# Reproductive Hormones, Semen Quality and Blood Profiles of Kalahari Red and *Kalawad* Goat Bucks Treated Ivermectin and Diminazene aceturate

**Odeyemi, A. J.,[1*] Shittu, O. O.,[2] Odeyemi, A. Y.,[3] Adekunle, E. O.,[1] Toviesi, D. P.,[2] Famakinde, S. A.,[2] and Smith, O. F.[1]**

[1]*Department of Animal Physiology Federal University of Agriculture, (FUNAAB), P.M.B 2240, Abeokuta*
[2]*Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR) FUNAAB*
[3]*Department of Animal Production and Health Federal University of Agriculture, (FUNAAB), P.M.B 2240, Abeokuta*

***Corresponding author:** odeyemiaj@funaab.edu.ng ; +2348036422308

**Abstract**

*Drugs, both natural and synthetic (especially antimicrobial or antiparasitic), have been useful in the treatment of various diseases with significant impacts on the overall health status and particularly on reproductive system of human and domestic animals; parasite-related issues, especially those affecting the gastrointestinal tract of goats and sheep, can result in the animal suffering irreversible harm or even death, as well as decreased performance and financial loss for the producer. This study was conducted to investigate the effect of Ivermectin and Diminazene aceturate at dose-therapeutic levels on semen quality, reproductive hormones and blood profiles of Kalahari Red (KR) and the crossbred – Kalawad (KW) bucks. A total of 48 animals with 24 bucks each of Kalahari and Kalawad aged 1- 1½ years old were randomly selected from the herds. The experiment was laid on a 2 x 3 x 4 factorial arrangement with two (2) breeds of goat, three (3) age groups and four (4) observation times. Data obtained were analysed using SAS 1999 package. The results showed that semen and reproductive hormones parameters were significantly affected by breed ($p<0.05$). The pH, semen concentration, progressive motility, acrosome integrity and livability in both breeds treated groups decreased ($p<0.05$) except in diminazene aceturate treated group with higher livability (92.18±0.29 %). Drug treated groups in both breeds had improved pack cell volume (PCV), white blood cell (WBC) and its differentials. KR and KW diminazene aceturate treated groups recorded ($p<0.05$) least (7.61±0.13 x $10^6$/dL) and highest (9.04±0.11 x $10^6$/dL) red blood cell (RBC) respectively. Total protein and globulin were influenced by breeds ($p<0.05$). Total protein increased ($p<0.05$) in both breeds with least values recorded in control groups. Control groups had highest cholesterol values (72.12±0.51 mg/dL and 73.68±0.59 mg/dL) in KR and KW. Triglyceride and creatinine were highest (60.27±0.61 and 61.39±0.64; 1.15±0.05 and 1.09±0.056 mg/dL) in KR and KW Ivermectin treated groups respectively. Results also indicated that cholesterol, triglyceride, creatinine and glucose were not significantly influenced ($p>0.05$) by both breeds and frequency of observations. The testosterone concentration decreased significantly ($p<0.05$) between treated groups of both KR and KW but the highest mean was obtained in Control groups (2.59±0.01 ng/mL). The follicle stimulating hormone (FSH) and testosterone concentrations were impacted by both breeds and frequency of observation. The highest FSH and testosterone (0.13±0.003 and 1.78±0.117 ng/mL) were recorded at 48 hours in KW, respectively. It is concluded that semen parameters, blood profiles, FSH and testosterone were greatly influenced by administration of the drugs. Therefore, the use of ivermectin and diminazene aceturate must be cautiously and carefully used particularly on bucks selected for breeding purposes.*

**Key words:** Kalahari Red, *Kalawad,* buck, Antiparasitic, Antimicrobial

# Hormones reproductives, qualité du sperme et profils sanguins de boucs Kalahari Red et *Kalawad* traités à l'Ivermectine et au Diminazène acéturate

**Résumé**

*Les médicaments, qu'ils soient naturels ou synthétiques (en particulier les antimicrobiens ou les antiparasitaires), sont utiles dans le traitement de diverses maladies et ont des impacts significatifs sur l'état de santé général, et particulièrement sur le système reproducteur des humains et des animaux domestiques ; les problèmes liés aux parasites, surtout ceux affectant le tractus gastro-intestinal des chèvres et des moutons, peuvent entraîner des dommages irréversibles, voire la mort*

*de l'animal, ainsi qu'une diminution des performances et des pertes économiques pour l'éleveur. Cette étude a été menée pour investiguer l'effet de l'Ivermectine et du Diminazène acéturate à des doses thérapeutiques sur la qualité du sperme, les hormones reproductives et les profils sanguins de boucs Kalahari Red (KR) et du croisement Kalawad (KW). Au total, 48 animaux, dont 24 boucs chacun de Kalahari et de Kalawad âgés de 1 à 1½ an, ont été sélectionnés aléatoirement dans les troupeaux. L'expérience a été conçue selon un dispositif factoriel 2 x 3 x 4 avec deux (2) races de chèvres, trois (3) groupes d'âge et quatre (4) temps d'observation. Les données obtenues ont été analysées à l'aide du logiciel SAS 1999. Les résultats ont montré que les paramètres du sperme et des hormones reproductives étaient significativement affectés par la race (p<0,05). Le pH, la concentration spermatique, la motilité progressive, l'intégrité de l'acrosome et la viabilité ont diminué (p<0,05) dans les groupes traités des deux races, sauf dans le groupe traité au diminazène acéturate où une viabilité plus élevée a été observée (92,18±0,29 %). Les groupes traités des deux races ont montré une amélioration de l'hématocrite (PCV), des globules blancs (WBC) et de leur formule différentielle. Les groupes traités au diminazène acéturate de KR et KW ont enregistré respectivement la valeur la plus basse (7,61±0,13 x 106/dL) et la plus élevée (9,04±0,11 x 106/dL) de globules rouges (RBC) (p<0,05). Les protéines totales et la globuline ont été influencées par les races (p<0,05). Les protéines totales ont augmenté (p<0,05) dans les deux races, les valeurs les plus basses étant enregistrées dans les groupes témoins. Les groupes témoins ont présenté les valeurs de cholestérol les plus élevées (72,12±0,51 mg/dL et 73,68±0,59 mg/dL) chez KR et KW respectivement. Les triglycérides et la créatinine ont été les plus élevés (60,27±0,61 et 61,39±0,64 ; 1,15±0,05 et 1,09±0,056 mg/dL) dans les groupes traités à l'ivermectine de KR et KW respectivement. Les résultats ont également indiqué que le cholestérol, les triglycérides, la créatinine et le glucose n'étaient pas significativement influencés (p>0,05) par les races ou la fréquence des observations. La concentration de testostérone a diminué significativement (p<0,05) entre les groupes traités des deux races KR et KW, mais la moyenne la plus élevée a été obtenue dans les groupes témoins (2,59±0,01 ng/mL). Les concentrations de l'hormone folliculo-stimulante (FSH) et de testostérone ont été impactées à la fois par les races et la fréquence d'observation. Les valeurs les plus élevées de FSH et de testostérone (0,13±0,003 et 1,78±0,117 ng/mL) ont été enregistrées à 48 heures chez KW, respectivement. Il est conclu que les paramètres spermatiques, les profils sanguins, la FSH et la testostérone sont fortement influencés par l'administration des médicaments. Par conséquent, l'utilisation de l'ivermectine et du diminazène acéturate doit être prudente et mesurée, en particulier sur les boucs sélectionnés pour la reproduction.*

**Mots-clés** : Kalahari Red, Kalawad, bouc, Antiparasitaire, Antimicrobien

## Introduction

Antimicrobial or antiparasitic drugs used in livestock production can cause bacterial resistance in treated animals, which may have an impact on the animals' general health and ability to reproduce. Antibiotic resistance is a major public health concern because the bacteria linked to the animals may be harmful to humans, easily spread to humans through food chains, and widely distributed in the environment through animal waste. In other words, it has become one of the biggest potential risks to public health worldwide due to indiscriminate or improper use of antibiotics by farmers using self-service or by inexperienced veterinarians in sub-Saharan Africa which could consequently, influence the hormonal, reproductive performance and overall health status of the animals. (O'Neill, 2014; Manyi-Loh *et al.*, 2018; Mshana *et al.*, 2021).

