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Genetic Variations in Haematological Indices of Local and Exotic Turkeys Inoculated with Attenuated *Salmonella typhimurium* Vaccine

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Authors' contributions

This work was carried out in collaboration among all authors. Author BMI conceived and supervised the experiment. Author MOO design the experiment. Author ODO carried out the experiment and wrote the original draft. Authors AJA and CEI review and edit the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Infection due to *Salmonella spp* is one of the threatening diseases to poultry industry because it can cause economic losses through mortality, morbidity and reduction in egg production. One hundred and sixty poults comprising 80 local and 80 exotic (Nicholas white) were used to examine the variations in haematological response to *Salmonella spp* in local and exotic turkeys inoculated with attenuated *Salmonella spp.* Both genotypes were reared separately on deep litter, under the same management practices and wing tagged for proper identification. At 7th week of age, 1ml of blood sample was collected from each turkey into anticoagulant tubes and labeled accordingly for base-line

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haematological analysis. The turkeys were inoculated at 8th week by subcutaneous injection of attenuated *Salmonella* vaccine at 0.5ml per turkey. On the 2nd and 7th days after inoculation, 1ml of blood samples was collected from each turkey for haematological analyses. The un-coagulated blood was used to determine packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC) and its differential counts, and haemoglobin (Hb). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated. The haematological data collected were analyzed using General Linear Model of SAS 9.0 software. The exotic turkey had higher ($p<0.05$) values of PCV (38.13±1.01), Hb (12.77±0.33gd/l), MCV (133.39±0.14fL) and MCH (43.35±1.27pg/cell) before inoculation. On 2nd day post inoculation, the local turkey had higher ($P<0.05$) values of PCV (43.93±1.40%), RBC (3.98±0.12 $10^6 \mu l^{-1}$) and Hb (14.56±0.47gd/l). Also, on the seventh day post inoculation, the local turkey had higher ($P<0.05$) values of PCV (42.13±1.20%), WBC (11.94±0.62 $10^3.\mu^{-1}$), Hb (14.09±0.38 gd/l) and MCH (40.65±0.34pg/cell). The mean values of PCV, Hb, MCV, MCH and MCHC of local turkeys were higher ($p<0.05$) on the 7th day than on the 2nd day post inoculation, while the RBC was higher ($P<0.05$) on the 2nd day post inoculation. The WBC, MCV and MCH values were higher ($p<0.05$) in exotic turkey on the 2nd day post inoculation. The local turkey showed quick haematological response to *Salmonella* vaccine especially post inoculation. Therefore, the local turkey could be said to have stronger potential to survive under disease prevailing environment than the exotic turkey.

Keywords: Post inoculation; pre inoculation; Local Turkey; Exotic Turkey; haematology; Salmonella spp; inoculation.

1. INTRODUCTION

The demand for turkey in Nigeria is far more than its supply due to its low production [1]. Among various factors limiting turkey production in Nigeria, outbreak of infectious disease poses more threats. This is because economic losses resulting from high mortality and morbidity of diseases are usually high. Also, information on turkey production and disease is rare in Nigeria, possibly because turkeys are seldom raised commercially [2]. Most of the diseases that affect poultry can be seen in turkey as poultry bird and these ranges from viral to bacterial and parasitic infection [2]. Several bacterial diseases that affect poultry are apparent in turkey, including *Escherichia coli,* fowl cholera, infectious coryza, Mycoplasma and salmonellosis [3].

Ricardo [4] revealed salmonellosis as one of the threatening diseases to poultry industry probably because it can contaminate poultry products thereby causing food poisoning in human being. There are more than 2,000 species or serotypes of bacteria belonging to genus *Salmonella;* all are potential pathogens of poultry [5]. *Salmonella* are gram negative enterobacteria which affect mammals and domestic fowl around the world.

Two serotypes (*Samonella* Gallinarum and *Samonella* Pullorum) are recognized in poultry to produce clinical *Salmonellosis* [4]. Pullorum disease and fowl typhoid are infectious, acute or chronic bacterial diseases affecting primarily chickens and turkeys. They may cause economic losses through mortality, morbidity and reduction in egg production [6]. Some common clinical signs in chicks and poults include anorexia, diarrhoea, dehydration, weakness and high mortality while in mature fowl decreased egg production, fertility, hatchability, anorexia and increased mortality. The major preventive measures include vaccination, use of antibiotics and other drugs. However, it has been reported that frequent and indiscriminate uses of antibiotics and vaccines often cause resistance to pathogens and also, increase health risk in man through consumption of antibiotic residues in poultry [7]. In addition, vaccines and antibiotics have not been able to completely prevent and eliminate the bacteria in poultry industry.

