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# Haematological study of a composite cattle population reflects pre-slaughter-induced breed and sex differences

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***Target Audience:*** *Butchers, Cattle breeders, Abattoir and lairage managers, Researchers and Animal Physiologists.*

## Abstract

*Sixty matured animals drawn from a composite population of White Fulani, Sokoto Gudali and Red Bororo cattle were used to evaluate haematological responses to pre-slaughter conditions. Blood samples were collected prior to slaughter and analysed to compare the blood profiles of the three cattle breeds. The results showed that the packed cell volume (PCV) varied significantly ($p<0.05$) among the three breeds, between the two sexes and in the interaction between breed and sex. The PCV, red blood cells (RBC), white blood cells (WBC) and haemoglobin (Hb) values were significantly ($p<0.05$) higher in the male than in the female cattle among the three breeds. All the cattle breeds had abnormally high WBC (21.01±1.07 - 22.43±1.69 $x10^3/mm^3$) and monocyte (9.04±0.20 - 9.33±0.33%) values prior to slaughter. The osmotic fragility of the red blood cells showed significant ($p<0.05$) breed and the sex effects with the males having a more osmotically stable red blood cells under hypotonic condition than the females. The males had higher whole blood viscosities but lower plasma and serum viscosities than the females while the female Red Bororo had higher whole blood, plasma and serum viscosities than their males. Conclusively, the experiment established the minimum and maximum osmotic fragility for these breeds of cattle at 0.50 and 0.30% saline concentration respectively. A case of pre-slaughter leucocytosis and monocytosis was observed. The female Sokoto Gudali were more composed and less fretful than the male in the face of potential danger to life because of their lower monocyte values and would hence produce meat of better quality.*

**Keywords:** Blood viscosity, cattle breeds, erythrocytes, osmotic fragility.

## Description of the Problem

The blood is a fluid matrix made up of many cellular components like the erythrocytes, leucocytes and platelets (1). The study of the mode of formation, morphology and functions of these cellular components and their use in the prediction of the state of health and general wellness of livestock is called haematology. In the study of haematology, many parameters like the red blood cell (RBC) counts, white blood cell (WBC) cell counts, haematocrit and haemoglobin concentration of the blood are taken into consideration. All these parameters are however affected by many factors like age, sex, physiological status, health, nutrition and breed or genotype (2; 3). Variations in the normal blood values have been known to occur not only among different animal species but also between breeds within a species (4). Variation is also

known to occur in blood parameters due to conditions animals are subjected to prior to slaughter and these have been proved to affect the quality of meat obtained from such animals (5). The ability of the animal to cope or its propensity to succumb to the lairage and slaughter slab stressful conditions could therefore define the quality of meat that eventually gets to the final consumer.

According to (6), there are three dominant Zebu breeds of cattle in Nigeria; these are the White Fulani, the Sokoto Gudali and the Red Bororo cattle. Most of the studies on the haematology of the zebu cattle have been done on the White Fulani. These reports include those by various researchers (7; 8; 9). Efforts to include the other two dominant zebu breeds of the West African sub-region – the Sokoto Gudali and Red Bororo in terms of their haematological profile necessitated this experiment. This study sought to compare the haematological indices of a composite population of cattle prior to slaughter at Akure abattoir, using the haemogram, differential white blood count, viscosity and osmotic stability of the red blood cells as response criteria. It is opined that a clear picture of the haematological responses of these cattle breeds to abattoir stressors could be obtained. This may provide a useful guide to better abattoir management practices and subsequent amelioration of the carcass quality upon slaughter.

## Materials and Methods

### Blood collection and handling of blood samples

Blood collection was carried out at the Akure Central Abattoir located at Oyarugbulem market along Ilesha-Ibadan express way Akure, Ondo-State, Nigeria. Akure is located on Latitude $7^{o}$ $18^{'}$ N and Longitude $5^{o}$ $10^{'}$ E in the humid rain forest zone of western Nigeria, characterized by two rainfall peaks and high humidity during the raining season. The mean annual rain fall is about 1500 mm and the rains last for about nine months usually March to November of every year. The mean annual relative humidity is over 75 % while the mean annual temperature is about $27^{o}$C.

Blood samples collected from the animals shortly before slaughter at the abattoir were promptly taken to the laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure for laboratory analyses. Prior to the collection of the blood samples from the animals, sample bottles with ethylene diamine tetra acetic acid (EDTA) were purchased. The test-tubes for the collection of blood for serum viscosity were thoroughly washed, rinsed with distilled water and were allowed to dry prior to blood collection. Both the EDTA sample bottles and test tubes were labelled accordingly.

Blood samples were collected from the abattoir prior to slaughtering of the animals on a fixed day (Wednesday) for three consecutive weeks. A total number of forty nine cattle were slaughtered on the day of sample collection in the first week out of which twenty (ten males and ten females) were randomly sampled. In the second week, forty seven cattle were slaughtered on the sample collection day of which twenty (ten males and ten females) were sampled while forty six cattle were slaughtered during the sample collection day in the third week and twenty (ten males and ten females) were equally sampled. Thus, a total number of sixty cattle were randomly sampled out of the 142 cattle slaughtered over three days within a-three week period comprising thirty males and thirty females of three different breeds (White Fulani, Red Bororo and Sokoto Gudali).