The growing human population worldwide increases the demand for faster food production, including animal-based foods, which exacerbates the already worrisome trends of synthetic antimicrobial use in animal production in the majority of African nations as well as in veterinary and animal science generally (Mshana

*et al.,* 2021). It is widely acknowledged that the main cause of the development and dissemination of antimicrobial resistance in both commensal and pathogenic bacterial populations is the usage of antibiotics (Prestinaci *et al.,* 2015). Nonetheless, these antimicrobial compounds continue to be crucial for treatment of human, animal, and plant diseases. Given the massive amounts of antimicrobials used in the livestock industry for a variety of purposes, such as disease prevention, treatment, growth promotion, and the processing and preservation of foods originating from animals, the animal health sector plays a crucial role in this challenge (Salam *et al.,* 2023). However, the use of multiple molecules or broad-spectrum antimicrobials for treating infections is a common practice among veterinarians as such treatments and prescriptions are often without any laboratory diagnostic support. This is either due to ignorance on the part of animal owners, lack of funds, or poor access to affordable laboratory diagnostic facilities, which is a major challenge in the animal health sector (Dankar *et al.,* 2023; Odey *et al.,* 2024). In the midst of these challenges, examination of blood profiles, reproductive hormones and semen quality of the animals administered common antiparasitic or antimicrobial drugs could serve as a veritable tool for livestock professionals in the management of animal health issues thus, reducing the chances of zoonotic transmission of resistant bacteria through food animals and their products, animal care and the environment (Olaru *et al.,* 2023). In addition, antimicrobials should only be used when absolutely necessary because many animal health conditions may not require antimicrobial treatment (Sarkar and Gould, 2006, Mathew *et al.,* 2007). Instead, appropriate management practices, such as timely and adequate nutrition, adequate biosecurity, and clean farm surroundings, can be applied.

According to Inchaisrie *et al*. (2010), reproductive issues frequently impact reproductive performance, which has a significant economic impact. Numerous physiological and management components that have a compounding influence on reproductive efficiency are likely the core cause of infertility (Carson and Kallen, 2021). According to Kate *et al*. (2008), animals that are overloaded with parasites may have difficulty reproducing, grow more slowly, and produce less in general, whether that production is for milk, meat, or fiber. Generations of overuse and improper use of the available anthelmintic dewormers have made it more difficult to prevent and control the parasites that infect ruminants, particularly goats. This is because parasites have become more resistant to common anthelmintics (Fissiha and Kinde, 2021).

Physiological and pathological health conditions, as well as the diagnostic and prognostic evaluation of numerous animal diseases, can all be evaluated with the help of the blood profile (Tambuwal *et al.,* 2002; Alade *et al.,* 2005). In order to comprehend the connection between blood properties and the environment (Madan *et al.,* 2016) as well as specific disorders (Tibbo *et al.,* 2008; El-Mandrawy *et al.,* 2018), haematological and biochemical investigations are of ecological and physiological importance. The changes in these parameters have been studied in cattle (Ghergariu *et al*., 1984) sheep (Kausslish and Arora, 1977) and Red Sokoto goats (Tambuwal *et al*., 2002) under tropical climate. It is feasible to validate clinical diagnoses, assess the severity of cases, provide suitable medication/treatment and evaluate results by determining the haematological and biochemical parameters of animals (Roubies *et al.,* 2006; Tschuor *et al.,* 2008). Goat breeds have significant differences in their haematological and biochemical characteristics (Azab and Abdel-Maksoud, 1999; Tambuwal *et al.,* 2002; Daramola *et al.,* 2005). The male sexual functions are highly susceptible to pharmacological agents as well as several chemicals and physical substances produced by industrial or agricultural operations (Oliver *et al.,* 2001; Favareto *et al.,* 2015). Also, various chemical types of pesticides and solvents have been shown to be hazardous to male reproduction in animal models and that fertile men's semen quality was decreased by agricultural chemicals (Sundaram and Witorsch 1995; Swan *et al.,* 2003).

Ivermectin, albendazole, nitazoxanide and levamisole are the most used antiparasitic drugs in sheep, goats, cattle, horses and pigs and was recommended against a variety of nematodes as well as trematodes (Cordero del Campillo, 1999). In addition, diminazene aceturate (Berenil) - a chemotherapeutic drug has been used extensively

for trypanosomiasis in livestock; nevertheless, its molecular and biochemical mechanisms of action are still poorly understood, and its impact on the host immune system has not been thoroughly investigated (Shiby and Jude, 2014).

Lack of studies on the effects of anti-helminthic on semen quality, reproductive hormones and blood profiles under farm conditions pose a drawback to clearly monitor the productivity of such animals. Therefore, this study investigated the direct effect, and evaluated male reproductive hormones associated with the use of antihelminthic drugs. Semen quality, haematological and biochemical indices of both Kalahari Red and *Kalawad* goat bucks treated with different anti-helminthic drugs.

## Materials and Methods

### *Experimental animals*

Twenty-four bucks each were randomly selected from the herd of Kalahari Red and *Kalawad* (Crossbred between West African dwarf doe and Kalahari Red buck) goats. Kalahari and *Kalawad* bucks with average weight of 35 - 40kg and 25kg - 30kg, respectively aged 1- 1½ years old were used for this study. The animals were managed under a semi-intensive system, housed in an open-ventilated pen with slated floor. The animals were allowed to graze on paddock solely planted with *Chloris gayana, Stylosanthes hamata ad libitum* on rotational basis and supplemented with concentrate feed (16% Crude protein) at 2% body weight dry matter. Water was supplied *ad libitum.*

### *Experimental design*

Bucks were randomly assigned in a block design consisting of three groups. Each of the three groups comprised of eight bucks each and expressed in a 2 x 3 x 4 factorial arrangement (with two breeds, three treatment groups and four observations). The blood samples and semen were collected from both the control group and the two treatment groups (ivermectin and diminazene aceturate) concurrently.

### *Administration of test drugs*

The treatment groups comprised of ivermectin treated and diminazene aceturate treated groups while bucks of the control group were not administered any of the drugs. The diminazene aceturate treated group was given an intramuscular injection of a solution of 188.8mg/mLof diminazene aceturate (Berenil) at a dose of 3.5mg/kg body weight while the ivermectin treated group was given a subcutaneous injection of a 1% w/v solution of ivermectin at a dose of 0.2mg/kg body weight. Both at recommended dose-prophylactic.

### *Blood Sample Collection and Analysis*

Blood samples were collected from the control group, ivermectin and diminazene aceturate treated groups at 48 hours, 96 hours, 144 hours and 192 hours post drug administration. A pair of 5mL of blood collected through jugular venipuncture using a vacutainer needle into Ethylenediaminetetraacetic acid (EDTA) and plain bottle(s) were used for haematological and biochemical analysis respectively. Haematological indices were determined with the aid of an auto haemo analyser while some of the biochemical parameters considered were determined with the aid of an automated spectrophotometer using the standardized kits. On the other hand, a pair of the sera harvested from samples after centrifugation at 3000rpm for 15 minutes were kept in the freezer at -20$^{o}$C until hormonal analysis were carried out. Follicle stimulating hormone (FSH) and testosterone concentration were assessed by radioimmunoassay using the breed specific standardised enzyme-linked immunosorbent assay (ELISA) kits while strict adherently to the manufacturer's instructions.