The use of genetic control in the resistance to salmonellosis in chicken was reported by [8]. It was suggested that some strains of chickens are more genetically susceptible or resistant to infection with *Salmonella* than others [8] and this is majorly attributed to cell-mediated immunity [9]. Therefore, the best alternative approach for the control of salmonellosis in poultry could be based on the use of disease resistant breeds.

Among various physiological assessment of health status of birds, haematological assessments are being used as one of the bases for diagnosis of avian diseases [10], monitoring recovery during treatment and assessment of the health status of a single bird or entire flock [11].

Haematological parameters refer to those components associated with blood and body fluids. The values of haematological parameters in domestic and wild birds could be important sources of information with valuable diagnostic significance because they could provide a baseline for studying the health status, and enhance the correct diagnosis in different pathological states [12]. Moreover, they can also be used to detect stress caused by various factors, such as environmental, nutritional, and pathological aspects [13]. Most importantly, through haematological analyses, information about the immunological status of an individual can be obtained and can serve as diagnostic tools in the development of a presumptive diagnosis [14] to evaluate the individual response to its internal and external environment [15]. Thus, haematological studies are of ecological and physiological interest in helping to understand the relationship of blood characteristics to the environment [16] and so could be useful in the selection of animals that are genetically resistant to certain diseases and environmental conditions [17,18].

Nigerian indigenous turkeys (local turkeys) are generally hardy, tolerant to most of the diseases of turkey in tropical region, can survive on low nutrient feed resources and best adapted to prevailing tropical climatic conditions [19]. However, their productivity is relatively low probably because they were only selected naturally to adapt to the tropical environment [20]. The exotic turkeys on the other hand are not as hardy as the indigenous turkeys and thus have lower rate of survivability in the tropical environment. However, they are peculiar for their body weight and early maturity probably because they have been selected for efficient feed utilization and higher weight gain in the temperate region [20]. There is paucity of information on haematological response of local and exotic turkeys. This study therefore aimed to compare haematological response of local and exotic turkey to *Salmonella* vaccine, which could eventually form part of baseline records for selection of improved breeds of turkeys in tropical environment.

2. MATERIALS AND METHODS

2.1 Description of Experimental Site

This research was carried out at the Turkey Breeding Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Alabata road, Abeokuta, Ogun state Nigeria. The farm location is 76 metre above sea level and falls within latitude $7^{o}15^{1}$N and longitude $3^{o}25^{1}$E. It is in Odeda Local Government area of Ogun state, Nigeria. It experiences approximately eight months of rainfall (usually from March to October), with a mean annual precipitation of 1,037mm. The monthly ambient temperature ranges from 25.1°C in August to 29.1°C in March with a mean relative humidity of 82% [21].

2.2 Management of Experimental Birds

A total of one hundred and sixty (160) turkeys comprising two genotypic groups including 80 local (Nigerian indigenous) and 80 exotic (Nicholas white) were used for this study. The two breeds (indigenous and Nicholas White) were purchased at day old from reputable hatchery in Ibadan, Oyo State Nigeria. Brooding was done for four weeks, during which adequate heat, ventilation, medication and feeding were provided. The poults were vaccinated against Marek's disease, Newcastle disease and infectious bronchitis at day old from the hatchery. Subsequent vaccinations including, Newcastle disease vaccine and Fowl pox vaccine were given at appropriate time. Broad spectrum antibiotics was administered as prophylactic as required. The two genotypes were reared separately in deep litter pens. All the experimental birds were wing tagged for proper identification and subjected to the same management practices throughout the experimental period of 9 weeks.

The birds were provided access to feed and water *ad libitum*. They were fed starter ration containing about 28% crude protein and 2860Kcal/MEkg of metabolizable energy from day old to six (6) weeks of age. This was followed by grower mash of 24% crude protein and 2850Kcal/MEkg of metabolizable energy.