Figure 1 shows the pie-chart distribution of the sampled composite cattle population.

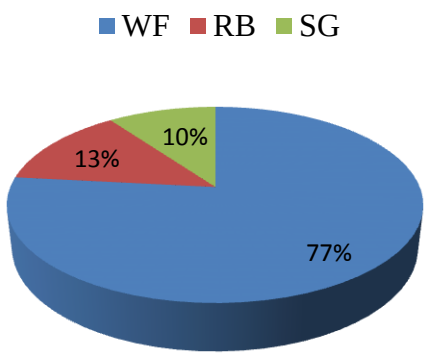


**Figure 1: Pie chart distribution of composite cattle population slaughtered at Akure abattoir** WF = White Fulani; RB = Red Bororo; SG = Sokoto Gudali

**Determination of whole blood, serum and plasma viscosities.**

Blood samples were collected from 60 adult cattle drawn from three different breeds through their jugular vein as they were being led out of the lairage to the slaughter slab into EDTA bottles and sterile test tubes. The blood samples in the EDTA bottles (five ml) were slightly agitated to avoid coagulation while blood samples for serum viscosity measurement (10 ml) were collected in test tubes. The blood samples for plasma viscosity were centrifuged for fifteen minutes at 3000 rpm so as to collect the plasma as the supernatant (10). The values (in centi Poise) of the whole blood, serum and plasma viscosity were determined using the Brookfield's model DV2T viscometer.

**Determination of the osmotic fragility of the red blood cell.**

The blood samples collected 10-15 minutes before slaughter as previously reported were used for the determination of osmotic fragility. The osmotic fragility was determined as previously described by (11) using NaCl and distilled water. Ten test tubes were washed and hung down the rack to dry. Each test tube was labelled from "A" to "J" and filled with 100mls of distilled water. Test tube "A" contained 0.00g of NaCl while test tube "B" to "J" contained 0.10 g to 0.90g of NaCl in 100 ml of distilled water respectively, to give a saline concentration that ranged from 0.00 to 0.90 g per 100ml of distilled water (0.00 to 0.90 % saline concentrations). One millilitre of blood collected from the animals was added to the saline solution in the test tubes from which the percentage of red blood cells haemolysed per saline concentration was calculated from haemocytometric readings and used as a measure of the red cell osmotic fragility or stability (12). Other haematological parameters like haematocrit, red blood cell counts, haemoglobin concentration, erythrocyte sedimentation rate, white blood cell counts and differential leucocyte counts were determined as described by (1)

**Experimental Design / Statistical Analysis**.

The experiment was a 2 x 3 factorial arrangement in a Completely Randomized Design involving two sexes (male and female) and three breeds (White Fulani, Sokoto Gudali and Red Bororo). All data collected were subjected to analysis of variance (ANOVA) Procedure of (13). Treatment means were compared by using Duncan's (14) multiple range test of the same statistical package.

