Comparative study of indigenous chickens on the basis of their health and performance

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ABSTRACT  Three hundred crossbred chickens (at age of 11 wk) were randomly housed in 15 open-sided deep litter pens with 20 chickens in each pen under completely randomized design for a period of 9 wk. Before evaluating their hematobiochemical and carcass characteristics, the birds were provided with grower mash ad libitum throughout the experimental period. Blood samples were taken from each genotypic group (nanaff, Nanaff, and NanaFf), when the birds were 18 and 20 wk old, respectively, for the evaluation of hematobiochemical parameters. At the end of the trial, 15 chickens from each of the 3 genotypic groups were randomly selected and slaughtered to determine the carcass parameters. The findings from the study revealed that except for total cholesterol, spleen, and neck weight, there was no significant genotypic effect (P > 0.05) on hematobiochemical and carcass parameters measured. The nanaff genotype birds had significantly higher (P < 0.05) cholesterol levels than both Nanaff and NanaFf genotype birds, both of which did not differ significantly. The Nanaff had significantly (P < 0.05) higher spleen and neck weight than both the nanaff and NanaFf. The latter 2 did not differ significantly (P > 0.05). Also, hematobiochemical assays of all the birds were within normal range. From a health point of view, the indigenous naked neck genotype seems superior because its fat and cholesterol contents were low. Thus, it is strongly recommended that there should be a conscious effort to develop and commercialize the naked-neck and frizzled birds especially in developing countries.

Key words: poultry, gene, naked neck, hematological parameters, indigenous chicken

INTRODUCTION

Crossbreeding has been a noteworthy device for the advancement of present-day types of chickens and could in like manner be used to enhance the rural chicken. Crossbreeding methodology typically includes a 2-route cross between an enhanced exotic and a local breed, with the point of joining the better creation limit of the previous with the latter flexibility to a harsh environmental condition Khawaja et al., (2016). Adeleke et al., (2011) in their study also reported improved performance and viability traits in reciprocal effects in crosses involving local chickens and exotic broiler breeder. This phenomenon in poultry is thought to originate from sex-linked genes (such as naked-neck: Na, frizzled: F and dwarf: dw). It has been established that these genes (Na, F) are highly tolerant to the tropical condition and can produce high number of good quality eggs and carcass with low production and handling costs. This depicts that the dam line is very important in practical poultry breeding.

Thus, to improve the productivity and efficiency of the indigenous birds within their local environments, it is necessary to preserve desirable genes, for example, disease resistance genes, and advance them (Sonaiya et al., 1999). Kral and Suchy (2000) reported that important information is provided by serum biochemical and hematological parameters on the immune status of animals, and this type of information is required for diagnostic and management function and could equally be integrated into breeding programs for the genetic advancement of native chickens.

Islam et al., (2004) stated that a critical examination of normal hematological parameters of birds is especially vital in diagnosing the diverse metabolic and pathological disorders. As a diagnostic tool, it can be used to evaluate
the health status of an individual and a flock. Characteristically, hematological changes are useful for the determination of various conditions of the body and also for the determination of environmental stress, pathological, and nutritional factors. Owing to these factors, in recent years, researchers and veterinarians, as well as poultry farmers, have found avian physiology to be of great importance (Islam et al., 2004).

Hematological and serum biochemistry assay of animals suggests the physiological disposition of the animals to nutrition (Madubuike and Ekenyem, 2006). Esonu et al., (2001) had stated that hematological constituents reflect the physiological responsiveness of the animals to its internal and external environment. The effects of various feed on the hematology and serum biochemistry of livestock have been studied by many scientists (Annougi and Folorunso, 2003; Olayeni et al., 2006; Kumar et al., 2014; Parveen et al., 2017) and concluded that feed affects animal physiology (Madubuike and Ekenyem, 2006).