### *Semen Collection and Evaluation*

Prior to the commencement of this study, the bucks were trained thrice per day (morning, afternoon and evening) consistently on daily basis for two months to prepare or stabilize the animals and facilitate easy collection of semen. Semen was collected with the aid of artificial vagina (AV). To facilitate this, a teaser doe was restrained so that the donor bucks become aroused and then mounts the doe. The buck was pushed away 2 to 3 times (false-mounting) to heighten its libido, after which it was allowed to mount the teaser doe. Following mounting of doe by the buck, an AV was placed to accommodate the penis. The stimulation provided by the AV's warm water bladder, lubrication, and pressure produced an ejaculate and the semen was then collected. Semen samples were collected from each animal at 48 hours, 96 hours, 144 hours and 192 hours post drug administration and each

labelled accordingly. Semen collections were done in the morning (7am - 9am); kept properly under temperature 36.8ºC – 37ºC and moved immediately to the laboratory within 20 minutes after collection. Other semen parameters of interest except volume and pH were evaluated with the aid of computer assisted semen analyser (CASA) - (SCA®) 5.0 designed with Common Astronomy Software application package (Microscopic, S.L, Barcelona, Spain).

***Semen volume and pH***

The semen collected using an AV was measured using a graduated semen collecting tube before being transferred into the 15 mL graduated Falcon tubes. The semen pH was determined using a pH meter (HANNA instruments®, South Africa). The electrode was rinsed with sterile water and wiped with a sterile paper towel and then dipped into the semen sample for pH evaluation. Before the next semen sample was evaluated, the electrode was dipped into the semen sample.

***Sperm motility and concentration***

The microscopic slide cover chamber (20 µm) of the CASA was used to assess the spermatozoa concentration and motility. Before being added to each semen sample, which had been kept at the same temperature in a water bath, the sperm washing solution Brackett and Oliphant medium (BOM) was pre-warmed to 37°C on a heated plate. 10mL of each semen sample were diluted with 500mL of BOM. For CASA determination of sperm motility, 20 frames were tracked for sperm progressive motility assessment and not less than 1000 spermatozoa were identified.

***Sperm viability and morphology***

Sperm morphological abnormalities (sperm with coiled tail, simple bent tail, curved mid piece tail, or simple bent tail) were assessed by eosin/nigrosin staining and then determined by CASA in live normal and dead spermatozoa. 5µL of raw semen and 20mL of eosin-nigrosin staining were used at a dilution rate of 1:4. Eosin-nigrosin is made up of 1.67g of eosin and 2.9g of sodium citrate in 100mL of sterile water (dissolved in nigrosin, 100g/L, and formalin, 5mL/L). Ten fields were observed for each sample.

***Acrosomal integrity***

The percentage of spermatozoa with intact acrosomes were determined by adding 50µL of each sperm sample to a 500µL formalin citrate solution (96 mL of 2.9% sodium citrate, with 4ml of 37% formaldehyde) and it was carefully mixed. The mixture was observed with the use of CASA and spermatozoa were determined for live sperms with intact acrosome (apical piece). Ten fields were observed for each sample.

***Sperm membrane integrity***

Using the Hypo-osmotic Swelling Test (HOST), which involved incubating 10µL of semen in 100µL of hypo-osmotic solution (fructose and sodium citrate) at 37ºC for 30 minutes; ten fields were observed for each sample and it was possible to identify spermatozoa that contained sperm cells with intact membrane integrity.

***Statistical analysis***

Data obtained were subjected to one way analysis of variance using SAS 1999, 9.1 version and means were tested using Duncan multiple range test to show differences between groups and ($P<0.05$) was considered as statistically significant.

**Results**

The results indicating the effect of breed treated with Ivermectin and Diminazene Aceturate on semen quality, reproductive hormones, haematological and biochemical indices of goat bucks is presented in Table 1. The results showed that all semen parameters and reproductive hormones considered were significantly influenced by breed ($p<0.05$). Also, PCV, RBC, WBC, LYM and monocyte were significantly affected ($p <0.05$) while HB, NEU, EOS and basophil were not influence. Among the biochemical indices considered, only total protein and globulin were significantly influenced ($p <0.05$).

The interactive effects of breed and treatment on semen quality and reproductive hormones of goat bucks is shown in Table 2. Results showed that there was no significant effect ($p>0.05$) in KW bucks semen volume irrespective of the group; No statistical difference in KR between the drugs, control and Ivermectin treated groups while there was significant effect ($p<0.05$) between the control group and diminazene aceturate treated group. There were significantly decrease ($p <0.05$) in pH, semen concentration, progressive motility, acrosome integrity and livability in both KR and KW treated groups except diminazene

aceturate treated group with higher livability (92.18±0.29%) which was not different from the control group in KR. Also, the percentage dead, coiled tail, single bent tail and curved midpiece were higher ($p<0.05$) in both breeds with treated groups. The mean value (0.13±0.002 ng/mL) of FSH in KW control group, diminazene aceturate group and diminazene aceturate group in KR were not significantly different ($p>0.05$). The testosterone concentration decreased significantly ($p<0.05$) between treated groups of both KR and KW but the highest mean was obtained in Control groups (2.59±0.01 ng/mL) followed closely by (1.61±0.04 ng/mL) in KW and KR respectively.

Table 3 shows the interactive effects of breed and treatment on haematological and biochemical indices following drugs administration. The results indicated that all haematological and biochemical indices considered were highly significant. Drug treated groups in both breeds had improved PCV, WBC and the differentials. HB increased significantly ($p<0.05$) in KW with least value (5.81±0.08g/dl) recorded in control group; but KR had significant decrease ($p<0.05$) with highest value (8.71±0.11g/dl) obtained in control group. RBC decreased significantly ($p<0.05$) in KR with drug treated groups with least mean (7.61±0.13 x 106/dL) obtained in diminazene aceturate treated group while KW mean value increased significantly ($p<0.05$) with highest value (9.04±0.11 x 106/dL) in diminazene aceturate group. Total protein significantly increased ($p<0.05$) in both breeds with least values recorded in control groups while ALB decreased significantly ($p<0.05$) with highest values recorded in the control groups of both breeds. Control groups had highest cholesterol values (72.12±0.51 and 73.68±0.59 mg/dl) in KR and KW while the least values (63.98±0.97 and 63.09±0.97 mg/dl) were obtained in Ivermectin treated groups respectively. Triglyceride and Creatinine had the highest mean (60.27±0.61 and 61.39±0.64; 1.15±0.05 and 1.09±0.056 mg/dl) in Ivermectin treated groups for KR and KW respectively. GLU decreased between the treated groups of both breed with highest values recorded in the control groups.

The interaction effect of breed and frequency (hours) post drug administration on semen quality and reproductive hormones of goat bucks is presented in Table 4. Results indicated that all semen quality parameters considered except livability were significantly impacted ($p<0.05$) by both breeds and frequency of post drug administration. Semen volume was at peak in both KR and KW at 96 and 192 hours respectively. Concentration was at peak ($p<0.05$) in both KR and KW (3.45±0.03 and 4.53±0.08 x 106/mL) at 48 hours post drug administration. Progressive motility in both breeds were similar ($p>0.05$) at 48 and 96 hours. Acrosome integrity in KW remained constant ($p>0.05$) among different frequency (hours) but differ significantly from means recorded in KR. The least membrane integrity (70.00±0.58 and 71.38±0.64%) were observed at 48 hours in KR and KW respectively. The percentage dead were not significantly different ($p>0.05$) in KR and KW respectively among the frequencies but higher means were observed in KR compared to KW. Percentage coiled tail, single bent tail and curved midpiece were not statistically different ($p>0.05$) in KR among the frequencies while highest values (4.58±0.14, 4.59±0.11 and 3.30±0.08 %) were observed in KW at 48 hours post drug administration and subsequent decreased ($p<0.05$) with least values obtained at 144 and 192 hours but not different statistically from values at 96 hours. The FSH and testosterone concentrations were significantly influenced by both breeds and frequency/observation times following post drugs administration. The highest means (0.13±0.003 and 1.78±0.0.117 ng/mL) were recorded at 48 hours in *Kalawad* for FSH and testosterone, respectively.