2.3 Data Collection

Blood samples (1ml) were collected from the experimental birds at 7^{th} week of age, before the birds were inoculated with attenuated *Salmonella* (*Salmonella* disease vaccine) for base line haematological study and also at 2^{nd} day and 7^{th} day after inoculation. The blood samples were collected with sterile needle and syringe from the wing veins and transferred into tubes containing ethylene diamine tetra acetic acid (EDTA) as an anticoagulant and labeled accordingly. The un-

coagulated blood was used to determine packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC) count, Heterophil (HET), lymphocyte (LYM), Monocyte (MON) and Basophil (BAS). The packed cell volume (PCV) was measured by a microhematocrit capillary tube using a Hematocrit reader [22]. Erythrocyte concentration (RBC), haemoglobin (Hb) and leucocytes concentration (WBC) counts were measured using an automated cell counter within 24 hours after collection of blood [23]. The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were also calculated [24]. The formulae used are:

MCV in femrolitres (fL) = 10 x PCV (%)/RBC counts (millions/µl).

MCH in pg/cell= haemoglobin (g/ 100 ml)/ RBC counts (millions/µl).

MCHC in g/dl= haemoglobin (g/ 100 ml) x 100/PCV (%)

2.3.1 Inoculation with *Salmonella* disease vaccine

Salmonella disease vaccine was purchased from National Veterinary Research Institute (NVRI), Vom Nigeria. At 8 weeks of age, the experimental turkeys were inoculated with *Salmonella* disease vaccine. This was done by subcutaneous injection of *Salmonella* disease vaccine at 0.5ml (LD_{50}) per turkey as recommended by the manufacturer.

2.4 Statistical Analysis

The haematological data obtained were transformed using logarithmic transformation ($Log_{10}x+1$) and thereafter analyzed for the effects of turkey genotype and post inoculation time of measurement. The analyses were done by using analysis of variance (ANOVA) using the General Linear Model (GLM) of the Statistical Analysis System, SAS 9.0 software (SAS Institute Inc., Cary, NC, USA). The model is:

$$Y_{ij} = \mu + A_j + \varepsilon_{ij}$$

Where: Y_{ij} is the haematological variables; µ is the population mean; A_j is the effect of i^{th}; genotype (i=1, 2) on haematological parameter and ε_{ij} is the residual error.

3. RESULTS

Mean values of haematological parameters of turkey as affected by genotype Pre and Post inoculation with Salmonella disease vaccine.

The mean values of haematological parameters of turkeys pre and post inoculation with *Salmonella* disease vaccine as affected by genotype is shown in Tables 1, 2 and 3. The Packed cell volume (PCV), Haemoglobin concentrate (Hb), Mean corpuscular volume (MCV) and Mean Corpuscular Haemoglobin (MCH) were significantly affected (P<0.05) by turkey genotypes before inoculation with the vaccine, with the exotic turkey having the higher mean values of PCV, HB, MCV and MCH. Conversely, the PCV, RBC (Red Blood Cell) and HB were significantly higher (P<0.05) in local turkeys 2nd day post inoculation with the vaccine, although MCV and MCH were significantly (P<0.05) higher in exotic turkeys 2nd day post inoculation (Table 2). Furthermore, at seventh day post inoculation, the local turkeys have significantly (P<0.05) higher values of PCV, WBC (White Blood Cell), HB, MCV and MCH (Table 3). Although, the WBC in local turkeys pre inoculation was not significantly (P>0.05) different from that of exotic turkeys, however, at seventh day post inoculation, the local turkeys have significantly (P<0.05) higher WBC ($11.94\pm0.62\ 10^3.\mu^{-1}$), than the exotic turkey ($9.27\pm0.54\ 10^3.\mu^{-1}$).

Haematological response of Local and exotic turkeys as affected by time of response (pre and post inoculation with Salmonella disease vaccine).

