Bangladesh J. Zool. **41**(2): 135-144, 2013

HAEMATOLOGICAL AND BIOCHEMICAL PROFILES OF *GALLUS* INDIGENOUS, EXOTIC AND HYBRID CHICKEN BREEDS (*GALLUS DOMESTICUS* L.) FROM RAJSHAHI, BANGLADESH

Ripon Kumar Dutta, M. Saiful Islam* and Md. Ashraful Kabir[1]

Department of Zoology, University of Rajshahi, Rajshahi-6205, Bangladesh

Abstract: A comparative account of haemato-biochemical profiles of an indigenus (IND) and five chicken breeds: *viz.* Cobb 500 (COB), cockerel (COC), Fayoumi (FAY), Rhode Island Red (RIR), and *Sonali* (SON, derived from RIR cock × FAY hen), has been presented. The haematological profile included total counts (TC) of RBC, WBC, platelets, haemoglobin (Hb%) and ESR and differential counts (DC) of WBC included neutrophils, eosinophils, lymphocytes, monocytes and basophils. All the haematological parameters except WBC, ESR and basophils showed significant difference among the breeds ($P < 0.01$). Vital biochemical parameters from blood sera such as calcium, cholesterol, creatinine, glucose and urea also showed significant difference among the chicken breeds ($P < 0.05$). The haemato-biochemical parameters, however, were not significantly correlated ($P > 0.05$) with each other among the chicken breeds. Except for cholesterol *vs.* urea in IND, none of the correlations tested for haemato-biochemical profiles of the experimental chickens was found significant. Relevance of this study in relation to health, clinico-pathology and improved breeding strategies of the poultry species in the country has been discussed.

Key words: Chicken breeds, haemato-biochemical parameters, blood sera,

INTRODUCTION

Blood plays an important role in the transportation of nutrients, metabolic waste products and gases around the body (Zhou *et al.* 1999). Moreover, blood represents a means of assessing clinical and nutritional health status of animals (Olorode and Longe 2000). The haemato-biochemical profiles are most commonly used in nutritional studies for chickens (Adeyemi *et al.* 2000) and other birds like pigeon (Pavlak *et al.* 2005), guinea fowl (Onyeanusi 2007), bronze turkey (Schmidt *et al.* 2009) and Japanese quail (Arora 2010). The full blood count examines mostly the cellular components of blood whereas biochemical testing focuses on its chemical constituents (Hrubec *et al.* 2002). It has been shown that data from blood profiles could be exploited in the improvement of chicken stocks (Ladokun *et al.* 2008). In addition, blood parameters help diagnoses of specific poultry hen pathologies and might serve as basic knowledge for studies in immunology and comparative avian pathology (Bonadiman 2009).

*Corresponding author. E-mail: saifulzoo.ru@gmail.com [1]Department of Biology, Cantonment Public School & College, Saidpur 5311, Nilphamari, Bangladesh.

Studies on Thai native chickens (Simaraks *et al.* 2005), naked-neck indigenous chickens of Kashmir (Pampori and Iqbal 2007), Cobb broilers (Anitha *et al.* 2007, Elagib *et al.* 2008, Barreiro *et al.* 2009, Daneshyar *et al.* 2009) and laying hens (Mohammed 2010, Al-Jaff 2011; El-Gendy *et al.* 2011, Yanagita *et al.* 2011) demonstrate that haemato-biochemical profiles of chickens are correlated with a number of factors such as gender, nutrition, rearing temperature, stocking density and stress conditions. Other studies revealed that serum protein may be used as an indirect measurement of dietary protein quality (Alikwe *et al.* 2010), whereas significant reduction in red and white blood corpuscles indicates haemolytic anaemia and exposes the birds to high risk of infection (Akporhuarho 2011).

Fluctuations or variations in haemato-biochemical profiles have been reported in chickens of the same age and sex, and reared under the same conditions but sampled at different times of the day (Azeez *et al.* 2009), due to changes in daily physical and metabolic activities (Islam *et al.* 2004), feed replacement (Ugwu *et al.* 2008, Adeyemo *et al.* 2010, Oloyede *et al.* 2010, Saied *et al.* 2011), polluted water (Akporhuarho 2011) and ecotypes (Elagib and Ahmed 2011). Recently it has been demonstrated that serum lipid and serum cholesterol decreased significantly in post-hatch broiler chicks (Ali *et al.* 2011).