The interaction effect of breed and frequency (hours) post drug administration on haematogical and biochemical indices of goat bucks is shown in Table 5. Among the haematological indices considered, neutrophil, eosinophil, basophil and monocyte were not significantly influenced by breeds and frequency of post drug administration. The least PCV value (24.19±0.455%) was obtained at 96 hours in KR ($p<0.05$) but did not different significantly ($p>0.05$) in KW across the frequencies. RBC and WBC were not statistically different in KW across the frequencies but differ significantly ($p<0.05$) in KR. Results also indicated that cholesterol, triglyceride, creatinine

and glucose were not significantly influenced by both breeds and frequency of post drugs administration. Total protein was not statistically different ($p>0.05$) in KW across the frequencies but differ statistically ($p<0.05$) in KR. Albumin and globulin were not significantly different ($p>0.05$) in both KR and KW at 96, 144 and 192 respectively but statistically different with value at 48 hours while there was significant difference ($p<0.05$) in KR across different frequencies.

**Table 1: Least square means showing the main effect of breed on semen quality, reproductive hormones, haematological and biochemical indices of goat bucks**

| Breed | Vol (mL) | pH | Conc ($10^6$/mL) | PM (%) | AI (%) | MI (%) | Liv (%) | % Dead | CT (%) | SBT (%) | CMP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| KR | 1.65±0.06[a] | 7.04±0.12[a] | 3.41±0.02[b] | 83.43±0.48[a] | 70.69±0.27[b] | 71.00±0.29[b] | 90.60±0.32[a] | 8.87±0.08[a] | 3.64±0.05[b] | 4.12±0.04[b] | 3.28±0.04[a] |
| KW | 1.23±0.01[b] | 6.98±0.12[b] | 4.05±0.06[a] | 80.96±0.40[b] | 79.40±0.46[a] | 73.40±0.43[a] | 89.40±0.56[b] | 5.99±0.13[b] | 4.35±0.05[a] | 4.40±0.03[a] | 2.86±0.08[b] |
| | <0.0001 | 0.003 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.02 | <.0001 | <.0001 | <.0001 | <.0001 |

| | FSH (ng/mL) | Testo (ng/mL) |
|---|---|---|
| KR | 0.12±0.001[b] | 1.14±0.04[b] |
| KW | 0.13±0.001[a] | 1.78±0.06[a] |
| P value | <0.0001 | <0.0001 |

| | PCV (%) | HB (g/dL) | RBC ($10^6$/dL) | WBC ($10^3$/µL) | Neu (%) | Lym (%) | Eos (%) | Bas (%) | Mon (%) |
|---|---|---|---|---|---|---|---|---|---|
| KR | 25.95±0.24[a] | 7.64±0.15 | 9.19±0.14[a] | 7.68±0.11[a] | 28.34±0.47 | 49.71±1.10[b] | 0.23±0.005 | 0.24±0.007 | 0.22±0.004[a] |
| KW | 23.85±0.27[b] | 7.82±0.16 | 7.72±0.12[b] | 6.82±0.14[b] | 28.02±0.40 | 54.43±1.41[a] | 0.22±0.006 | 0.25±0.007 | 0.20±0.005[b] |
| | <0.0001 | 0.41 | <0.0001 | <0.0001 | 0.61 | 0.009 | 0.18 | 0.7 | 0.0001 |
| Reference value* | 22 – 38 | 8 - 12 | 8 – 18 | 4.00 – 13.00 | 30 – 48 | 50 – 70 | 1 - 8 | 0 - 1 | 0 - 4 |

| | TP (g/dL) | ALB (g/dL) | GLOB (g/dL) | CHOL (mg/dL) | TRIG (mg/dL) | CREAT (mg/dL) | GLU (mg/dL) |
|---|---|---|---|---|---|---|---|
| KR | 6.48±0.05[b] | 3.24±0.06 | 3.23±0.08[b] | 66.84±0.58 | 54.75±0.56 | 0.91±0.03 | 62.45±0.78 |
| KW | 7.01±0.04[a] | 3.56±0.04 | 3.65±0.06[a] | 66.92±0.66 | 55.98±0.56 | 0.87±0.03 | 62.01±0.64 |
| P value | <0.0001 | 0.11 | <0.0001 | 0.93 | 0.12 | 0.29 | 0.66 |
| Reference value** | 6.0 – 7.0 | 2.3 – 3.6[#] | 2.7 – 3.8[#] | 61.5 – 76.1 | - | 1.2 – 1.9 | 50 - 75 |

[abc..] Means along column with the different superscript(s) differ(s) significantly ($p<0.05$)

KR = Kalahari Red goat, KW = *Kalawad* goat, Vol = Volume, Conc = Concentration, PM= Progressive motility, AI = Acrosome integrity, MI = Membrane integrity, Liv = Livability, CT = Coiled tail, SBT = Single bent tail, CMP = Curved mid piece, FSH = Follicle stimulating hormone,

Testo = Testosterone, PCV = Packed cell volume, HB = Haemoglobin, RBC = Red blood cell, WBC = White blood cell, Neu = Neutrophil, Lym = Lymphocyte, Eos = Eosinophil, Bas = Basophil, Mon = Monocyte, TP = Total protein, ALB = Albumin, GLOB, Globulin, CHOL = Cholesterol, TRIG = Triglyceride, CREAT = Creatinine, GLU = Glucose, *According to Feldman et al. (2000), **From https://goat-link.com., # From Merck Veterinary Manual (2016).

**Table 2: Interaction effects of breed and treatment on semen quality and reproductive hormones of goat bucks**

| Breed | Treatment | Vol (ml) | pH | Conc ($10^6$/ml) | PM (%) | AI (%) | MI (%) | Liv (%) | % Dead | CT (%) | SBT (%) | CMP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KR | Control | 1.52±0.02$^{b}$ | 7.16±0.01$^{a}$ | 3.54±0.01$^{c}$ | 87.82±0.41$^{a}$ | 72.53±0.55$^{c}$ | 73.08±0.34$^{b}$ | 91.34±0.49$^{ab}$ | 8.09±0.10$^{c}$ | 3.11±0.07$^{e}$ | 3.75±0.02$^{d}$ | 2.98±0.03$^{bc}$ |
| | Ivermectin | 1.64±0.11$^{ab}$ | 6.93±0.02$^{d}$ | 3.35±0.02$^{d}$ | 81.75±0.32$^{c}$ | 70.14±0.33$^{d}$ | 69.02±0.50$^{d}$ | 88.29±0.63$^{c}$ | 9.50±0.09$^{a}$ | 3.80±0.02$^{d}$ | 3.99±0.38$^{c}$ | 3.14±0.02$^{b}$ |
| | DiminaA | 1.79±0.14$^{a}$ | 7.03±0.01$^{c}$ | 3.33±0.02$^{d}$ | 80.72±0.93$^{cd}$ | 69.40±0.32$^{d}$ | 70.91±0.37$^{c}$ | 92.18±0.29$^{a}$ | 9.02±0.11$^{b}$ | 4.01±0.04$^{c}$ | 4.61±0.03$^{a}$ | 3.73±0.03$^{a}$ |
| KW | Control | 1.26±0.01$^{c}$ | 7.10±0.03$^{b}$ | 4.56±0.06$^{a}$ | 85.01±0.30$^{b}$ | 82.64±0.49$^{a}$ | 75.78±0.73$^{a}$ | 89.83±1.31$^{bc}$ | 4.63±0.10$^{f}$ | 3.80±0.06$^{d}$ | 4.34±0.04$^{b}$ | 2.09±0.04$^{d}$ |
| | Ivermectin | 1.19±0.02$^{c}$ | 6.88±0.03$^{d}$ | 3.86±0.10$^{b}$ | 79.21±0.56$^{de}$ | 78.20±0.77$^{b}$ | 72.24±0.69$^{bc}$ | 88.45±0.73$^{c}$ | 6.01±0.13$^{e}$ | 4.51±0.08$^{b}$ | 4.46±0.06$^{b}$ | 2.84±0.08$^{c}$ |
| | DiminaA | 1.22±0.02$^{c}$ | 6.94±0.02$^{d}$ | 3.72±0.10$^{bc}$ | 78.68±0.52$^{e}$ | 77.37±0.79$^{b}$ | 72.19±0.67$^{bc}$ | 88.78±0.77$^{c}$ | 7.31±0.09$^{d}$ | 4.73±0.06$^{a}$ | 4.39±0.07$^{b}$ | 3.65±0.14$^{a}$ |
| | P value | <0.0001 | <0.0001 | <0.000 | <0.0001 | <0.0001 | <0.0001 | 0.0008 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