According to Machebe et al., (2010), the quality and quantity of ration given to an animal affects its physiological condition. Total serum protein has been reported as an indication of the protein retained in the animal body (Esonu et al., 2001; Parveen et al., 2017). Ladokun et al., (2008) in a study of the hematological and serum biochemical indices of NaNa and normally feathered (nana) chicken realized that the nana feathered bird had a higher (not significant) value of total protein albumin, globulin, and cholesterol.

Comparatively little research and development work have been carried out on rural poultry, despite the fact that they are usually more numerous than the commercial chickens in most developing countries. In light of this, it is imperative to compare the hematological and biochemical parameters of 3-way crossbred chickens with reciprocal f1 crossbred chickens.

MATERIALS AND METHODS

All research was approved by the Institutional Ethical Committee at the Kwame Nkrumah University of Science and Technology.

Experimental Birds

Three hundred crossbred chickens (at age of 11 wk) were randomly housed in 15 open-sided deep litter pens with 20 chickens in each pen under Completely Randomized Design for a period of 9 wk (from October to December, 2009). In total, there were one hundred (100) heterozygous naked necks (NanaFf), one hundred (100) double heterozygous frizzled naked necks (NanaFF) and one hundred (100) normal feathered birds (nanaff). The birds used were the offspring of crosses between local heterozygous naked neck (Nana) and heterozygous frizzled (Ff) males and hybrid commercial Lohmann females. The heterozygous naked neck (Nana) and heterozygous frizzled (Ff) were crossed with normal feathered (nanaff) Lohmann Brown Classic layers in 2 separate matings producing offspring that were heterozygous for the naked neck gene (NanaFf), heterozygous for the frizzled gene (nanaFF) and those that had normal Feathers (nanaff) in the first filial (F1) generation. The F1 heterozygous naked neck males were then mated to the F1 heterozygous frizzled females in a reciprocal cross to produce NanaFf, nanaFf, Nanaff and nanaff in the F2 generation in both matings.

The naked neck (NanaFf), frizzled (nanaFF), normal Feathered (nanaff) and double heterozygous frizzled-naked neck birds (NanaFF) of the second filial generation (F2) were selected and mated producing homozygous naked neck (NaNaFf), heterozygous naked neck (NanaFf), homozygous frizzled (nanaFF), heterozygous frizzled (nanaFF), normal Feathered (nanaff) and frizzled naked neck birds (NaNaFf, NanaFF, NanaFF and NaNaFF) as the third filial (F3) generation. Heterozygous naked neck (NanaFf), double heterozygous frizzled naked neck (NanaFf) and normal Feathered (nanaff) birds of the F4 generation were selected for this research work.

Management of the Birds

Housing and Feeding The birds were kept in an open-sided partitioned deep litter house with a stock density of 0.15 m²/bird for 9 wk. There were 15 pens in all with each pen housing 20 chickens. Feed (commercial grower diet) and water were supplied ad libitum in 2.5 kg capacity hanging feeders and 10 L capacity plastic fountain drinkers, respectively. The feed and nutrient compositions are shown in Table 1 (Akate Farm & Trading Co. Ltd., 2009).

Medication and Vaccination The schedule used for medication and vaccination was as follows: week 1, 2, and 4, the vaccine given was HB1, Gumboro and Doxin 200, and Lasota, respectively. The method of administration was through drinking water.