With a view to create a baseline data on haemato-biochemical profiles of chicken breeds available in Rajshahi, some vital blood parameters of an indigenous, four exotic and a hybrid chicken have been estimated. The present results would help assessing poultry diseases, identifying healthy chickens, improving desirable breeds and designing appropriate breeding strategies for poultry birds in the country.

MATERIAL AND METHODS

Experimental animals: A total of 30 marketable-sized, healthy male chickens (6 breeds × 5 replicates each), consisting of a non-descriptive *Deshi* or indigenous (IND), four exotics *viz.* Cobb 500 (COB), Cockerel (COC), Fayoumi (FAY) and Rhode Island Red (RIR), and a crossbred Sonali (SON) derived from RIR cock × Fayoumi hen, were used. IND chicks were reared on free-range and semi-scavenging systems at domestic houses, while the rest of the breeds were raised on deep litter system at private-owned poultry farms situated within the Rajshahi City Corporation areas. Age (in months) of the IND chickens ranged between 6 and 8 while that of COB, COC, FAY, RIR and SON varied between 1 and 1.5; 1.5 and 1.8; 1.8 and 2.5; 18 and 20 and 1.5 and 2.5, respectively.

Blood samplings: Owing to the least variability compared to other sites (Arora 2010), jugular veins were punctured with sterile needles to collect 2cc of blood

from each bird, 0.5 cc of which was dispensed into clean bottles containing the anticoagulant EDTA, while the rest was allowed to clot. The non-coagulated blood was used to determine the haematological profile. Afterwards the same quantity of blood was collected as described above and was subject to centrifugation for 5 min to get the blood serum samples, the latter were used to measure the biochemical profile of the experimental birds.

Haematological and biochemical techniques: Haematological profile included total counts (TC) of the RBC (red blood corpuscles, $\times 10^6$ cells.μl^{-1}) and WBC (white blood corpuscles, $\times 10^4$ cells.μl^{-1}), differential counts (DC) of the WBC, number of platelets ($\times 10^6$ cells.μl^{-1}), haemoglobin (Hb%) and ESR (erythrocyte sedimentation rate, mm.hr^{-1}), which were estimated using the techniques described elsewhere (Ritchie *et al.* 1994; Pampori and Iqbal 2007). A haemocytometer consisting of a counting chamber and special cover slip was used for TC of the RBC and WBC. In addition, DC of the WBC were made using the haemocytometer and WBC pipette, where the numbers of neutrophils, eosinophils, lymphocytes, monocytes and basophils were recorded per 100 cells. Platelet counts were made by using 100mL of 3% sodium citrate, 1mL of formalin and 2 drops of 1% brilliant cresyl blue in saline. The estimation of Hb% was done by using 0.1N HCl and distilled water that converted the haemoglobin into acid haematin. ESR values were recorded in mm at the first hr by the Westergren method (Ritchie *et al.* 1994). For serum samples, 3 test tubes (labelled as blank, standard and test, respectively), a water bath and a colorimeter with 546 nm filters were used to measure calcium (CAL), cholesterol (CHO), creatinine (CRE), glucose (GLU) and urea (URE). Values of the biochemical profile were recorded in mg.100 m/l.

Statistical procedures: To detect any significant differences in haemato-biochemical profiles among the chicken breeds under study, a statistical package (SPSS version 11.0 for Windows) was used to calculate mean, standard deviation (SD), analysis of variance (ANOVA), least significant differences (LSD) and co-efficient of correlation (r) values. All statements of significance were based at least on 95% confidence limits (*i.e.* $P < 0.05$).

