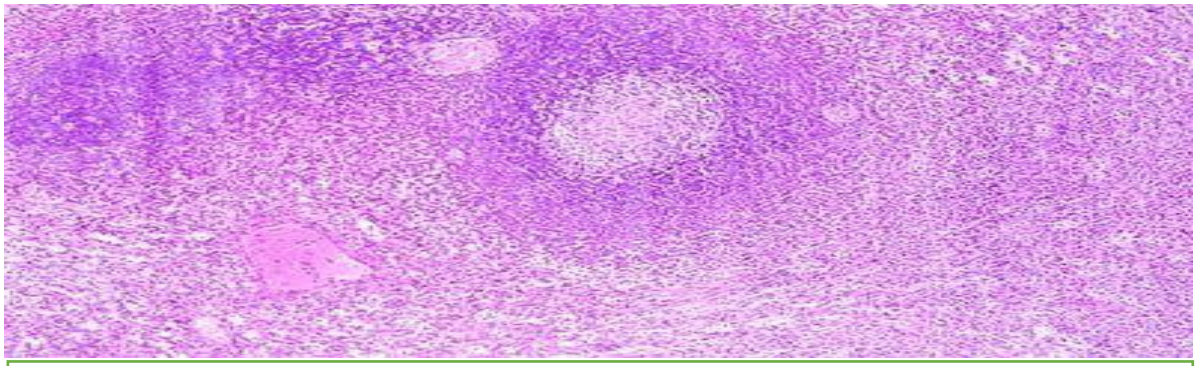
Mild thrombosis and partial small vessel walls with occlusion is observed (H&E X 200)

Fig 14 Treatment 4



Histopatological presentations of the spleen shows massive hemorrhage and necrosis in the parenchyma with several lymphocytes and neutrophils infiltrations in the splenic membrane (H&E X50)

Fig 15 Treatment 5



Histopathological presentations of the spleen shows massive haemorrhage and necrosis in the parenchyma with several lymphocytes and neutrophils infiltrations in the splenic membrane (H&E X 50)