The haematological parameters of local and exotic turkeys before inoculation two days post inoculation and seven days post-inoculation are presented in Tables 4 and 5. It was observed that time (pre and post inoculation) had significant (P<0.05) effect on response of PCV, RBC, Hb, MCH and MCHC of local turkey genotype to *Salmonella* disease vaccine. The PCV, RBC and Hb were significantly (P<0.05) higher in local turkeys genotype at 2nd day and seventh days post inoculation than pre inoculation (Table 4). The HET, LYM, MON, EOS and BAS of local turkeys were not significantly (P>0.05) affected by time (pre and post inoculation with *Salmonella* disease vaccine). However, the EOS and BAS increased in local turkeys seventh day post inoculation as compared to their values before inoculation (i.e. from 0.77±0.16% and 1.10±0.15% to 0.97±0.17% and 1.37±0.16% respectively). The mean corpuscular haemoglobin concentration (MCHC) value of local turkeys at seventh day post inoculation (33.51±0.13g/dl) was higher than the value (33.27±0.12g/dl) before inoculation even though it was not significant (P>0.05).

Similarly, the WBC, RBC, MCV and MCH of exotic turkey genotype were significantly (P<0.05) affected by time (pre and post inoculation with *Salmonella* disease vaccine) Table 5. The WBC, MCV and MCH of exotic turkey were significantly higher before inoculation than seventh day post inoculation while no significant effect was observed in WBC, MCV and MCH before and 2nd days post inoculation. Conversely, the RBC of exotic turkey was significantly (P<0.05) higher seventh day post inoculation than before and 2nd days post inoculations.

4. DISCUSSION

The result of haematological profile of local and exotic turkey genotypes in the current study showed that the haematological parameters of turkeys were influenced by genotypes both pre and post inoculation with *Salmonella* disease vaccine.

The higher PCV recorded in exotic turkey than local turkey before inoculated with *Salmonella* disease vaccine disagreed with the report of [25] that local turkey had higher PCV than the crossbred and exotic turkeys. This could be attributed to high feed intake in exotic turkey since PCV is correlated with nutritional status as reported by [25] and exotic turkeys have been bred for improved body weight and high efficiency of feed intake and utilization [20]. The value of PCV obtained for both local and exotic turkeys before inoculation were within the range of values (39.77±0.46) for matured turkey as reported by [26] and (30.66±0.91) reported by [27] in Indian turkey. [28] also reported normal

Table 1. Mean values of haematological parameters of turkey as affected by genotype before inoculation with *Salmonella* disease vaccine

Haematological parameters	Genotype	
	Local turkey	Exotic turkey
Packed Cell Volume (%)	33.20±1.31^{b}	38.13± 1.01^{a}
White Blood Cells (10^3.µl^{-1})	11.21± 0.79	12.17± 0.72
Red Blood Cell (10^6µl^{-1})	2.95± 0.12	2.87± 0.10
Heterophils (%)	29.90±1.29	31.53±1.36
Lymphocytes (%)	67.03± 1.23	65.33± 1.35
Monocytes (%)	1.50± 1.19	1.03± 2.00
Eosinophils (%)	0.77± 0.16	0.97± 0.14
Basophils (%)	1.10± 0.15	1.23± 0.16
Haemoglobin gdl^{-1})	11.05± 0.44^{b}	12.77± 0.33^{a}
Mean Corpuscular Volume (fL)	131.33± 0.08^{b}	133.39± 0.14^{a}
Mean Corpuscular Haemoglobin (pg/cell)	37.30± 0.14^{b}	43.35± 1.27^{a}
Mean Corpuscular Haemoglobin Concentration (g/dl)	33.27± 0.12	33.6± 0.17

Means in the same row with different superscripts (a,b) are significantly different (P<0.05)

Table 2. Mean values of haematological parameters of turkey as affected by genotype at 2nd day post inoculation with *Salmonella* disease vaccine

Haematological parameters	Genotype	
	Local turkey	Exotic turkey
Packed Cell Volume (%)	43.93± 1.40^{a}	35.93± 1.10^{b}
White Blood Cells (10^3.µl^{-1})	10.86± 0.56	10.87± 1.10
Red Blood Cell (10^6µl^{-1})	3.98± 0.12^{a}	2.85± 0.10^{b}
Heterophils (%)	33.57± 1.57	30.63± 1.21
Lymphocytes (%)	63.33± 1.60	66.20± 1.22
Monocytes (%)	1.33± 0.19	1.23± 0.17
Eosinophils (%)	0.73± 0.14	0.93± 0.16
Basophils (%)	1.03± 0.16	1.10± 0.16
Haemoglobin gdl^{-1})	14.56± 0.47^{a}	12.00± 0.37^{b}
Mean Corpuscular Volume (fL)	131.19± 0.16^{b}	133.12± 0.21^{a}
Mean Corpuscular Haemoglobin (pg/cell)	36.57± 0.53^{b}	42.55± 0.40^{a}
Mean Corpuscular Haemoglobin Concentration (g/dl)	33.13± 0.11	33.43± 0.23