RESULTS AND DISCUSSION

Haematological profile: Results on the haematological profile of the chicken breeds are presented in Table 1. The TC of RBC showed highly significant difference between breeds ($F_{5,24}=7.05$, $P=0.000$), where IND had the highest number that differed significantly from all other breeds, COB had the lowest. COC, RIR and SON had similar numbers of RBC but they differed from COB and FAY. Data on the TC of WBC, however, did not differ significantly among the

breeds ($F_{5,24}$=1.30, P>0.05) where IND had the highest WBC that differed from the rest of the chickens. FAY, RIR and SON displayed similar WBC counts and COC had the lowest value. Similar to RBC, differences in platelet counts among the groups of chickens were also significant ($F_{5, 24}$=10.47, P=0.000) where IND and COB had the highest and the lowest values, respectively. But the platelet counts between COC and RIR, and that between FAY and SON did not differ statistically. The percentage of Hb showed a highly significant difference ($F_{5,24}$=12.36, P=0.000) among the chickens where IND had the highest and COC the lowest values. As in WBC, ESR of the chickens did not reveal a significant difference ($F_{5,24}$=0.66, P>0.05). The ESR in RIR was the lowest that differed statistically from the rest of the breeds.

Table 1. Haematological profile of one indigenous and five exotic breeds male chickens from Rajshahi, Bangladesh

Breeds*	Age (month)	RBC ($\times10^6$cells.μl^{-1})	WBC ($\times10^4$cells.μl^{-1})	Platelets ($\times10^6$cells.μl^{-1})	Hb (%)	ESR ($mm.hr^{-1}$)
IND	6.20±1.20	2.74±0.19^a	2.33±0.25^a	2.67±0.22^a	11.2±0.84^a	8.60±1.34^a
COB	1.10±0.10	2.12±0.13^d	2.27±0.10^b	2.14±0.08^d	7.20±0.84^c	8.20±1.09^a
COC	1.60±0.20	2.54±0.17^c	2.21±0.08^c	2.24±0.09^c	6.40 ±1.14^c	8.40±0.55^a
FAY	1.90±1.20	2.62±0.18^b	2.23±0.04^d	2.48±0.14^b	9.80±0.84^b	8.80±0.84^a
RIR	18.9±0.60	2.32±0.24^c	2.17±0.13^d	2.22±0.12^c	9.40±1.95^b	7.80±0.48^b
SON	1.80±1.20	2.48±0.19^c	2.15±0.04^d	2.48±0.14^b	9.80±0.84^a	8.80±0.84^a
Ref*	-	(2.5 – 3.5)	(1.2 – 3.0)	(1.5 – 3.2)	(7 – 13)	(8 – 12)

*N=5 per breed; figures show mean ± SD values; superscripts for each parameter in the same column differ significantly by LSD (P<0.05); *Reference values (Jain 1993); abbreviations are elaborated in Materials and Methods.

Data on DC of WBC in the experimental chicken breeds (Fig. 1) revealed highly significant differences for neutrophils ($F_{5, 24}$=32.21, P=0.00), eosinophils ($F_{5, 24}$=10.78, P=0.00), lymphocytes ($F_{5, 24}$=17.05, P=0.00) and monocytes ($F_{5, 24}$=27.07, P=0.00). Basophils, however, did not vary between the breeds ($F_{5, 24}$=0.36, P>0.05). COC had the highest neutrophils and IND the lowest; eosinophils were highest in IND and lowest in SON and FAY; SON had the highest lymphocytes followed by FAY, RIR, IND, COB and COC; while the monocytes showed the following sequence: IND > RIR > COC > COB > SON = FAY.

Biochemical profile: Data on the amount of calcium in blood sera of the experimental birds showed a significant difference among the adult males ($F_{5, 24}$=50.98, P=0.00), where RIR had the highest and SON had the lowest values (Table 2). Moreover, a significant difference existed among IND, COB and SON breeds, although RIR, COC and FAY did not differ in their sera calcium contents. Cholesterol in blood sera of the birds also showed significant difference among breeds (($F_{5,24}$=59.83, P=0.00), where RIR had the highest amount and

IND had the lowest. Similarly, difference in creatinine among chicken breeds were significant ($F_{5,24}$=10008.16, P=0.00), where IND exhibited the highest and SON the lowest values. In terms of the glucose contents, FAY showed the highest followed by RIR, COB, COC, SON and IND, resulting in a significant difference among the breeds ($F_{5,24}$=677.21, P=0.00). The amount serum urea showed the following sequence: RIR > SON > COB > FAY > COC > IND, which also revealed a significant difference among the chicken breeds ($F_{5,24}$=43.64, P=0.00).