**Table 1: Haematological parameters of a composite cattle population sampled prior to slaughter at Akure abattoir.**

| Source of variation | No of animals | ESR (mm/hr) | PVC (%) | RBC (x10$^6$mm$^3$) | WBC (x10$^3$/mm$^3$) | Hb (g/dl) | LYM (%) | NEU (%) | MON (%) | EOS (%) | BAS (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Breeds** | | | | | | | | | | | |
| WF | 46 | 0.51±0.04 | 38.87±1.42$^a$ | 9.30±0.42 | 21.01±1.07 | 11.63±0.47 | 57.74±0.75$^a$ | 24.91±0.5 | 9.04±0.20 | 6.65±0.29$^a$ | 1.57±0.14$^a$ |
| RB | 8 | 0.63±0.13 | 37.25±3.64$^b$ | 9.90±0.99 | 22.31±2.69 | 12.43±1.22 | 56.75±1.44$^b$ | 26.00±1.35 | 9.25±0.25 | 6.25±0.85$^b$ | 1.57±0.48$^a$ |
| SG | 6 | 0.50±0.03 | 35.00±2.52$^b$ | 9.74±0.68 | 22.43±1.69 | 11.67±0.82 | 56.33±2.03$^b$ | 26.33±1.45 | 9.33±0.33 | 7.00±0.58$^a$ | 1.00±0.00$^b$ |
| *P*-values | | 0.71 | 0.04 | 0.83 | 0.79 | 0.34 | 0.03 | 0.77 | 0.67 | 0.03 | 0.03 |
| **Sex** | | | | | | | | | | | |
| Male | 30 | 0.51±0.04 | 38.87±1.30$^a$ | 10.25±0.33$^a$ | 23.93±0.73$^a$ | 12.96±0.43$^a$ | 57.73±0.93 | 25.07±0.72 | 8.93±0.25$^b$ | 6.73±0.32 | 1.67±0.22 |
| Female | 30 | 0.53±0.05 | 31.53±1.50$^b$ | 8.60±0.55$^b$ | 18.72±1.34$^b$ | 10.52±0.50$^b$ | 57.20±0.89 | 25.33±0.70 | 9.27±0.27$^a$ | 6.53±0.40 | 1.67±0.22 |
| *P*-values | | 0.73 | 0.03 | 0.03 | 0.03 | 0.04 | 0.44 | 0.79 | 0.03 | 0.65 | 0.53 |
| WF male | 22 | 0.52±0.06 | 38.27±1.71$^a$ | 10.05±0.43$^a$ | 23.63±0.98$^a$ | 12.76±0.57$^a$ | 58.54±1.19$^a$ | 24.36±0.89$^b$ | 8.81±0.33$^b$ | 6.63±0.44$^a$ | 1.45±0.16$^b$ |
| WF female | 24 | 0.54±0.06 | 31.85±1.70$^b$ | 8.74±0.63$^b$ | 19.04±1.51$^b$ | 10.63±0.57$^b$ | 56.69±0.92$^b$ | 25.69±0.75$^a$ | 9.23±0.30$^a$ | 6.77±0.41$^a$ | 1.61±0.21$^b$ |
| RB male | 6 | 0.52±0.01 | 40.67±1.76$^a$ | 10.88±0.13$^a$ | 24.98±0.46$^a$ | 13.57±0.59$^a$ | 55.33±0.33$^b$ | 27.33±0.33$^a$ | 9.00±0.00$^b$ | 7.00±0.58$^a$ | 1.33±0.33$^b$ |
| RB female | 2 | 1.00±0.01 | 27.00±0.22$^b$ | 6.95±0.04$^b$ | 14.30±0.14$^b$ | 9.00±0.04$^b$ | 61.00±0.25$^a$ | 22.00±0.02$^b$ | 10.00±0.01$^a$ | 4.00±0.01$^c$ | 3.00±0.02$^a$ |
| SG male | 2 | 0.50±0.01 | 40.00±0.24$^a$ | 10.62±0.06$^a$ | 24.15±0.16$^a$ | 13.30±0.08$^a$ | 56.00±0.24$^b$ | 26.00±0.02$^a$ | 10.00±0.01$^a$ | 7.00±0.01$^a$ | 1.00±0.01$^c$ |
| SG female | 4 | 0.50±0.02 | 32.00±0.88$^b$ | 8.40±0.01$^b$ | 19.05±0.28$^b$ | 10.70±0.16$^b$ | 60.60±0.67$^a$ | 24.00±0.04$^b$ | 9.00±0.02$^b$ | 6.00±0.02$^b$ | 1.00±0.02$^c$ |
| *P*-values | | 0.42 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 |

$^{a, b, c}$ *= Means on the same column but with different superscripts are significantly (P<0.05 different*

*WF = White Fulani; RB = Red Bororo; SG = Sokoto Gudali; LYM = Lymphocyte; NEU = Neutrophil; MON = Monocyte; EOS = Eosinophil; BAS = Basophil; ESR = Erythrocyte sedimentation rate; PCV = Packed cell volume; RBC = Red blood corpuscles; WBC = White blood corpuscles; Hb = Haem oglobin*

**Results**

**Haematological parameters of a composite population of pre-slaughtered cattle at Akure abattoir.**

The interaction between breed and sex (Table 1) showed that the female White Fulani (WF) breed had higher ESR (0.54±0.06 mm/hr.) than the male (0.52±0.06 mm/hr.). The female Red Bororo (RB) had the highest ESR value (1.00±0.00 mm/hr.) of all the three breeds of cattle while the Sokoto Gudali (SG) breed had the same numerical value (0.50±0.00 mm/hr) for both the male and female sexes. The RB had the highest ($p$<0.05) packed cell volume (PCV) of (37.25±3.64 %) while WF had the lowest value (34.87±1.42 %). Significant differences ($p$<0.05) also existed between the sexes in which a PCV value of 38.87±1.30 % was recorded among the males while 31.53±1.50 % was recorded among the females. The interaction between the breed and sex showed that male WF with (38.27±1.71 %), male RB with (40.67±1.78 %) and male SG with (40.00±0.00 %) were significantly different from female WF (31.85±1.70 %), female RB (27.00±0.00 %) and female SG (32.00±0.00 %) while the highest value (40.67±1.76 %) was recorded with male RB and the lowest (27.00±0.00 %) was recorded with female RB.

The red blood cell count (RBC) was not significantly different among the breeds, but there was a significant sex difference between the males ($10.25\pm0.33\times10^{6}mm^{-3}$) and the females ($8.60\pm0.55\times10^{6}mm^{-3}$). The interaction between sex and breed showed that there were significant (p<0.05) differences among the breeds and sexes. Female RB had the lowest value ($6.95\pm0.00\times10^{6}mm^{-3}$), female SG had ($8.40\pm0.00\times10^{6}mm^{-3}$), female WF had ($8.74\pm0.63\times10^{6}mm^{-3}$), male WF had ($10.05\pm0.43\times10^{6}mm^{-3}$), male RB had ($10.58\pm0.13\times10^{6}mm^{-3}$) while the male SG had the highest value ($10.62\pm0.00\times10^{6}mm^{-3}$).