Means in the same row with different superscripts (a,b) are significantly different (P<0.05)

Table 3. Mean values of haematological parameters of turkey as affected by genotype at 7th day post inoculation with *Salmonella* disease vaccine

Haematological parameters	Genotype	
	Local turkey	Exotic turkey
Packed Cell Volume (%)	42.13±1.20[a]	36.47±1.64[b]
White Blood Cells ($10^3.\mu l^{-1}$)	11.9± 0.62[a]	9.27± 0.54[b]
Red Blood Cell ($10^6\mu l^{-1}$)	3.36± 0.10	3.33± 0.10
Heterophils (%)	29.57±1.34	32.90±1.39
Lymphocytes (%)	65.47±1.58	63.57±1.37
Monocytes (%)	1.17±0.19	1.23±0.18
Eosinophils (%)	0.97±0.17	1.17±0.18
Basophils (%)	1.37±0.16	1.13±0.14
Haemoglobin gdl^{-1})	14.09±0.38[a]	12.28±0.37[b]
Mean Corpuscular Volume (fL)	132.59±0.19[a]	130.91±0.08[b]
Mean Corpuscular Haemoglobin (pg/cell)	40.65±0.34[a]	36.63±0.32[b]
Mean Corpuscular Haemoglobin Concentration (g/dl)	33.51± 0.13	33.53± 0.14

Means in the same row with different superscripts (a,b) are significantly different (P<0.05)

range of PCV for chicken as (22-35 %). Thus, the values of PCV obtained in the current study for both local and exotic turkeys indicate that they were healthy before inoculated with *Salmonella* disease vaccine. More so, the PCV of both genotypes were influenced by *Salmonella* disease vaccine but the local turkey significantly had higher PCV after inoculation than the exotic turkey. This suggested better feed utilization in local turkey and hence better adaptation to low input and disease prevalent environment. [29] obtained similar result in broilers and local chicken. The authors found out that the PCV of local chicken was higher than that of broilers after exposure to *Eimera* parasites.

The WBC functions mainly in the protection of the body from pathogen [30]. The WBC value of exotic turkey was higher than that of local turkey before inoculation. This may indicate the presence of pathogen in exotic turkey and also suggests the strong adaptive potential of local turkey to the tropical environment; however, the WBC of exotic turkey came down after inoculation with *Salmonella* disease vaccine while that of local turkey went up following inoculation. Since the major functions of the WBC and its differentials are to fight infections, defend the body by phagocytosis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response [31]. Therefore, it could be said that *Salmonella* disease vaccine induces the activation of immune cells rapidly in local turkeys than in exotic turkeys in the current study. According to [32], animals with low WBCs are exposed to high risk of disease infection, while those with high WBCs are capable of generating antibodies and display high degree of resistance to infectious diseases [32] and hence high adaptability to local environmental and disease prevalent conditions [18; 33; 34; 35]. Thus, it suggests better ability of local turkey to respond quickly to infectious diseases. However, the values of WBC obtained for both genotypes were higher than the values reported by [25] but lower than the values reported by [36] for male and female turkeys.

Moreover, the value of RBC was higher in local turkey than in exotic turkey before and after inoculation with *Salmonella* disease vaccine but the values increased in both genotypes after inoculation. The values of RCB were greatly influenced by the *Salmonella* disease vaccine which implied better cellular respiration and metabolism in both genotypes. The function of RBC is to transport oxygen from the lungs to tissues and remove carbon dioxide from the tissues to the lung in the body via haemoglobin [36]. Higher RBC values obtained in local turkey than in exotic turkey imply better chances of healthy living and interaction with the environment in the former. However, the values of RBC obtained for both genotypes in the current study fell within the physiological range (2.5 - 3.5 x106 µl) reported by [28] on chicken and (2.28 - 2.81) reported by [37] on turkey.