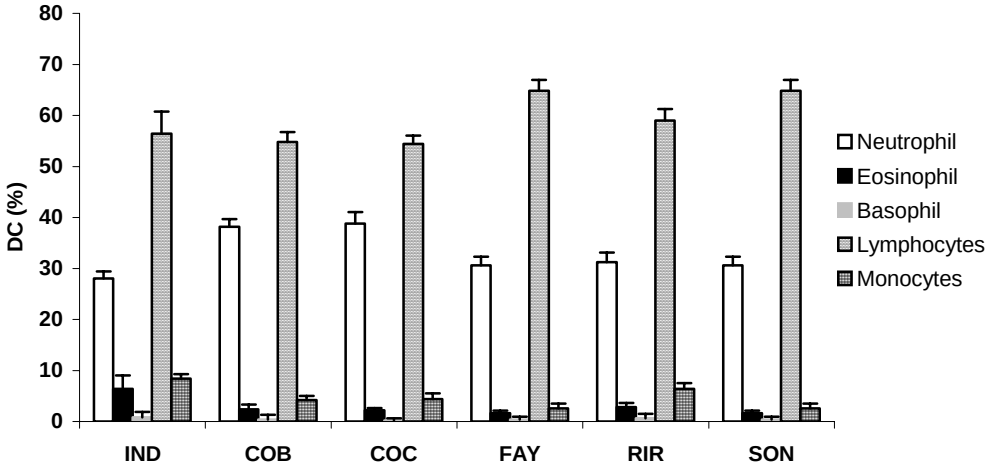

Fig. 1. Estimated differential counts (DC) of WBC of one indigenous and five exotic breeds male chickens from Rajshahi, Bangladesh

Table 2. Biochemical profile of one indigenous and five exotic breeds male chickens from Rajshahi, Bangladesh

Breeds*	Age (month)	CAL	CHO	CRE	GLU	URE
IND	6.20±1.20	10.6±0.26^{b}	75.0±2.24^{d}	0.63±0.06^{a}	76.0±1.58^{e}	1.7±0.160^{e}
COB	1.10±0.10	9.60±0.35^{c}	83.0±2.24^{b}	0.60±0.16^{e}	154±2.17^{b}	12.2±1.90^{c}
COC	1.60±0.20	11.6±0.69^{a}	78.0±3.16^{c}	0.64±0.21^{c}	147±3.85^{c}	11.0±2.24^{d}
FAY	1.90±1.20	11.5±0.37^{a}	76.0±3.16^{c}	0.56±0.23^{b}	160±3.16^{a}	11.4±0.96^{d}
RIR	18.9±0.60	12.9±0.63^{a}	95.2±1.92^{a}	0.90±0.22^{d}	159±3.11^{a}	16.2±2.59^{a}
SON	1.80±1.20	8.88±0.24^{d}	93.4±2.41^{a}	0.54±0.24^{e}	127±0.24^{d}	13.8±0.74^{b}
Ref*	-	(8.1 – 12)	(129 – 297)	(0.5 – 2)	(197 – 299)	(1.9 – 12.5)

*N=5 per breed; all values are mean ± SD; biochemical profile are in (mg/100mL^{-1}); superscripts for each parameter in the same column differ significantly by LSD (P<0.05); *Reference values (Clinical Diagnostic Division 1990) abbreviations are elaborated in Materials and Methods.

Correlations between haemato-biochemical parameters: As presented in Tables 3 and 4, all the chicken breeds showed insignificant (P>0.05) correlations for various haemato-biochemical parameters except for cholesterol vs. urea in IND. However, negative correlations were found to exist between RBC and Hb in

COB, FAY, RIR and SON. Similarly, correlations between WBC and eosinophil in FAY and SON and those between platelets and ESR in COC and RIR were also negative. COC and FAY also displayed negative correlations between glucose and urea; COB showed a similar correlation between glucose and creatinine; FAY and SON between cholesterol and urea; COB, COC and FAY between cholesterol and creatinine; and FAY between urea and creatinine. These correlations clearly represent the blood profiles of healthy and young adult chicken breeds in Rajshahi under study.