The white blood cell values (WBC) did not show any significant difference among the three breeds of cattle. There were however significant sex differences in the white blood cell (WBC) value, the males had higher ($p$<0.05) values ($23.93\pm0.73\times10^{3}$ $mm^{-3}$) than the females ($18.72\pm1.34\times10^{3}$ $mm^{-3}$). The interaction between breeds and sexes also showed significant WBC values in which male RB recorded $24.98\pm0.46\times10^{3}$ $mm^{-3}$ while female RB recorded $14.30\pm0.00\times10^{3}$ $mm^{-3}$. The male WBC values were significantly higher than those of the females in all the breeds. The values of haemoglobin did not differ significantly among the breeds, while values between the sexes had significant differences with male recording 12.96±0.43 $gdl^{-1}$ and the female 10.52±0.50 $gdl^{-1}$. There were equally significant differences in the interaction between the breeds and sexes. Male RB recorded the highest value (13.57±0.59 $gdl^{-1}$) while female RB recorded the lowest value (9.00±0.00 $gdl^{-1}$). All males of the three breeds of cattle had higher haemoglobin values than their females.

Lymphocyte values showed significant differences among the breeds and in the interaction between the breeds and sexes but showed no significant ($p$>0.05) difference between the sexes. WF had the highest value (57.74±0.75 %) among the three breeds while SG had the lowest (56.33±2.03 %). The interaction between the breeds and sexes showed that female RB had the highest value (61.00±0.00 %) while male RB had the lowest value (55.33±0.33 %). The male WF had a significantly higher lymphocyte values (58.54 %) than the female WF (56.69 %) while both the RB and SG females had higher lymphocyte values than their males. Neutrophil values did not show any breed or sex differences but there were significantly different neutrophil values when the interaction between the sexes and breeds were taken into consideration. The male RB had (27.33±0.33 %) as the highest value and the lowest (22.00±0.00 %) for female RB

breed. The blood monocytes showed no significant difference among the breeds. The female cattle however had significantly higher monocyte values (9.27±0.27 %) than the males (8.93±0.25 %). The interaction between breed and sex showed that the male SG with (10.00±0.00 %) had the highest monocyte values while male WF had the lowest (8.81±0.33 %). Generally, all the animals had a high monocyte values than normal (3-5%).

Percentage eosinophil was significantly affected by breed and the interaction between the breed and sex. The breeds had (6.65±0.29 %), (6.25±0.85 %) and (7.00±0.58 %) for WF, RB and SG respectively. Between the sexes, females had (6.53±0.40 %) while the males had (6.73±0.32 %). Their interaction showed that male RB had the highest value (7.00±0.58 %) while female RB had the lowest value (4.00±0.00 %). Basophil values were significantly affected by breeds where RB had the highest value (1.75±0.48 %) and SG had the lowest value (1.00±0.00 %). The females had higher basophil values (1.67±0.22 %) than the males (1.40±0.13 %). In the interaction between breed and sex, female RB had the highest (3.00±0.00 %) followed by female WF (1.61±0.21 %) while male WF had (1.45±0.16 %), male RB had (1.33±0.33 %) while both the male and female SG had the lowest value (1.00±0.00 %).

**Red blood cell membrane stability**

Table 2 shows the values of osmotic fragility of red blood corpuscles (RBC) of the three cattle breeds prior to slaughter. It revealed a progressive increase in the number of red blood cells counted as the saline concentration increased from 0.00 % to 0.90 %. At 0.00 %, no red blood cell was counted when the breeds, sexes and their interactions were taken into consideration since the cells were completely haemolysed at 0.00 % saline concentration. At 0.10 % saline concentration, there were significant differences in osmotic fragility among the breeds with WF recording ($0.02\times10^6ml^{-1}$), RB ($0.03\times10^6ml^{-1}$) while SG had ($0.03\times10^6ml^{-1}$). This showed that SG and RB breeds were the least osmotically fragile breed at 0.10% saline concentration. Sex effect also showed significant difference at this saline concentration with the males recording ($0.02\times10^6ml^{-1}$ of RBC) while ($0.03\times10^6ml^{-1}$ of RBC) was recorded for the females. Their interaction showed that male WF at ($0.02\times10^6ml^{-1}$) was more osmotically fragile than the female WF ($0.03\times10^6ml^{-1}$); male RB ($0.03\times10^6ml^{-1}$) was equally more fragile than their females ($0.04\times10^6ml^{-1}$) while the male SG ($0.03\times10^6ml^{-1}$) were more osmotically resistant to lysis than their females ($0.02\times10^6ml^{-1}$). At 0.20 % saline concentration, there were statistically significant breed differences where WF, RB and SG had the value ($0.02\times10^6ml^{-1}$), ($0.05\times10^6ml^{-1}$) and ($0.3\times10^6ml^{-1}$) respectively but there were no significant differences between the sexes. The interaction between breeds and sexes produced significant difference only between the male and female SG breed. At 0.30 % saline concentration, there were significant differences in osmotic fragility among the breeds with values of $0.26\times10^6ml^{-1}$, $0.28\times10^6ml^{-1}$ and $0.24\times10^6ml^{-1}$ for WF, RB and SG respectively. Sexes however had no significant influence on the stability of the RBC at this saline concentration. Their interactions showed significant differences with male WF ($0.26\times10^6ml^{-1}$), male RB ($0.27\times10^6ml^{-1}$), male SG ($0.23\times10^6ml^{-1}$), female WF ($0.26\times10^6ml^{-1}$), female RB ($0.29\times10^6ml^{-1}$) and female SG ($0.25\times10^6ml^{-1}$) respectively. The red blood cells of females of both the RB and SG were more osmotically stable than their males at this saline concentration.