| | | FSH (ng/mL) | Testo (ng/mL) |
|---|---|---|---|
| KR | Control | 0.11±0.002$^{c}$ | 1.61±0.04$^{b}$ |
| | Ivermectin | 0.11±0.002$^{c}$ | 1.06±0.02$^{e}$ |
| | DiminaA | 0.13±0.001$^{a}$ | 0.77±0.01$^{f}$ |
| KW | Control | 0.13±0.002$^{a}$ | 2.59±0.01$^{a}$ |
| | Ivermectin | 0.12±0.002$^{b}$ | 1.52±0.01$^{c}$ |
| | DiminaA | 0.13±0.001$^{a}$ | 1.23±0.04$^{d}$ |
| | P value | <0.0001 | <0.0001 |

$^{abc..}$ Means along column with the different superscript(s) differ(s) significantly ($p<0.05$)

KR = Kalahari Red goat, KW = *Kalawad* goat, DiminaA = Diminazene Aceturate, Vol = Volume, Conc = Concentration, PM= Progressive motility, AI = Acrosome integrity, MI = Membrane integrity, Liv = Livability, CT = Coiled tail, SBT = Single bent tail, CMP = Curved mid piece, FSH = Follicle stimulating hormone, Testo = Testosterone

**Table 3: Interaction effects of breed and treatment on blood profiles of goat bucks**

| Breed | Treatment | PCV (%) | HB (g/dL) | RBC ($10^6$/dL) | WBC ($10^3$/µL) | Neu (%) | Lym (%) | Eos (%) | Bas (%) | Mon (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| KR | Control | 23.74±0.24$^{b}$ | 8.71±0.11$^{ab}$ | 10.05±0.16$^{a}$ | 8.72±0.17$^{a}$ | 33.86±0.23$^{a}$ | 60.68±0.65$^{b}$ | 0.27±0.005$^{a}$ | 0.31±0.004$^{a}$ | 0.25±0.002$^{a}$ |
| | Ivermectin | 27.03±0.38$^{a}$ | 6.05±0.20$^{d}$ | 9.91±0.13$^{a}$ | 7.56±0.11$^{b}$ | 27.91±0.25$^{c}$ | 51.86±0.99$^{c}$ | 0.24±0.003$^{b}$ | 0.26±0.007$^{b}$ | 0.17±0.002$^{c}$ |
| | DiminaA | 27.09±0.26$^{a}$ | 8.17±0.12$^{c}$ | 7.61±0.13$^{c}$ | 6.75±0.13$^{c}$ | 23.25±0.32$^{e}$ | 36.59±0.44$^{d}$ | 0.19±0.008$^{c}$ | 0.16±0.003$^{c}$ | 0.25±0.001$^{a}$ |
| KW | Control | 20.96±0.31$^{c}$ | 5.81±0.08$^{d}$ | 6.61±0.15$^{d}$ | 8.64±0.09$^{a}$ | 32.95±0.22$^{b}$ | 66.18±0.69$^{a}$ | 0.28±0.002$^{a}$ | 0.32±0.002$^{a}$ | 0.25±0.003$^{a}$ |
| | Ivermectin | 23.92±0.17$^{b}$ | 8.62±0.09$^{b}$ | 7.45±0.09$^{c}$ | 5.96±0.04$^{d}$ | 27.27±0.12$^{d}$ | 60.71±0.68$^{b}$ | 0.23±0.004$^{b}$ | 0.26±0.005$^{b}$ | 0.21±0.007$^{b}$ |
| | DiminaA | 26.68±0.17$^{a}$ | 9.04±0.11$^{a}$ | 9.09±0.10$^{b}$ | 5.84±0.03$^{d}$ | 23.85±0.17$^{e}$ | 36.39±1.00$^{d}$ | 0.15±0.004$^{d}$ | 0.16±0.004$^{c}$ | 0.14±0.002$^{d}$ |
| P value | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Reference value* | | 22 - 38 | 8 - 12 | 8 - 18 | 4.00 – 13.00 | 30 – 48 | 50 – 70 | 1 – 8 | 0 - 1 | 0 - 4 |

| | | TP (g/dl) | ALB (g/dl) | GLOB (g/dl) | CHOL (mg/dl) | TRIG (mg/dl) | CREAT (mg/dl) | GLU (mg/dl) |
|---|---|---|---|---|---|---|---|---|
| KR | Control | 6.37±0.09$^{d}$ | 3.85±0.09$^{a}$ | 2.52±0.09$^{e}$ | 72.12±0.51$^{a}$ | 50.44±0.62$^{d}$ | 0.74±0.009$^{b}$ | 70.01±0.69$^{a}$ |
| | Ivermectin | 6.65±0.08$^{c}$ | 2.96±0.07$^{d}$ | 3.69±0.12$^{bc}$ | 63.98±0.97$^{b}$ | 60.27±0.61$^{a}$ | 1.15±0.054$^{a}$ | 58.96±1.03$^{c}$ |
| | DiminaA | 6.68±0.08$^{c}$ | 2.93±0.06$^{d}$ | 3.48±0.12$^{c}$ | 64.42±0.76$^{b}$ | 53.55±0.71$^{bc}$ | 0.84±0.001$^{b}$ | 58.38±1.12$^{c}$ |
| KW | Control | 6.41±0.09$^{d}$ | 3.56±0.06$^{b}$ | 3.13±0.11$^{d}$ | 73.68±0.59$^{a}$ | 51.89±0.63$^{cd}$ | 0.75±0.009$^{b}$ | 66.06±0.75$^{b}$ |
| | Ivermectin | 7.30±0.04$^{a}$ | 3.28±0.07$^{c}$ | 4.02±0.07$^{a}$ | 63.09±0.97$^{b}$ | 61.39±0.64$^{a}$ | 1.09±0.056$^{a}$ | 60.28±1.04$^{c}$ |
| | DiminaA | 7.06±0.04$^{b}$ | 3.24±0.06$^{c}$ | 3.82±0.08$^{ab}$ | 63.99±0.71$^{b}$ | 54.67±0.75$^{b}$ | 0.78±0.019$^{b}$ | 59.71±1.12$^{c}$ |
| P value | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Reference value** | | 6.0 – 7.0 | 2.3 – 3.6$^{\#}$ | 2.7 – 3.8$^{\#}$ | 61.5 – 76.1 | - | 1.2 – 1.9 | 50 - 75 |

$^{abc..}$ Means along column with the different superscript(s) differ(s) significantly ($p<0.05$)

KR = Kalahari Red goat, KW = *Kalawad* goat, DiminaA = Diminazene Aceturate, PCV = Packed cell volume, HB = Haemoglobin, RBC = Red blood cell, WBC = White blood cell, Neu = Neutrophil, Lym = Lymphocyte, Eos = Eosinophil, Bas = Basophil, Mon = Monocyte, TP = Total protein, ALB = Albumin, GLOB, Globulin, CHOL = Cholesterol, TRIG = Triglyceride, CREAT = Creatinine, GLU = Glucose, *According to Feldman et al. (2000), **From https://goat-link.com., # From Merck Veterinary Manual (2016).