Table 3. Co-efficient of correlation (r) values among different haematological parameters of male chickens of different breeds from Rajshahi, Bangladesh

Breeds*	RBC *vs.* Hb	WBC *vs.* Eosinophil	Platelets *vs.* ESR
IND	0.55ns	0.82ns	0.14ns
COB	-0.50ns	0.84ns	0.38ns
COC	0.81ns	0.29ns	-0.15ns
FAY	-0.63ns	-0.72ns	0.19ns
RIR	-0.24ns	0.60ns	-0.03ns
SON	-0.50ns	-0.85ns	0.19ns

*All values are at 8 df; vs.=versus; ns=not significant (P>0.05); abbreviations are elaborated in Materials and Methods.

Table 4. Co-efficient of correlation (r) values among different biochemical parameters of male chickens from Rajshahi, Bangladesh

Breeds*	GLU *vs.* URE	GLU *vs.* CRE	CHO *vs.* URE	CHO *vs.* CRE	URE *vs.* CRE
IND	0.00ns	0.35ns	0.92*	-0.10ns	0.24ns
COB	0.19ns	-0.58ns	0.29ns	-0.49ns	0.49ns
COC	-0.12ns	0.84ns	0.78ns	-0.08ns	0.21ns
FAY	-0.28ns	0.41ns	-0.46ns	0.69ns	-0.27ns
RIR	0.21ns	0.32ns	0.64ns	0.29ns	0.52ns
SON	5.39ns	0.70ns	-0.19ns	0.87ns	-0.23ns

*All values are at 8 df; vs.=versus; ns=not significant (P>0.05); *= P<0.05; abbreviations are elaborated in Materials and Methods.

The highest platelet counts in indigenous chickens have previously been reported (Islam *et al.* 2004). The present findings also showed highest platelets in IND followed by SON, FAY, COC, RIR and COB. With regard to Hb%, a highly significant difference among the chickens was obvious from the present results, where IND had the highest and COC the lowest values. This is similar to the finding that adult male Nigerian indigenous chickens had 11.4±2.75% Hb (Durotoye *et al.* 2004), although no significant difference in Hb existed among three indigenous Sudanese chicken ecotypes (Elagib and Ahmed 2011). ESR, like WBC counts, did not reveal a significant difference among the present chicken breeds. The ESR in RIR was the lowest that differed statistically from the rest of the breeds.

The present biochemical parameters showed significant variations among the adult male chickens, which conform to several earlier findings (Simaraks *et al.* 2005, Barek *et al.* 2003, Qiao *et al.* 2005). The present variation in serum calcium among different genotypes of chickens is similar to some previous reports (Onyeanusi 2007, Simaraks *et al.* 2005, Elagib *et al.* 2008, Barreiro *et al.* 2009) who observed such variations due to sex, reproductive organs, high temperature and age, respectively. We find a significant difference in serum cholesterol among different chicken breeds, where IND showed the lowest and RIR the highest levels. The present difference in serum creatinine among chicken breeds was also significant, where IND exhibited the highest and SON the lowest values. This is similar to a recent study (Polat *et al.* 2011) in which creatinine levels varied significantly in broiler chickens due to diet. Serum glucose was found to be the highest in FAY followed by RIR, COB, COC, SON and IND, resulting in a significant difference among the breeds. In contrast, no significant differences in the serum glucose in Nigerian indigenous chickens were shown by an earlier study (Ladokun *et al.* 2008). In this study, the serum urea of the adult male chickens showed significant difference among the breeds, in which the highest concentration of urea was recorded in RIR and the lowest in IND. These are in good agreement with several findings (Simaraks *et al.* 2005, Durotoye *et al.* 2000; Qiao *et al.* 2005, Schmidt *et al.* 2010). In contrast, however, no significant difference was recorded for uric acid in cock and hen of the indigenous chicken of Kashmir (Pampori and Iqbal 2007) and serum urea did not vary in broiler chickens due to diets (Polat *et al.* 2011). The reason for such variations might be due to the differences in renal functions associated with metabolic activities in different genotypes of the chicken breeds.