Hematological Parameters Measured

At week 18, blood samples from 9 birds (3 birds per genotypic group) randomly selected from each treatment was taken. After 2 wk, another sample was also taken from randomly selected birds from each treatment. At each sampling period, blood from the wing vein of each chicken was taken with the use of a 23-gauge needle fixed to a 3 mL syringe (Campbell, 1995). After the removal of feathers around the wing vein, a sterile cotton swab soaked in 70% ethanol was used to dilate the vein slightly before bleeding. Blood samples were obtained by puncturing the bronchial veins on the underside of the web of the wing. Blood samples taken were quickly transferred into appropriate blood tubes pretreated with EDTA and thoroughly shaken to mix both blood sample and EDTA (Jain, 1993). The sample glass tubes were submerged in an icebox filled with ice cubes to prevent deterioration of the samples (Ritchie et al., 1994). An assay of the blood samples was carried out at the KNUST Hospital Laboratory, Ghana. Preparation for a single blood cell for each type of blood cell was done using blood films. They were fixed and stained with the use of Wright-Giemsa’s
staining method. Manual counts on total red and white blood cells were carried out using hemocytometer (Campbell, 1995). Packed cell volume (PCV) was measured with a standard technique using microhematocrit capillary tubes. The samples were centrifuged at 500 rpm (revolutions per minute) for 3 min in a macrocentrifuge to generate serum for biochemical analysis. Hemoglobin concentration (Hb) was also determined with the use of cyanmethemoglobin method. Erythrocyte indices (mean value of corpuscular volume, mean value of corpuscular hemoglobin [MCH], and mean value of corpuscular hemoglobin concentration [MCHC]) were also determined. The results obtained were computed for total red blood concentration, PCV, and Hb concentration, respectively (Ritchie et al., 1994).

Serum Biochemical Parameters

For biochemical analysis, the sera obtained as described above were frozen, and the frozen plasma was allowed to thaw and pipetted into a dry clean bottle and stored at −20°C. Using a spectrophotometer at a wavelength of 500 nm, total protein, albumin, and total cholesterol were analyzed. The level of globulin was calculated as the difference between total plasma protein and albumin (Campbell, 1995).

Live Weight and Carcass Indices

At the end of the 19th wk, 3 chickens per replicate (45 chickens in all) were randomly selected and slaughtered. Birds were slaughtered using the killing cone method. The birds were put in a plastic cone with their heads facing down (inverted). The cone was to keep the birds still, and an extremely sharp knife was used to cut the jugular vein and the carotid artery of the birds’ neck and allowed to bleed out. After scalding in hot water (90°C) for about a minute, the feathers were manually plucked, and the carcasses were washed with clean running water. Each carcass was cut into parts after evisceration for carcass evaluation. The internal organs, such as heart, kidney, and gizzard, were all weighed separately and recorded.

RESULTS AND DISCUSSION

Hematological and Serum Biochemical Indices of Crossbred Chicken

Hematological Parameters

The mean hematological and serum biochemical values of Nanaff (heterozygous naked neck), nanaff (normally feathered birds), and NanaFf (double heterozygous frizzled naked neck) genotype chicken are shown in Table 2. The results of the hematological characteristics of the 3 different genotypes at both 18 and 20 wk of age showed no significant differences (P > 0.05) in mean values of Hb, PCV, red blood concentration, white blood cells (WBC), MCH, MCHC, mean value of corpuscular volume, and MCHC. The results of the present study are in agreement with the hematological values reported by Oke et al., (2007), where no significant (P > 0.05) genotypic effect was observed between the naked neck and normal feathered chicken. However, research findings reported by Khawaja et al., (2013) reveals that erythrocyte number, Hb, and PCV increases with advancement of the age of the chicken (4–48 wk). This is possibly because of the positive relationship between blood volume and age advancement as reported by Islam et al., (2004). Other factors that have been reported to influence hematological parameters in birds include age, sex, season, and nutrition. The observed hematological values of blood cells of the 3 different genotypes of the tested chickens in this study revealed that all the mean values of blood cells fell within expected blood values for the normal growth of chickens, and they were within the range of values reported by Pollock et al., (2001). This is an indication that the health conditions of the 3 chickens’ genotypes investigated could be classified as conditions for normal growth of chickens. Thus, the naked neck and frizzling genes have no effect on the hematological parameters which determine chicken health.