The Hb, MCV and MCH values were higher in local turkey after inoculation with *Salmonella* disease vaccine than in exotic turkey. The Hb helps to transport oxygen from the lungs round the body and remove carbon dioxide from the body to the lungs, the MCV is used to calculate the average erythrocyte size while the MCH is

Table 4. Haematological response of Local turkey genotype as affected by time of response (pre and post inoculation with *Salmonella* disease vaccine)

Time of collection of blood	Pre inoculation	2nd day post inoculation	7th day post inoculation
Packed Cell Volume (%)	33.20±1.31^{b}	43.93±1.40^{a}	42.13±1.20^{a}
White Blood Cells ($10^3.\mu l^{-1}$)	11.21± 0.79	10.86± 0.56	11.94± 0.62
Red Blood Cell ($10^6\mu l^{-1}$)	2.95± 0.12^{c}	3.98± 0.12^{a}	3.36± 0.10^{b}
Heterophils (%)	29.90±1.29	33.57±1.57	29.57±1.34
Lymphocytes (%)	67.03±1.23	63.33±1.60	65.47±1.58
Monocytes (%)	1.50± 1.19	1.33± 0.19	1.17± 0.19
Eosinophils (%)	0.77± 0.16	0.73± 0.14	0.97± 0.17
Basophils (%)	1.10± 0.15	1.03± 0.16	1.37± 0.16
Haemoglobin (gdl^{-1})	11.05± 0.44^{b}	14.56± 0.47^{a}	14.09± 0.38^{a}
Mean Corpuscular Volume (fL)	131.33± 0.08^{b}	131.19± 0.16^{b}	132.59± 0.19^{a}
Mean Corpuscular Haemoglobin (pg/cell)	37.30± 0.14^{b}	36.57± 0.53^{b}	40.65± 0.34^{a}
Mean Corpuscular Haemoglobin Concentration (g/dl)	33.27± 0.12^{ab}	33.13± 0.11^{b}	33.51± 0.13^{a}

Means in the same column with different superscripts (a, b, c) are significantly different (P<0.05)

Table 5. Haematological response of Exotic turkey genotype as affected by time of response (pre and post inoculation with *Salmonella* disease vaccine)

Time of collection of blood	Pre inoculation	2nd day post inoculation	7th day post inoculation
Packed Cell Volume (%)	38.13±1.01	35.93±1.10	36.47±1.64
White Blood Cells ($10^3.\mu l^{-1}$)	12.17± 0.72^{a}	10.87± 1.10^{ab}	9.27± 0.54^{b}
Red Blood Cell ($10^6\mu l^{-1}$)	2.87± 0.10^{b}	2.85± 0.10^{b}	3.33± 0.10^{a}
Heterophils (%)	31.53±1.36	30.63±1.21	32.90±1.39
Lymphocytes (%)	65.33±1.35	66.20±1.22	63.57±1.37
Monocytes (%)	1.03± 2.00	1.23± 0.17	1.23± 0.18
Eosinophils (%)	0.97± 0.14	0.93± 0.16	1.17± 0.18
Basophils (%)	1.23± 0.16	1.10± 0.16	1.13± 0.14
Haemoglobin (gdl^{-1})	12.77± 0.33	12.00± 0.37	12.28± 0.37
Mean Corpuscular Volume (fL)	133.39± 0.14^{a}	133.12± 0.21^{a}	130.91± 0.08^{b}
Mean Corpuscular Haemoglobin (pg/cell)	43.35± 1.27^{a}	42.55± 0.40^{a}	36.63± 0.32^{b}
Mean Corpuscular Haemoglobin Concentration (g/dl)	33.69± 0.17	33.43± 0.23	33.53± 0.14

Means in the same column with different superscripts (a, b, c) are significantly different (P<0.05)

used to measure haemoglobin amount per blood cell [28]. The reduction in Hb, MCV and MCH values in exotic turkey after inoculation suggests that, the adaptation of exotic turkey is related to reduction in cellular oxygen requirements [38] in order to adjust to environmental stressors such as disease condition. The values of MCHC observed for both local and exotic turkeys were reduced 2nd post inoculation even though the MCHC of both genotypes did not differs significantly both pre and post inoculation. However, the MCHC of local turkey tends to increase at seventh day after inoculation while that of exotic turkey was not, which implies quicker and better adaptability of local turkey to the prevailing environmental conditions. This is because MCHC is normally used to know the amount of haemoglobin relative to the size of the cell per red blood cell [28]. More so, decrease in MCHC is associated with iron deficiency (anaemia) [39], which is an indication of diseased condition and poor adaptability. Thus, through haematological analysis, it can be deduced from the current study that, the local turkey has better chance to adapt and survive to/in harsh and disease prevalent environment than exotic turkey.