**Table 4: Interaction effect of breed and frequency (hours) post drug administration on semen quality and reproductive hormones of goat bucks**

| Breed | Frequency (Hrs) | Vol (mL) | pH | Conc ($10^6$/mL) | PM (%) | AI (%) | MI (%) | Liv (%) | % Dead | CT (%) | SBT (%) | CMP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KR | 48 | 1.36±0.01$^{bc}$ | 7.03±0.03$^{ab}$ | 3.45±0.03$^{c}$ | 83.27±0.95$^{ab}$ | 71.57±0.54$^{b}$ | 70.00±0.58$^{c}$ | 89.71±0.65 | 8.92±0.15$^{a}$ | 3.63±0.09$^{c}$ | 4.11±0.09$^{c}$ | 3.29±0.07$^{a}$ |
| | 96 | 2.32±0.18$^{a}$ | 7.03±0.03$^{ab}$ | 3.31±0.03$^{c}$ | 81.81±0.95$^{ab}$ | 69.97±0.55$^{b}$ | 70.95±0.58$^{bc}$ | 90.65±0.65 | 8.87±0.18$^{a}$ | 3.66±0.11$^{c}$ | 4.14±0.09$^{c}$ | 3.23±0.08$^{a}$ |
| | 144 | 1.44±0.03$^{b}$ | 7.04±0.02$^{a}$ | 3.44±0.03$^{c}$ | 84.32±0.95$^{a}$ | 70.62±0.54$^{b}$ | 71.53±0.58$^{bc}$ | 91.03±0.65 | 8.85±0.18$^{a}$ | 3.64±0.09$^{c}$ | 4.12±0.09$^{c}$ | 3.30±0.08$^{a}$ |
| | 192 | 1.47±0.02$^{b}$ | 7.04±0.02$^{ab}$ | 3.44±0.03$^{c}$ | 84.32±0.95$^{a}$ | 70.62±0.54$^{b}$ | 71.53±0.58$^{bc}$ | 91.03±0.65 | 8.84±0.18$^{a}$ | 3.64±0.09$^{c}$ | 4.12±0.09$^{c}$ | 3.30±0.08$^{a}$ |
| KW | 48 | 1.17±0.02$^{c}$ | 7.02±0.03$^{ab}$ | 4.53±0.08$^{a}$ | 80.85±0.99$^{b}$ | 78.28±1.06$^{a}$ | 71.38±0.64$^{bc}$ | 89.25±1.13 | 6.21±0.20$^{b}$ | 4.58±0.14$^{a}$ | 4.59±0.11$^{a}$ | 2.95±0.16$^{ab}$ |
| | 96 | 1.18±0.02$^{c}$ | 6.91±0.04$^{c}$ | 3.91±0.13$^{b}$ | 81.69±0.73$^{ab}$ | 79.09±0.88$^{a}$ | 77.53±0.53$^{a}$ | 88.16±1.14 | 6.03±0.28$^{b}$ | 4.38±0.09$^{a}$ | 4.46±0.04$^{a}$ | 2.94±0.18$^{a}$ |
| | 144 | 1.21±0.02$^{c}$ | 6.94±0.04$^{bc}$ | 3.94±0.13$^{b}$ | 80.66±0.73$^{b}$ | 80.10±0.88$^{a}$ | 72.29±0.88$^{b}$ | 89.38±1.14 | 5.87±0.28$^{b}$ | 4.22±0.09$^{b}$ | 4.27±0.04$^{bc}$ | 2.75±0.18$^{b}$ |
| | 192 | 1.34±0.01$^{bc}$ | 7.03±0.03$^{ab}$ | 3.82±0.13$^{b}$ | 80.66±0.73$^{b}$ | 80.15±0.88$^{a}$ | 72.41±0.67$^{b}$ | 89.28±1.13 | 5.85±0.27$^{b}$ | 4.22±0.09$^{b}$ | 4.27±0.04$^{bc}$ | 2.79±0.18$^{b}$ |
| P value | | <0.0001 | 0.008 | 0.0001 | 0.004 | <0.0001 | <0.0001 | 0.31 | <0.0001 | <0.0001 | <0.0001 | 0.003 |

| | | FSH (ng/mL) | Testo (ng/mL) |
|---|---|---|---|
| KR | 48 | 0.12±0.003$^{b}$ | 1.14±0.077$^{b}$ |
| | 96 | 0.12±0.003$^{b}$ | 1.11±0.079$^{b}$ |
| | 144 | 0.12±0.003$^{b}$ | 1.11±0.079$^{b}$ |
| | 192 | 0.12±0.003$^{b}$ | 1.22±0.075$^{b}$ |
| KW | 48 | 0.13±0.003$^{a}$ | 1.78±0.0.117$^{a}$ |
| | 96 | 0.13±0.003$^{a}$ | 1.76±0.124$^{a}$ |

| | | | |
|---|---|---|---|
| | 144 | 0.13±0.003[a] | 1.76±0.124[a] |
| | 192 | 0.13±0.003[a] | 1.82±0.123[a] |
| P value | | <0.0001 | <0.0001 |

[abc..] Means along column with the different superscript(s) differ(s) significantly ($p<0.05$)

KR = Kalahari Red goat, KW = *Kalawad* goat, Vol = Volume, Conc = Concentration, PM= Progressive motility, AI = Acrosome integrity, MI = Membrane integrity, Liv = Livability, CT = Coiled tail, SBT = Single bent tail, CMP = Coiled mid piece, FSH = Follicle stimulating hormone, Testo = Testosterone

**Table 5: Interaction effect of breed and frequency (hours) post drug administration on haemato-biochemical indices of goat bucks**