Earlier studies have shown that a strong correlation exists between calcium concentration and weight of the reproductive organs in Guinea fowls (Onyeanusi 2007), and that a negative association between high temperature and serum calcium prevails (Elagib *et al.* 2008). The present chickens revealed some negative correlations with respect to their haemato-biochemical profiles. These lend support from two reports, where the serum cholesterol was negatively correlated with the increased age of the chicks (Ali *et al.* 2011), and a moderately negative and significant correlation coefficient existed between globulin and cholesterol in chickens of warmer climate (El-Gendy *et al.* 2011).

In a semi-humid tropical country like Bangladesh, there is dearth of information on haemato-biochemical profiles of available poultry species. Our findings therefore imply that blood parameters could serve as a baseline data, which could be exploited in the diagnosis of healthy chickens, combating

diseases, improvement of the desirable breeds as well as for designing appropriate breeding strategies for poultry birds in the country.

Acknowledgements: The authors would like to thank numerous poultry sellers and growers in the study areas for their co-operation and sincere help in providing chickens and their information required for this research. This work was partly supported by a funding to MSI from the University Grants Commission (UGC) of Bangladesh. Laboratory technicians also deserve special mention for their assistance in haematological and biochemical profiling.

LITERATURE CITED

ADEYEMI, O.A., FASINA, O.E. and BALOGUN, M.O. 2000. Utilization of full fat jatropha seeds in broiler diet: Effect on haematological parameters and blood chemistry. *Proc. 25th Conf. Nigerian Soc. Anim. Prod.* held at Michael Okpara University of Agriculture, Umudike, Nigeria, March 19-23, pp.108-109.

ADEYEMO, G.O., OLOGHOBO, A.D. and ADEBIYI, O.A. 2010. The effect of graded levels of dietary methionine on the haematology and serum biochemistry of broilers. *Int. J. Poult. Sci.* **9**(2): 158-161.

AKPORHUARHO, P.O. 2011. Effect of crude oil polluted water on the haematology of cockerel reared under intensive system. *Int. J. Poult. Sci.* **10**(4): 287-289.

ALI, O.H.A., MALIK, H.E.E. and ELHADI, H.M. 2011. Changes in the concentrations of liver total lipids, serum total lipids and serum cholesterol during early days post-hatch in broiler chicks. *Asian J. Poult. Sci.* **5**: 51-55.

ALIKWE, P.C.N., FAREMI, A.Y. and EGWAIKHIDE, P.A. 2010. Biochemical evaluation of serum metabolites, enzymes and haematological indices of broiler-chicks fed with varying levels of rumen epithelial scraps in place of fish meal proteins. *Res. J. Poult. Sci.* **3**(2): 27-31.

AL-JAFF, F.K. 2011. Effect of coriander seeds as diet ingredient on blood parameters of broiler chicks raised under high ambient temperature. *Int. J. Poult. Sci.* **10**(2): 82-86.

ANITHA, B., MOORTHY, M. and VISHWANATHAN, M. 2007. Muscle cholesterol and serum biochemical changes in broilers fed with crude rice bran oil. *Int. J. Poult. Sci.* **6**(12): 855-857.

ARORA, K.L. 2010. Differences in hemoglobin and packed cell volume in blood collected from different sites in Japanese quail (*Coturnix japonica*). *Int. J. Poult. Sci.* **9**(9): 828-830.

AZEEZ, O.I., OYAGBEMI, A.A. and OYEWALE, J.O. 2009. Diurnal fluctuation in haematological parameters of the domestic fowl in the hot humid tropics. *Int. J. Poult. Sci.* **8**(3): 247-251.

BAREK, M.A., AHMAD, N., MAJUMDER, S., ISLAM, K. and ISLAM, R. 2003. Haemato-biochemical parameters and performances of broiler fed with soybean oil and protein supplementation. *Bangladesh J. Anim. Sci.* **32**(1-2): 131-138.

BARREIRO, F.R., SAGULA, A.L., JUNQUEIRA, O.M., PEREIRA, G.T. and BARALDI-ARTONI, S.M. 2009. Densitometric and biochemical values of broiler tibias at different ages. *Poult. Sci.* **88**(12): 2644-2648.

BONADIMAN, S.F., STRATIEVSKY, G.C., MACHADO, J.A., ALBERNAZ, A.P., RABELO, G.R. and DAMATTA, R.A. 2009. Leukocyte ultrastructure, hematological and serum biochemical profiles of ostriches (*Struthio camelus*). *Poult. Sci.* **88**(11): 2298-2306.