An increase in hemoglobin concentration could be related to an increase in metabolic activity necessary to satisfy the energy demands for maintenance under stress conditions. According to Pollock et al., (2001), a hemoglobin concentration below 7 g/dL is evidence of sign of
anemia in chickens. It could, therefore, be inferred that none of the various genotypes proved to be anemic because they all had hemoglobin concentrations above 7 g/dL as depicted in Table 2.

**Serum Biochemical Components** At the 18th wk, the mean values of total protein, albumin, cholesterol, and globulin of the different genetic groups were not significantly influenced \( (P > 0.05) \) by the different genotypes (Table 3). These findings are in consonance with the reports of earlier works by Ladokun et al., (2008) in a study of hematological and serum biochemical indices of an indigenous naked neck and normal feathered chickens. Also, when the birds were 20 wk old, the mean values of total protein, albumin, and globulin of the different genetic groups were not significantly affected \( (P > 0.05) \). However, the normal feathered genotype had a significantly higher \( (P < 0.05) \) cholesterol content \( (4.067 \text{ mmol/L}) \) than the heterozygous frizzled naked neck \( (3.467 \text{ mmol/L}) \) and the double heterozygous frizzled naked neck showed no significant differences \( (P > 0.05) \). This suggests that the presence of Na gene in a single state significantly decreased total cholesterol level in Nana compared with the nanaff genotype.

The results show that all the mean values of the serum biochemical components considered fitted within the range of values reported by Pollock et al., (2001) with the exception of total protein and albumen values for the naked neck birds. Galal et al., (2007) recorded a nonsignificantly \( (P > 0.05) \) higher total plasma protein in normal-size heterozygous naked neck birds compared with normal feathered ones. They explained that the higher value was because of the acute phase of an immune response (hyperactive of immunity system), where the liver cells produced and secreted acute phase protein, which gives protection to birds against infection or any invasion. The high total plasma protein shows the important role of globulin in terms of immunity. A higher globulin level may indicate a higher level of immunity and may help to reduce the negative effects associated with malnutrition (Ladokun et al., 2008). In addition, the study revealed that none of the various genotypes was suffering from liver disease, exudation because of severe skin lesions (burns) and excess fluid therapy because from Table 3, all the parameters fitted within the normal range as reported by Margaret (2001).

**Live Weight and Carcass Parameters of Crossbred Chicken**

**Live Weights, Bled, Defeathered, Dressed, and Chilled Weights** Results of live weight, bled weight, defeathered, dressed, and chilled weights are presented in Table 4. The results show that the various genotypes were not significantly different \( (P > 0.05) \) in live weight, bled weight, defeathered weight, dressed weight, and chilled weight.

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### Table 2. Mean hematological values of the 3 genotypes (i.e., nanaff, NanaFf, and NanaFf).

| Age (wk) | Genotype | Hb (g/dL) | WBC \( \times 10^3/\mu L \) | RBC \( \times 10^6/\mu L \) | PCV (%) | MCH (pg) | MCHC (g/dL) | Platelet \( \times 10^9/\mu L \) |
|----------|----------|-----------|-----------------|-----------------|--------|--------|-----------|-----------------|
| 18       | nanaff   | 13.53     | 13.37           | 2.92            | 36.73  | 126.13 | 46.39     | 36.55           |
|          | Nanaff   | 13.93     | 14.02           | 3.02            | 37.77  | 125.20 | 46.23     | 37.18           |
|          | NanaFf   | 12.60     | 13.42           | 2.72            | 35.63  | 132.03 | 46.86     | 36.45           |
|          | L.s.d.   | 1.61      | 1.39            | 0.44            | 7.25   | 10.49  | 4.48      | 0.08            |
|          | S.e.d.   | 0.66      | 0.57            | 0.18            | 3.00   | 4.30   | 1.83      | 2.49            |
|          | P-value  | 0.196     | 0.488           | 0.306           | 0.814  | 0.298  | 0.939     | 0.788           |
| 20       | nanaff   | 12.23     | 13.42           | 2.62            | 32.17  | 123.17 | 46.73     | 38.03           |
|          | Nanaff   | 14.03     | 14.14           | 3.02            | 36.43  | 121.07 | 46.50     | 38.47           |
|          | NanaFf   | 12.60     | 13.36           | 2.71            | 32.73  | 120.77 | 46.27     | 38.30           |
|          | L.s.d.   | 2.89      | 1.30            | 0.58            | 7.04   | 8.45   | 4.68      | 1.89            |
|          | S.e.d.   | 1.18      | 0.53            | 0.24            | 2.88   | 3.45   | 1.91      | 0.77            |
|          | P-value  | 0.339     | 0.326           | 0.282           | 0.340  | 0.760  | 0.971     | 0.855           |