| Breed | Frequency (Hrs) | PCV (%) | HB (g/dL) | RBC ($10^6$/dL) | WBC ($10^3$/µL) | Neu (%) | Lym (%) | Eos (%) | Bas (%) | Mon (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| KR | 48 | 26.51±0.42$^{a}$ | 7.61±0.33$^{ab}$ | 9.45±0.29$^{a}$ | 7.69±0.31$^{ab}$ | 28.18±0.97 | 51.17±2.21$^{ab}$ | 0.23±0.009 | 0.25±0.02 | 0.22±0.008 |
| | 96 | 24.19±0.45$^{b}$ | 7.04±0.31$^{b}$ | 8.65±0.28$^{b}$ | 7.13±0.14$^{bc}$ | 27.79±0.97 | 47.53±2.21$^{b}$ | 0.23±0.009 | 0.25±0.02 | 0.22±0.008 |
| | 144 | 26.56±0.42$^{a}$ | 7.71±0.31$^{ab}$ | 9.44±0.28$^{a}$ | 7.69±0.13$^{ab}$ | 29.03±0.97 | 49.85±2.21$^{ab}$ | 0.23±0.009 | 0.24±0.01 | 0.22±0.008 |
| | 192 | 26.55±0.43$^{a}$ | 8.19±0.15$^{a}$ | 9.21±0.24$^{ab}$ | 8.19±0.24$^{a}$ | 28.35±0.90 | 50.29±2.29$^{ab}$ | 0.23±0.009 | 0.25±0.02 | 0.22±0.008 |
| KW | 48 | 24.07±0.46$^{b}$ | 7.69±0.27$^{ab}$ | 7.91±0.26$^{c}$ | 6.92±0.25$^{c}$ | 28.31±0.77 | 53.31±0.89$^{ab}$ | 0.22±0.012 | 0.25±0.02 | 0.19±0.011 |
| | 96 | 23.89±0.55$^{b}$ | 7.93±0.34$^{ab}$ | 7.57±0.23$^{c}$ | 6.86±0.29$^{c}$ | 28.06±0.81 | 56.44±2.35$^{a}$ | 0.22±0.012 | 0.25±0.02 | 0.19±0.011 |
| | 144 | 24.04±0.55$^{b}$ | 7.93±0.34$^{ab}$ | 7.59±0.25$^{c}$ | 6.74±0.28$^{c}$ | 27.81±0.81 | 53.31±2.89$^{ab}$ | 0.22±0.012 | 0.25±0.02 | 0.19±0.011 |
| | 192 | 23.42±0.63$^{b}$ | 7.71±0.31$^{ab}$ | 7.79±0.27$^{c}$ | 6.74±0.28$^{c}$ | 27.90±0.84 | 54.66±3.19$^{ab}$ | 0.22±0.012 | 0.25±0.02 | 0.19±0.011 |
| P value | | <0.0001 | 0.028 | <0.0001 | <0.0001 | 0.98 | 0.026 | 0.97 | 1.00 | 0.06 |
| Reference value ** | | 22 – 38 | 8 - 12 | 8 - 18 | 4.00 – 13.00 | 30 – 48 | 50 – 70 | 1 - 8 | 0 - 1 | 0 - 4 |
| | | TP (g/dL) | ALB (g/dL) | GLOB (g/dL) | CHOL (mg/dL) | TRIG (mg/dL) | CREAT (mg/dL) | GLU (mg/dL) | | |
| KR | 48 | 6.37±0.12$^{c}$ | 3.76±0.09$^{a}$ | 2.61±0.05$^{c}$ | 67.16±1.32 | 54.99±1.09 | 0.92±0.05 | 61.47±1.75 | | |
| | 96 | 6.17±0.06$^{c}$ | 2.88±0.10$^{c}$ | 3.31±0.14$^{b}$ | 65.84±1.09 | 53.98±1.14 | 0.88±0.05 | 62.57±1.33 | | |
| | 144 | 6.65±0.06$^{b}$ | 3.35±0.10$^{b}$ | 3.31±0.14$^{b}$ | 67.18±1.15 | 55.02±1.14 | 0.92±0.05 | 62.89±1.61 | | |
| | 192 | 6.72±0.13$^{b}$ | 2.99±0.10$^{c}$ | 3.72±0.22$^{ab}$ | 67.18±1.15 | 55.02±1.14 | 0.92±0.05 | 62.89±1.61 | | |
| KW | 48 | 7.11±0.06$^{a}$ | 3.04±0.10$^{c}$ | 4.07±0.14$^{a}$ | 67.16±1.32 | 54.99±1.09 | 0.92±0.05 | 61.82±1.59 | | |
| | 96 | 7.02±0.06$^{a}$ | 3.48±0.06$^{b}$ | 3.55±0.09$^{b}$ | 66.86±1.41 | 55.43±1.09 | 0.92±0.05 | 61.89±1.20 | | |
| | 144 | 7.02±0.06$^{a}$ | 3.48±0.06$^{b}$ | 3.55±0.09$^{b}$ | 66.86±1.41 | 55.43±1.09 | 0.83±0.05 | 61.89±1.20 | | |
| | 192 | 6.90±0.14$^{ab}$ | 3.45±0.05$^{b}$ | 3.46±0.15$^{b}$ | 66.79±1.23 | 58.06±1.17 | 0.81±0.05 | 62.44±1.11 | | |
| P value | | <0.0001 | <0.0001 | <0.0001 | 0.99 | 0.36 | 0.57 | 0.99 | | |
| Reference value** | | 6.0 – 7.0 | 2.3 – 3.6$^{\#}$ | 2.7 – 3.8$^{\#}$ | 61.5 – 76.1 | - | 1.2 – 1.9 | 50 - 75 | | |

$^{abc..}$ Means along column with the different superscript(s) differ(s) significantly ($p<0.05$)

KR = Kalahari Red goat, KW = *Kalawad* goat, PCV = Packed cell volume, HB = Haemoglobin, RBC = Red blood cell, WBC = White blood cell, Neu = Neutrophil, Lym = Lymphocyte, Eos = Eosinophil, Bas = Basophil, Mon = Monocyte, TP = Total protein, ALB = Albumin, GLOB, Globulin, CHOL = Cholesterol, TRIG = Triglyceride, CREAT = Creatinine, GLU = Glucose, *According to Feldman et al. (2000), **From https://goat-link.com., # From Merck Veterinary Manual (2016).

**Discussion**

Antibiotic resistance is of great public health concern because the antibiotic-resistant bacteria associated with the animals may be pathogenic to humans, easily transmitted to humans via food chains, and widely disseminated in the environment via animal wastes.

The semen indices of Kalahari Red and *Kalawad* bucks treated ivermectin and diminazene aceturate varied significantly within breeds. The Kalahari Red and *Kalawad* were found to have decreased pH, spermatozoa concentration, progressive motility, acrosome integrity, membrane integrity and livability but *Kalawad* had better concentration, acrosome integrity, membrane integrity, percentage dead and percentage curved midpiece spermatozoa. The trend observed in this study could be due to toxic nature or different body chemical reactions to the drugs in maintaining homeostasis. However, the quality of the semen in the tropics is not limited to the reports of Vilakazi and Webb, (2004) who opined to be lower during the hot months, impacted by thermal stress (Menon *et al.,* 2011) and has been reported to affect semen output, particularly where there is marked seasonal variations in environmental temperature but also by some veterinary drugs use in a prophylactic or therapeutic treatment.

The live spermatozoa percentage in the semen of Kalahari and *Kalawad* bucks administered drugs were similar. These values are in consonant with Sultana *et al.* (2013) observation (92.95±0.74 %) of live spermatozoa in Black Bengal goats. In this study, the results for progressive motility were similar to values reported by Odeyemi *et al.* (2021), who reported (80.00%) in Kalahari Red. The acrosome integrity and membrane integrity values recorded in that study, (83.50% and 82.5%) were higher than the findings in this study. Husain (2007) and Apu *et al.* (2008) found breed variation with 83.73±0.94 to 89.27±1.40% and 84.99±0.38 to 85.62±0.57% live spermatozoa in Black Bengal semen, respectively, which are slightly lower than the findings in the current study. Thus, variations in the percentage of live spermatozoa and percentage abnormality reflects the genetic superiority of a breed and various factors the animals are subjected to at certain times. The results showed that average semen volumes were slightly higher in Kalahari bucks administered drugs (increased compared to the control) than in *Kalawad* bucks (decreased compared to the control). These findings are partly in line with observations in a number of tropical or subtropical breeds of sheep (Kishk, 2008; Mohamed and Abdelatif, 2010). However, the average volume and pH of the ejaculate would therefore, increase or decrease according to body growth or body chemical reactions to different drugs by the breeds of goats.

Additionally, both Kalahari Red and *Kalawad* bucks' spermatozoa concentration in the semen is clearly influenced by the drugs. The present findings disagreed with Singh *et al.* (2016) who indicated no significant buck influence on sperm concentrations and pH. The highest concentration of sperm cells in the semen was discovered in Kalahari and *Kalawad* bucks treated with diminazene aceturate, when the percentage dead, coiled tail, single bent tail and curved midpiece spermatozoa were also at maximum. The spermatozoa concentration findings in this study did not accord with that of Syrian Damascus bucks (Daker and Suleiman, 2004) or Nubian bucks and their crossbred bucks (Elsharif and Makawi, 2004). The high percentages of dead sperm recorded in this study is not consistent with the findings of Elsharif and Makawi, (2004); Elsheikh *et al.* (2013); Wang *et al.* (2015).