Statistical differences were observed at 0.40 % saline concentration among the breeds with RBC values of ($0.48\times10^6ml^{-1}$), ($0.52\times10^6ml^{-1}$) and ($0.40\times10^6ml^{-1}$) for WF, RB

and SG respectively. Values obtained for the two sexes were similar while the interaction between sex and breed showed that female RB had the highest value ($0.58\times10^6ml^{-1}$) while female SG had the lowest value ($0.40\times10^6ml^{-1}$) with statistical differences among the males and females of the breeds. At 0.50 % saline concentration, there were significant differences among the breeds where WF had ($4.07\times10^6ml^{-1}$), RB ($4.77\times10^6ml^{-1}$) and SG ($4.34\times10^6ml^{-1}$); and between the sexes where the males recorded $4.54\times10^6ml^{-1}$ while $3.84\times10^6ml^{-1}$ was recorded for the females. The interaction between breeds and sexes showed that male SG had the highest value ($5.12\times10^6ml^{-1}$) while female WF had the lowest value ($3.77\times10^6ml^{-1}$). A comparison of osmotic fragility from 0.50 % to 0.90 % saline concentration showed WF as the breed of cattle most susceptible to hypotonic salt concentration among the three cattle breeds. Also the male animals had a significantly better osmotic stability than the females beyond 0.50 % salt concentration. The interaction between the breeds and sexes within this range of saline concentration (0.50-0.90 %) showed that the male cattle switched from being more osmotically fragile to being more osmotically stable as saline concentration increased from 0.50 % to 0.90 %. At 0.90 % saline concentration, significant difference did not exist among the breeds but the sex difference showed that males had a significantly red blood cell counts ($9.63\times10^6ml^{-1}$) than the females ($8.52\times10^6ml^{-1}$). The interactions also showed significant differences where male RB had $10.12\times10^6ml^{-1}$ while the female RB had $6.83\times10^6ml^{-1}$ as the highest and lowest values respectively. It was generally observed that the RB breed had consistently the best osmotically stable RBC across all saline concentrations. The WF breed had the least osmotically stable RBC in the region of minimum osmotic fragility (saline concentration of 0.50 %) and also at the region beyond the maximum osmotic fragility (0.30 % saline concentration). Also the saline concentrations of minimum and maximum osmotic fragility for these breeds of cattle were established by this trial as 0.50 and 0.30 % saline concentration respectively.

**Blood viscosities of cattle sampled prior to slaughter at Akure abattoir**

The values of whole blood, serum and plasma viscosities for the three breeds of cattle sampled prior to slaughter at Akure abattoir are presented in Table 3. The Table showed that there were no significant ($p>0.05$) breed effects on whole blood viscosity. White Fulani (WF), Red Bororo (RB) and Sokoto Gudali had values of (3.07 cP), (3.26 cP) and (3.30 cP) respectively. There were significant sex effects ($p<0.05$) between the male (3.31cP) and the female (2.92 cP). The interaction between the sexes and breeds showed significant differences in which the male SG had the highest value (3.96 cP) followed by female RB (3.59 cP) while female WF had the lowest value (2.86 cP). The female RB had the highest whole blood viscosity (3.59 cP) while the female WF had the least (2.86 cP) among the female cattle. Also, the male SG breed had the highest whole blood viscosity (3.96 cP) while the male RB had the least (3.15 cP). The plasma viscosity showed significant ($p<0.05$) differences among the breeds where RB had the highest value (1.38 cP) while WF had lowest value (1.22 cP). Between the sexes, the male had (1.22 cP) while the female had (1.28 cP). However, the interactions between the breeds and sexes showed that female RB had the highest value (1.53 cP) while male WF had the lowest value (1.20 cP).Serum viscosity varied significantly among the breeds. RB had the highest value (1.54 cP) while SG had the lowest value (1.39 cP). Sex differences in serum viscosity showed that the males recorded (1.38 cP) while female had the highest value (1.50 cP). The interaction

between breed and sex were significantly different from each other. Female RB had the highest value (1.77 cP) and male WF had the lowest value (1.35cP).