Times of response (pre and post inoculation with *Salmonella* disease vaccine) significantly influenced the haematological parameters of both local and exotic turkeys, although they were within the normal range as specified by [37]. The PCV, RBC and HB values in local turkey were influenced by *Salmonella* disease vaccine, with the more effects on the 2nd day of inoculation than 7th day. This suggests that post inoculation time play a significant role in the haematological response of local turkey to *Salmonella* disease vaccine. This result confirmed the findings of [40] who observed differences in post vaccination times of response of haematological parameters of chicken. The WBC, LYM, MON, EOS and BAS decrease on the 2nd day of vaccination but (with the exception of LYM) increased on the 7th day after inoculation. The decrease in WBC, LYM, MON, EOS and BAS on day 2 after inoculation is expected because the vaccine could have created imitation infection which have initial adverse effects on WBC (also called macrophages), which is normal for the building of immune cells. Also, increase in WBC, MON, EOS and BAS on the 7th day after inoculation could be as a result of stimulation of immune response cell by *Salmonella* disease vaccine which suggests that a slight inflammation could have taken place, which would have enhanced secondary immunity. [41] also obtained similar result on WBC, LYM, MON, EOS and BAS of piglets vaccinated with Resveratrol Dry Suspension. [42] also reported higher LYM and MON in female turkey vaccinated with commercial strain of Newcastle disease vaccine. The MCV, MCH and MCHC increased progressively on the 2nd day and 7th day after inoculation of local turkeys with *Salmonella* vaccine. However, this did not agree with the findings of [43] who reported decrease in MCV and MCH of rabbit after inoculation with Haemorrhagic Disease virus (HDV). This may be attributed to differences in vaccines and species of animal used.

On the other hand, the exotic turkey showed varied times response of haematological parameters (pre and post inoculation) to *Salmonella* disease vaccine. The WBC, MCV and MCH progressively decrease in values from pre inoculation period to 7th day post inoculation. The PCV decreased on the 2nd day of inoculation but increased on the 7th day. However, the values were still within the normal range (7.70 - 17.40, 133.08 - 163.79, 34.34 - 51.77, 35.00 - 39.00 for WBC, MCV, MCH and PCV respectively) reported by [37]. The decrease in WBC in exotic turkeys may be inimical to their health as WBC is the component of blood that helps to confer immunity against pathogens. This may imply that exotic turkey can easily be brought down by infectious diseases and thus connotes poor adaptation to disease prevalent environment. Further, the RBC, HB, HET, EOS, BAS and MCHC values in exotic turkey decrease on the 2nd day but increase on the 7th day post inoculation. The initial decrease in the level of HB, HET, EOS and BAS may be normal, because the vaccine needs some time for immuno-conversion before it can proffer protection, while increase in their levels on the 7th day post inoculation is an evidence that immunological memory has been built which would enable the immune cells to fight subsequent invasions from the pathogen.

Differences in time of haematological response of both turkey genotypes to *Salmonella* disease vaccine inoculation may be attributed to several factors such as genotype, stress, nutrition, vitamin and mineral balance and their overall health. According to [44], the first time an animal immune system encounters a pathogen (disease-causing agent), it often cannot respond quickly enough to prevent disease, however, the

immune system usually succeeds in neutralizing the infection over time and thereby creating memory cells should in case such infection reoccur [44].

5. CONCLUSIONS

There was variation in response of the haematological parameters of local and exotic turkeys before and after inoculation with *Salmonella* disease vaccine with local turkeys displaying high capacity for cell mediated response. The times of haematological response also varied within the genotypes. These variations could be responsible for stronger adaptive potential to tropical environment and strong resistant to infectious diseases in local turkeys than in exotic turkeys.

ETHICAL APPROVAL

Ethical clearance was given by Federal University of Agriculture Abeokuta Ogun State (FUNAAB) Nigeria ethical review board in accordance with international standard on the care and use of experimental animals.

STATEMENT

Results presented in this paper are original, not published before and paper is not sent to the publication in another Journal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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