The slight variation in erythrocytes and leucocytes values measured in this study which fall within the reference values tends to confirm that drugs administration affects the blood profile of both Kalahari Red and *Kalawad* bucks. Increase in RBC and HB among the KW treated group in this study was accompanied by an increase in the packed cell volume (PCV). This agreed with the reports of Olugbemi *et al*. (2010) and Naifeh *et al.* (2023) who reported that oxygen carrying capacity of the animals' blood would be increased when RBC increased and higher values indicate a greater potential for better function and state of health. But decrease in RBC and HB values recorded in this study could be attributed to difference in the genetic make- up in relation with effectiveness of body chemical reactions mechanism (breed specific) of Kalahari goats. These findings partly agreed with the report of Hackbath *et al.,* (1983) and *Etim et al.* (2014) who reported that elevated RBC values were linked with excellent high quality dietary protein and effeciency of metabolic processes in disease free animals.

The significant reductions below the reference value in the WBC and lymphocytes predispose the animals to reduced immunological responses to infections. The treated groups in both breeds had significant reduction in WBC and its differential in this study. This implies that the use of these drugs in Kalahari and *Kalawad* must strictly follow dose-prophylatic to avoid immulological compromise consequent upon overdose or below recommended dose effects. It had been reported that a significant decrease in the WBC of the blood indicates a decline in the production of the defensive mechanism to combat infections, a situation which would naturally make the animal more susceptible to various physiological stress resulting in diseases, greater mortality and poor growth (Carr and Maggini, 2017). In this study, the highest WBC was observed at 192 and 48 hours in Kalahari and *Kalawad* bucks. This observation shows that the principal function of phagocytes, which is to defend against invading microorganisms by ingesting and destroying them, thus contributing to cellular inflammatory processes, was enhanced (Lim *et al.,* 2017) which may account for its antibacterial activity in maintaining physiological state (Wynn and Vannella, 2016); Thus, enhancing the health condition of the experimental animals. These results are in line with the findings of Piccione *et al*., 2010. The results of basophils and monocytes show that the animals have no bacterial or viral infection hence, their values were significant among the treatment groups. However, some of haematological values were similar to the reference values reported for other goat breeds (Bijan *et al.,* 2012; Shittu *et al.,* 2016; Zahira *et al.,* 2019; Mohammed *et al.,* 2021), while others differed (Tibbo *et al.,* 2008). The difference observed between the values for the Kalahari Red goat and the values previously obtained for different breeds might be due to various differences in environmental, management factors, age or treatments and timing of data collection post drug administration

There are various reported values for biochemical parameters among different breeds of goat including Girgentana (Piccione *et al*., 2010), West African dwarf (Daramola *et al*., 2005), Red Sokoto (Onakpa *et al.,* 2010) and West African dwarf and Kalahari Red (Shittu *et al.,* 2016) which indicated that biochemical parameters values of goats are breed-dependent. Hence, interpretation and reasonable use of blood profiles are often limited by lack of values for physiological parameters relevant to the individual caprine breed/species and in each species to breeding lines and production types (Kral and Suchy, 2000). The increase in total protein, globulin and creatinine; decrease in albumin and cholesterol among the treated groups in both Kalahari and *Kalawad* recorded in this study is in line with the report of Sharma *et al*. (2009) and Nair and Jacob (2016) who reported that the functionality or disposition of the drug in body and, as a result, the blood constituents may change depending on the specific disease (e.g., bacterial urinary infections or bacterial bile duct infections) and then the global therapeutic or [prophylactic] protocol (administration route, intervals between administrations, duration of therapy, etc.) in each animal breed, animal age, sex, and body condition should be carefully considered.

In this study, increased the total protein and globulin were observed in both breeds. The results are in accordance with findings by other researchers (Trotta *et al.,* 2009; Rubino *et al.,* 2006). The increase can be attributed to the administered drugs. This is in agreement with the report of Wang *et al.* (2022) who reported that hyperproteinemia / hypergammaglobulinaemia can be attributed to an increase in blood protein and globulin concentration in response to parasitic antigen and the released of haemoglobin from destructed erythrocytes. The administered drugs reduced the albumin, cholesterol and glucose levels in this study but the values fall within the normal range for goats.

The concentration of the total protein in ivermectin and diminazene aceturate treated groups reported in the present study were comparable to the normal range of goats (6.4-7g/dL) reported by Dhanotiya (2004); higher than 5.09±0.17g/dL recorded by Shittu *et al.* (2016) but lower than 7.48 ± 9.4g/dL demonstrated by Zubcic (2001). These differences may be due to the influence of breed, age, drug or feed that were fed to goats. This is in consonant with the report of Mbassa and Poulsen (1991). The stability in total protein values in the treatment groups irrespective of the drug used suggest that the drug is adequate for the goats. The concentrations of albumin (ivermectin treated group in both breeds) observed in the present study were similar to 3.3 ± 6.1, 2.7 -3.9 and 3. 29±1.82 g/dl reported by Zubcic (2001), Dhanotiya (2004), and Shittu *et al.* (2016) respectively. In this study, creatinine levels in ivermectin and diminazene aceturate treated groups

in both breeds were enhanced but lower than the reference value. This could be attributed to toxic level of the drugs used.

The use of ivermectin and diminazene aceturate caused decrease in serum testosterone concentrations of both breeds with slight increase in follicle stimulating hormone in this study. This could be attributed to imbalance synergistic reactions of the body mechanisms as a result of drug administration. The secretion of FSH and testosterone in each breed remained constant irrespective of the time of frequency. Follicle stimulating hormone is necessary to increase the level of the androgen binding protein production by sertoli cells and to develop the blood-testis barrier and other functions of the cells and consequently increase the spermatozoa yield or concentration. This finding is in line with the report of Bijan *et al.* (2012) who reported that spermatozoa increased if the follicle stimulating hormone increased or present.

## Conclusion

The values for haematological and biochemical indices observed in the present study can be used for monitoring health status, diagnosing diseases, and improving the management and conservation of the breeds. The drugs - ivermectin and diminazene aceturate investigated in this study have been found to enhanced follicle stimulating hormone but lowered the serum testosterone concentration. Hence, the use of these drugs can be encouraged in these breeds at a recommended dosage. However, other indices of fertility such as ejaculate volume, semen concentration, progressive motility, acrosome integrity, membrane integrity and sperm abnormalities were positively and negatively impacted reflecting the genetic potential of both breeds. Therefore, the use of ivermectin and diminazene aceturate must be cautiously used particularly on bucks selected for breeding purposes. Bucks treated with these drugs at 192 hours or eight (8) days post drug administration may not be considered for either artificial insemination or natural mating in the herds of Kalahari Red and *Kalawad* goats for breeding efficiency.

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### *Competing Interests*

The authors have no relevant financial or non-financial interests to disclose.

### *Authors' contributions*

The study conception and design: Odeyemi, Adebisi Joshua, Shittu, Olalekan Oluseyi and Smith, Olusiji Federick; Acquisition, data collection and analysis: Odeyemi, Adebisi Joshua, Shittu, Olalekan Oluseyi Famakinde, Samuel Ayodele, Toviesi, Dedewanu Peter, Adekunle, Ezekiel Oluwafemi and Odeyemi, Adekemi Yemisi. The first draft of the manuscript was written by Odeyemi, Adebisi Joshua and all authors commented on previous versions of the manuscript.

All authors read and approved the final manuscript.

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### *Data Availability*

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### *Ethical Approval*

The experimental procedure has been approved by the Animal Experimental Board of the Department of Animal Physiology, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria. Also, the guidelines for Animal Research of Nigeria Institute of Animal Science (NIAS) was duly followed.

### *Consent to participate*

Informed consent was obtained from all individual participants included in this study prior their inclusion.

### *Conflict of interest Statement*

The authors declare no conflict of interest.

### *ORCID*

https://orcid.org/0000-0003-0005-9208

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