**Table 2: Number of red blood cells counted at different saline concentrations in three breeds of cattle sampled prior to slaughtering**

| Source of variation | No of animals | Saline Concentration 0.00 | 0.10 | 0.20 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Breeds** | | | | | | | | | | | |
| **WF** | 46 | 0.00±0.00 | 0.02±0.002$^{b}$ | 0.02±0.001$^{c}$ | 0.26±0.004$^{b}$ | 0.48±0.009$^{a}$ | | 4.07±0.240$^{c}$ | 5.16±0.280$^{b}$ | 6.59±0.350$^{b}$ | 8.06±0.420$^{b}$ | 8.72±0.430 |
| **RB** | 8 | 0.00±0.00 | 0.03±0.005$^{a}$ | 0.05±0.006$^{a}$ | 0.28±0.016$^{a}$ | 0.52±0.044$^{a}$ | | 4.77±0.240$^{a}$ | 5.89±0.370$^{a}$ | 7.09±0.600$^{a}$ | 8.45±0.780$^{a}$ | 9.30±0.860 |
| **SG** | 6 | 0.00±0.00 | 0.03±0.003$^{a}$ | 0.03±0.003$^{b}$ | 0.24±0.009$^{c}$ | 0.40±0.010$^{b}$ | | 4.34±0.410$^{b}$ | 5.56±0.400$^{ab}$ | 7.22±0.460$^{a}$ | 8.52±0.330$^{a}$ | 9.33±0.620 |
| ***p*-values** | | | 0.02 | 0.02 | 0.02 | 0.04 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.87 |
| **Sex** | | | | | | | | | | | | |
| **Male** | 30 | 0.00±0.00 | 0.02±0.002$^{b}$ | 0.04±0.002 | 0.26±0.006 | 0.48±0.020 | | 4.54±0.200$^{a}$ | 5.77±0.240$^{a}$ | 7.20±0.310$^{a}$ | 8.72±0.330$^{a}$ | 9.63±0.300$^{a}$ |
| **Female** | 30 | 0.00±0.00 | 0.03±0.002$^{a}$ | 0.04±0.002 | 0.26±0.005 | 0.48±0.010 | | 3.84±0.310$^{b}$ | 4.82±0.350$^{b}$ | 6.23±0.460$^{b}$ | 7.60±0.550$^{b}$ | 8.08±0.570$^{b}$ |
| ***p*-values** | | | 0.02 | 0.10 | 0.10 | 0.22 | | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| **Breed x Sex** | | | | | | | | | | | | |
| **WF male** | 22 | 0.00±0.00 | 0.02±0.003$^{c}$ | 0.04±0.002$^{b}$ | 0.26±0.006$^{b}$ | 0.47±0.015$^{b}$ | | 4.40±0.250$^{c}$ | 5.61±0.320$^{b}$ | 7.06±0.410$^{b}$ | 8.62±0.430$^{a}$ | 9.48±0.400$^{b}$ |
| **WF female** | 24 | 0.00±0.00 | 0.03±0.003$^{b}$ | 0.04±0.002$^{b}$ | 0.26±0.006$^{b}$ | 0.49±0.011$^{b}$ | | 3.77±0.380$^{d}$ | 4.75±0.430$^{c}$ | 6.15±0.550$^{c}$ | 7.55±0.680$^{c}$ | 8.01±0.690$^{c}$ |
| **RB male** | 6 | 0.00±0.00 | 0.03±0.006$^{b}$ | 0.05±0.008a | 0.27±0.022$^{b}$ | 0.50±0.055$^{b}$ | | 4.85±0.320$^{b}$ | 6.20±0.280$^{a}$ | 7.63±0.360$^{a}$ | 9.12±0.580$^{a}$ | 10.12±0.340$^{a}$ |
| **RB female** | 2 | 0.00±0.00 | 0.04±0.003$^{a}$ | 0.05±0.001a | 0.29±0.010$^{a}$ | 0.58±0.010$^{a}$ | | 4.53±0.120$^{b}$ | 4.96±0.220$^{c}$ | 5.47±0.320$^{d}$ | 6.45±0.420$^{d}$ | 6.83±0.440$^{d}$ |
| **SG male** | 2 | 0.00±0.00 | 0.03±0.003$^{b}$ | 0.04±0.006$^{a}$ | 0.23±0.010$^{c}$ | 0.41±0.011$^{a}$ | | 5.12±0.150$^{a}$ | 6.22±0.230$^{a}$ | 7.51±0.350$^{a}$ | 8.66±0.400$^{a}$ | 9.84±0.440$^{a}$ |
| **SG female** | 4 | 0.00±0.00 | 0.02±0.004$^{b}$ | 0.03±0.004$^{b}$ | 0.25±0.010$^{b}$ | 0.40±0.015$^{c}$ | | 3.95±0.230$^{d}$ | 5.23±0.400$^{c}$ | 7.08±0.760$^{b}$ | 8.44±0.570$^{b}$ | 9.07±0.970$^{b}$ |
| ***p*-values** | | | 0.02 | 0.04 | 0.03 | 0.04 | | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 |

*$^{a, ab, b, c, d}$ = Means of the same column but with different superscripts are statistically ($P<0.05$) significant*

*WF = White Fulani; RB = Red Bororo; SG = Sokoto Gudali*

**Discussion**

The haematological parameters (Table 1) revealed that there were no breed and sex differences in the erythrocyte sedimentation rates among the three breeds of cattle - White Fulani (WF), Red Bororo (RB) and Sokoto Gudali (SG). This observation agrees with the findings of (15) on Keteku breed of cattle and with the reports of (9) and (16) on White Fulani and Kuri breeds of cattle respectively. These authors reported that there were no sex differences in the erythrocyte sedimentation rates of these breeds of cattle.