Abbreviations: L.s.d, least significant difference; Hb, hemoglobin; MCH, mean value of corpuscular hemoglobin; MCHC, mean value of corpuscular hemoglobin concentration; MCV, mean value of corpuscular volume; S.e.d, standard error of deviation.

### Table 3. Mean serum biochemical values of the 3 genotypes (i.e., nanaff, NanaFf, and NanaFf) at 18 and 20 wk of age.

| Parameter                          | Total protein (g/L) | Albumen (g/L) | Globulin (g/L) | Cholesterol mmol/L |
|------------------------------------|---------------------|---------------|----------------|--------------------|
| **Eighteen (18)**                  |                     |               |                |                    |
| nanaff                             | 46.07               | 29.03         | 17.03          | 4.20               |
| Nanaff                             | 50.93               | 33.40         | 17.53          | 3.90               |
| NanaFf                             | 42.47               | 25.80         | 16.67          | 4.00               |
| L.s.d.                             | 16.18               | 13.02         | 5.46           | 1.34               |
| S.e.d.                             | 6.61                | 5.32          | 2.23           | 0.55               |
| P-value                            | 0.478               | 0.413         | 0.923          | 0.86               |
| **Twenty (20)**                    |                     |               |                |                    |
| nanaff                             | 49.03               | 28.90         | 20.43          | 4.07a              |
| Nanaff                             | 61.76               | 38.47         | 21.97          | 3.47b              |
| NanaFf                             | 54.27               | 27.07         | 19.80          | 3.53b              |
| L.s.d.                             | 13.50               | 11.95         | 2.62           | 0.43               |
| S.e.d.                             | 5.70                | 4.89          | 1.07           | 0.18               |
| P-value                            | 0.089               | 0.117         | 0.195          | 0.027              |

*Means* within column bearing different superscripts are significantly different.

Abbreviations: L.s.d, least significant difference; P, probability value; S.e.d, standard error of deviation.
defeathered weight, dressed, and chilled weights of chickens as affected by the type of gene are presented in Table 4. There were no significant differences (\(P > 0.05\)) between the means of the live, bled, defeathered, dressed, and chilled weights of the chicken with the 3 genotypes. The absence of significant difference between the Nanaff, nanaff, and NanaFf gene birds in this study disagrees with the findings of Adedeji et al., (2006), who recorded a significantly (\(P < 0.05\)) higher body weight among naked neck birds at 15 wk of age compared with normal feathered ones. Azharul et al., (2005) reported that crossbred chickens performed better in terms of growth performances in the intensive system under rural condition compared with a pure breed. They emphasize that the body weight gain is mainly related to the feed consumption and to the feed efficiency, which depends on the physiological condition of the birds, climatic change, and other factors.