BOWES, V.A., JULIAN, R.J. and STIRTZINGER, T. 1989. Comparison of serum biochemical profiles of male broilers with female broilers and While Leghorn chickens. *Canadian J. Vet. Res*. **53**: 7-11.

CLINICAL DIAGNOSTIC DIVISION (CDD). 1990. *Veterinary Reference Guide*. Eastern Kodak Co. Rochester, NY, USA.

DANESHYAR, M., KERMANSHAHI, H. and GOLIAN, A. 2009. Changes of biochemical parameters and enzyme activities in broiler chickens with cold-induced ascites. *Poult. Sci*. **88**(1): 106-110.

DUROTOYE, L.A., FADARIO, M.O. and AVWEMORUE, A.K. 2000. Diurnal variation in blood parameters in the chicken in the hot tropical climate. *African J. Biomedical Res*. **3**(3): 143-147.

ELAGIB, H.A.A. and AHMED, A.D.A. 2011. Comparative study on haematological values of blood of indigenous chickens in Sudan. *Asian J. Poult. Sci*. **5**: 41-45.

ELAGIB, H.A.A., MOHAMED, H.E. and ELZUBEIR, E.A. 2008. The effects of methionine and energy levels on haematological and biochemical indices in broiler under hot climate. *Res. J. Poult. Sci*. **2**: 15-20.

EL-GENDY, E.A., EL-KOMY, E.M., EL-FAR, A.A., EL-GAMRY, K.A. and EL-MALLAH, G.M. 2011. Developmental stability in chickens local to warm climatic region. 2. Variation in blood metabolites due to genetic selection and crossing. *Int. J. Poult. Sci*. **10**(5): 358-364.

HERRERA, I.R., SCHNEIDER, M.J., BLORE, P.J. and DONOGHUE, D.J. 2011. The relationship between blood and muscle samples to monitor for residues of the antibiotic enrofloxacin in chickens. *Poult. Sci*. **90**: 481-485.

HRUBEC, T.C., WHICHARD, J.M., LARSEN, C.T. and PIERSON, F.W. 2002. Plasma versus serum: Specific differences in biochemical analytic values. *J. Avian Med. Surgery* **16**(2): 101-105.

ISLAM, M.S., LUCKY, N.S., ISLAM, M.R., AHAD, A., DAS, B.R., RAHMAN, M.M. and SIDDIQUI, M.S.I. 2004. Haematological parameters of Fayoumi, Assil and local chickens reared in Sylhet region in Bangladesh. *Int. J. Poult. Sci*. **3**(2): 144-147.

JAIN, N.C. 1993. *Essentials of Veterinary Hematology*. Lea & Febiger, Philadelphia,USA.

LADOKUN, A.O., YAKUBU, A., OTITE, J.R., OMEJE, J.N., SOKUNBI, O.A. and ONYEJI, E. 2008. Haematological and serum biochemical indices of naked neck and normally feathered Nigerian indigenous chickens in a sub humid tropical environment. *Int. J. Poult. Sci*. **7**(1): 55-58.

MOHAMMED, A. 2010. Effect of acetyl salicylic acid (ASA) in drinking water on productive performance and blood characteristic of layer hens during heat stress. *Int. J. Poult. Sci*. **9**(4): 382-385.

MORITA, V.D.S., BOLELI, I.C. and OLIVEIRA, J.A. 2010. Hematological and incubation parameters of chicks from young breeder's eggs: Variation with sex and incubation temperature. *Int. J. Poult. Sci*. **9**(6): 606-612.

OLORODE, B.R. and LONGE, O.G. 2000. Effect of replacing palm kernel cake with shear butter cake on quality characteristics, haematology and serum chemistry of laying hens. *Nigerian J. Anim. Prod*. **27**: 19-23.

OLOYEDE, O.B., MINARI, J.B. and MUHAMMAD, N.O. 2010. Evaluation of growth characteristics and haematological indices of broiler-chicks fed raw and processed Bambara groundnut seed as a component of poultry feed. *Int. J. Poult. Sci*. **9**(7): 652-655.