The values obtained on packed cell volume (PCV) were different among the three breeds of cattle and comparatively, males had higher PCV than the females. This conforms to what is obtained in the literature (17; 18) of sex differences in PCV values in different animal species in which higher values were recorded in males than in the females. The mean Red Blood Cells (RBC) were similar in WF, RB and SG and all of them fell within the range of values for cattle given by (19), while the RBC of males were significantly higher than those of females. Similarly, the RBC count of two different breeds of cattle (N'dama and White Fulani cattle) was reported to be similar (20). The red blood cell count of the three cattle breeds in this trial was also comparable to that reported by (1).

In the present study, there were sex differences in the total White Blood Cell (WBC) counts (Table 1). The WBC counts were however similar among the breeds and this agrees with the normal value of WBC that ranged between $11\text{-}22\times10^3$ $\mu l^{-1}$ (21) but a higher total WBC counts was however observed in the male than the female. This is in consonance with the work of (22; 23) who observed a higher total WBC counts in the males than in the females goats and donkeys respectively. The values obtained for WBC in this study were however higher than those reported for cattle by (1). A case of leucocytosis was therefore observed in these cattle breeds. This might not be unconnected with the trauma of transportation, bad lairage facilities at the abattoir, reported cases acute inflammation and heavy parasitic loads of Nigerian cattle population (24) all of which contribute to the high WBC values. Jain (1) also reported on physiologic leucocytosis as a result of epinephrine response. The slaughter procedure at most of the abattoirs in Nigeria in which the butcher brandishes the killer knife in the full view of the cattle would have elicited fear and a rapid epinephrine surge in the animals and the concomitant leucocytosis that followed. This is also reflected in the upper range of lymphocytes (56.33-61.00 %) in all the cattle investigated. The average value of lymphocyte in cattle is 58%. Leucocytosis is common in young animals and is often triggered by emotional and physical disturbances (1).

The Hb values were significantly higher in the male cattle than the female cattle but have similar values among the breeds of WF, SG and RB cattle. It was reported that the Kuri breed of cattle has higher PCV and Hb values than the White Fulani breed of cattle (16). It seems that the higher the Hb and ESR in the RB cattle than in the WF and SG in the present study may be due to breed differences. In this study, the values obtained for neutrophil and monocyte did not vary significantly among the breeds of WF, RB and SG. The values obtained between sexes (male and female) were not equally significantly different from each other. There were clear differences in the interactions between the breeds and sexes. The male WF had higher lymphocyte values than their females while the male RB and SG had lower values than their females. All the cattle breeds had elevated monocyte values than normal since elevated monocyte values (monocytosis) is an evidence of reaction to fear as occasioned by epinephrine surge (1), the female cattle were more fretful than the

males because of the significantly higher monocytes in the females (9.27±0.27 %) than in the males (8.93±0.25 %). The equally elevated monocyte values in the animals however made the classification of leucocytosis exhibited by the animals to be of stress-induced origin or corticosteroid-induced leucocytosis (1). Such leucocytosis are characterised by monocytosis and eosinopaenia as observed in all the pre-slaughtered animals. In terms of composure or temperament, the female SG is more composed than its male counterpart in the face of perceived danger to life because of their lower monocyte values. The relative reactions of these animals to the pre-slaughter fear-induced stressors could go a long way to affect the carcass quality of their meat. For instance, the concomitant epineprine surge as a result of fear could predispose the carcass to DFD (dark firm and dry carcass) because of the drastic reduction in the muscular glycogen reserves prior to slaughter.

The values obtained for percentage of red blood cells haemolysed per saline concentration among the breeds, between the sexes and their interaction showed that there was progressive decrease in the number of RBCs haemolysed as the saline concentration decreased from the isotonic 0.90 % NaCl to 0.00 % NaCl, in accordance with the work of (25). The maximum osmotic fragility was observed at 0.30 % saline concentration for all the breeds while the minimum osmotic fragility was recorded at 0.50 % for the three breeds. This was similar to the work of (26) who gave the maximum and minimum resistance of pig's RBC to osmotic fragility between 0.29 and 0.52 % saline concentration. The range of value between the minimum and maximum resistance to osmotic fragility is often as a result of breed and sex differences, blood pH and diseases (27). Observation on the effect of sex on osmotic fragility showed that the male animal had numerically higher values than the female at higher saline concentrations especially between 0.50-0.90 % saline concentration while females had higher values and hence better osmotic stability than the males at lower saline concentration.

**Table 3: Blood viscosities (cP) of three breeds of cattle sampled prior to slaughter.**

| Source of variation | Number of animals | Whole blood iscosity (cP) | Plasma viscosity (cP) | Serum viscosity (cP) |
|---|---|---|---|---|
| Breeds | | | | |
| WF | 46 | 3.07±0.11 | 1.22±0.04$^{b}$ | 1.43±0.05$^{a}$ |
| RB | 8 | 3.26±0.21 | 1.38±0.12$^{a}$ | 1.54±0.13$^{a}$ |
| SG | 6 | 3.30±0.44 | 1.32±0.06$^{a}$ | 1.39±0.15$^{b}$ |
| p-values | | 0.79 | 0.03 | 0.03 |
| Sex | | | | |
| Male | 30 | 3.31±0.11$^{a}$ | 1.22±0.04 | 1.38±0.03 |
| Female | 30 | 2.92±0.14$^{b}$ | 1.28±0.65 | 1.50±0.69 |
| p-values | | 0.03 | 0.81 | 0.72 |
| Breed x Sex | | | | |
| Male WF | 22 | 3.29±0.13$^{a}$ | 1.20±0.44$^{b}$ | 1.35±0.03$^{b}$ |
| Female WF | 24 | 2.86±0.16$^{b}$ | 1.24±0.08$^{b}$ | 1.50±0.29$^{b}$ |
| Male RB | 6 | 3.15±0.25$^{b}$ | 1.32±0.16$^{b}$ | 1.46±0.14$^{b}$ |
| Female RB | 2 | 3.59±0.26$^{a}$ | 1.53±0.06$^{a}$ | 1.77±0.04$^{a}$ |
| Male SG | 2 | 3.96±0.14$^{a}$ | 1.21±0.08$^{b}$ | 1.40±0.06$^{b}$ |
| Female SG | 4 | 2.98±0.52$^{b}$ | 1.38±0.55$^{b}$ | 1.39±0.25$^{b}$ |
| p-values | | 0.02 | 0.02 | 0.02 |

*$^{a, b}$ = Means in the same column but with different superscripts are statistically (P<0.05) significant.*
*WF = White Fulani; RB = Red Bororo; SG = Sokoto Gudali; cP = centiPoise.*

Table 3 shows the value of whole blood, plasma and serum viscosities of the three cattle breeds. The values obtained for whole blood showed that SG had the highest whole blood viscosity value than the RB and WF breeds although there was no significant difference ($P>0.05$) among the breeds. The RB breed had the highest values for plasma and serum viscosities with significant differences among the breeds. The values showed that the male animals had higher whole blood but lower plasma and serum viscosities value than the female animals. This is in agreement with previous experiment on the blood viscosity of cattle, sheep, rabbit and mouse (28). The values of the blood plasma and serum viscosity were lower when compared with the viscosity of the whole blood because the formed element (Haematocrit) that would have made them more viscous had been removed by centrifugation. Also the blood plasma had the least viscosity among the three blood viscosities considered.

On the effect of breed versus sex, the male SG had the most viscous whole blood while the male RB had the most viscous plasma and serum viscosities. The female RB had the most viscous whole blood, blood plasma and blood serum. Only the female RB had a more viscous whole blood than their males while all the female breeds had higher blood plasma viscosity than their males. This is because all the males in the three breeds had higher haematocrit, RBC and WBC (the formed elements) than the females, the removal of all these from the blood plasma of the males relative to the females would make the blood plasma of the male less viscous. A higher blood serum viscosity in the males than in females was only recorded in the SG breed. The implications of high blood viscosity are symptomatic of acute phase reaction or severe inflammatory response (29). A lot of pressure is put on the heart to pump blood to all the arteries in the face of high blood viscosity and thus may injure the inner linings of the arteries and affect the delivery of oxygen to the organs and tissues in the body. Aro *et al*. (10) reported lowered whole blood viscosity in cockerels fed graded levels of fermented cassava tuber wastes, an indication that the processing of cassava tuber wastes through fermentation may help in ameliorating blood values like high viscosities in livestock.

**Conclusion and Applications**

1. All the three breeds of cattle showed elevated pre-slaughter WBC values than normal, probably ascribable to the trauma of transportation, bad lairage facilities at the abattoir and the inhumane slaughter methods and the possible heavy parasitic load of Nigerian cattle population.
2. A case of pre-slaughter leucocytosis due to fear response was observed in these animals. This fear induction and the accompanying leucocytosis could predispose the carcass to dark, firm and dry meat (DFD) upon slaughter.
3. The composite cattle population also had elevated pre-slaughter monocyte values, a case of clinical monocytosis-an evidence of reaction to fear which is normally accompanied by epinephrine surge.
4. The higher monocyte values in the female than in the male cattle is therefore suggestive of more fretful disposition of the females than the male cattle.
5. This trial established minimum and maximum osmotic stability of 0.50 and 0.30 % for this composite cattle population.

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