ONYEANUSI, B.I. 2007. Calcium and phosphorus levels in Nigerian guinea fowls. *Int. J. Poult. Sci*. **6**(8): 610-611.

PAMPORI, Z.A. and IQBAL, S. 2007. Haematology, serum chemistry and electrocardiographic evaluation in native chicken of Kashmir. *Int. J. Poult. Sci.* **6**(8): 578-582.

PAVLAK, M., VLAHOVIC, K., JARCIC, J., DORC, A. and ZUPANCIC, Z. 2005. Age, sexual and seasonal differences of haematological values and antibody status to *Chlamydophila* sp. in feral and racing pigeons (*Columba livia* forma *domestica*) from an urban environment (Zagreb, Croatia). *European J. Wildlife Res.* **51**(4): 271-276.

POLAT, U., YESILBAG, D. and EREN, M. 2011. Serum biochemical profile of broiler chickens fed diets containing rosemary and rosemary volatile oil. *J. Bio. Environ. Sci.* **5**(13): 23-30.

QIAO, S., WU, Y., LAI, C., GONG, L., LU, W. and LI, D. 2005. Properties of *Aspergillar* xylanase and the effects of xylanase supplementation in wheat-based diets on growth performance and the blood biochemical values in broilers. *Asian-Australian J. Anim. Sci.* **18**(1): 66-74.

RITCHIE, B.W., HARRISON, J.G. and HARRISON, R.L. 1994. *Avian Medicine.* Winger's Publishing, Inc, Florida.

SAEID, J.M. and AL-NASRY, A.S. 2010. Effect of dietary coriander seeds supplementation on growth performance carcass traits and some blood parameters of broiler chickens. *Int. J. Poult. Sci.* **9**(9): 867-870.

SAIED, J.M., AL-JABARY, Q.H. and THALIJ, K.M. 2011. Effect of dietary supplement yeast culture on production performance and hematological parameters in broiler chicks. *Int. J. Poult. Sci.* **10**(5): 376-380.

SCHMIDT, E.M.S., PAULILLO, A.C., LAPERA, I.M., MARTINS, G.R.V., JUNIOR, L.N. and TESTI, A.J.P. 2010. Serum biochemical parameters of female bronze turkeys (*Meleagris gallopavo*) during egg-laying season. *Int. J. Poult. Sci.* **9**(2): 177-179.

SCHMIDT, E.M.S., PAULILLO, A.C., MARTINS, G.R.V., LAPERA, I.M., TESTI, A.J.P., JUNIOR, L.N., DENADAI, J. and FAGLIARI, J.J. 2009. Hematology of the bronze turkey *(Meleagris gallopavo*): Variations with age and gender. *Int. J. Poult. Sci.* **8**(8): 752-754.

SIMARAKS, S., CHINRASRI, O. and ANEGWANICH, S. 2005. Haematological, electrolyte and serum biochemical values of the Thai indigenous chickens (*Gallus domesticus*) in northeastern Thailand. *Songklanakarin J. Sci. Tech.* **26**(3): 425-430.

SULAIMAN, M.H., ADUTA, D.M. and SALAMI, S.O. 2010. The comparative study of the blood cellular composition in muscovy ducks in Nigeria. *Int. J. Poult. Sci.* **9**(9): 836-841.

UGWU, S.O.C., ONYIMONYI, A.E. and OZONOH, C.I. 2008. Comparative performance and haematological indices of finishing broilers fed palm kernel cake, bambara offal and rice husk as partial replacement for maize. *Int. J. Poult. Sci.* **7**(3): 299-303.

YANAGITA, K., SHIRAISHI, J., KAWAKAMI, S. and BUNGO, T. 2011. Time course changes in the blood parameters and the expression of diencephalic CRH and AVT mRNA due to acute isolation stress in chicks. *J. Poult. Sci.* **48**(2): 125-129.

ZHOU, W.T., FUJITA, M. and TAMMAMTO, S. 1999. Thermoregulatory responses and blood viscosity in dehydrated heat-exposed broilers (*Gallus domesticus*). *J. Thermal Bio.* **24**(3): 185-192.

(Manuscript received on 20 November 2012; revised on 29 July 2013)