**Gizzard Weight, Spleen, and Heart Weight** The Nanaff genotype was not significantly (\(P > 0.05\)) higher in gizzard weight (47.7 g) compared with the nanaff (42.1 g) and NanaFf (45.7 g) genotype as established in Table 4. This is in agreement with the findings of Galal et al., (2007), who recorded no significant difference between the heterozygous naked neck and normal feathered birds. The heart weight of NanaFf chicken recorded was not significantly (\(P > 0.05\)) heavier than those of both the Nanaff and nanaff chicken. There was no significant (\(P > 0.05\)) difference between the spleen weight of the frizzled-naked neck and the normally feathered chicken, but both had significantly (\(P < 0.05\)) lower spleen weights than those of the naked neck chicken. This is in agreement with the findings of Galal et al., (2007), who reported that the heterozygous naked neck genotype had significantly higher relative thymus and spleen weights compared with normal type. They suggested that the presence of the naked neck gene in a single state increased the relative weights of the lymphoid organs in the chicken. Fathi et al., (2013) also stated that the \(F\) gene is localized in the feather follicle, and this influences the internal organs (spleen, gizzard, heart, and alimentary canal) by causing abnormalities in the internal organs and structural abnormality in the feathers.

**Drumstick, Thigh, Wing, Neck, Breast, and Breast Muscle Weight** Frizzled-naked neck chicken had drumstick weight (400.9 g) that was not significantly different (\(P > 0.05\)) from the weights recorded by the other genotypes. Thigh weights of the naked neck (194.7 g) and frizzled-naked neck chicken (192.9 g) were also not significantly higher than those of normal feathered chicken (192.1 g). However, wing weights of the naked neck (152.0 g) and frizzled-naked neck chicken (153.7 g) seemed to be slightly higher than those of normal feathered chicken (151.4 g), but the observed differences in wing weights among the 3 genotypes were not statistically different (\(P > 0.05\)).

The breast weights for the 3 genotypes were 248.0, 246.5, and 245.5 g, respectively, for normal feathered, naked neck, and frizzled-naked neck chicken, and there

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Table 4. Mean live weight and weights of carcass parameters of the 3 genotypes (i.e., nanaff, Nanaff, NanaFf).

| Genotype   | Parameter (g) | LW | BW | DFW | DW | CW | NW | BsW | BMW | TW | WW | GW | HW | SW | l.s.d. | s.e.d. | \(P\)-value |
|------------|---------------|----|----|-----|----|----|----|-----|-----|----|----|----|----|----|--------|--------|-------------|
| nanaff     |               | 1,730 | 1,671 | 1,497 | 1,317 | 1,053 | 81.1 | b  | 248.0 | 167.3 | 386.5 | 192.9 | 192.1 | 151.4 | 42.1 | 6.87 | 3.67 | b |
| Nanaff     |               | 1,767 | 1,697 | 1,573 | 1,373 | 1,060 | 95.5 | a  | 246.5 | 169.9 | 385.0 | 194.7 | 194.7 | 152.0 | 47.7 | 6.87 | 4.07 | a |
| NanaFf     |               | 1,687 | 1,610 | 1,510 | 1,300 | 1,053 | 83.4 | b  | 245.5 | 171.0 | 400.9 | 23.8 | 23.8 | 23.8 | 23.8 | 23.8 | 23.8 | b |
| l.s.d.     |               | 146.90 | 145.60 | 137.81 | 122.70 | 119.40 | 9.87 | 29.40 | 23.56 | 45.05 | 22.32 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 |
| s.e.d.     |               | 72.80 | 72.10 | 68.30 | 60.80 | 59.20 | 4.89 | 14.57 | 11.67 | 22.32 | 11.81 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 |
| \(P\)-value|               | 0.551 | 0.468 | 0.493 | 0.882 | 0.991 | 0.011 | 0.986 | 0.845 | 0.737 | 0.975 | 0.943 | 0.135 | 0.419 | 0.002 |

a,b means within column bearing different superscripts are significantly different.
were no significant differences \( (P > 0.05) \) among the 3 genotypes. The lack of significant differences among these chicken cuts (parts) was earlier reported by Patra et al., (2002). Also, the breast muscle weight recorded in this study was not significantly higher than that of the normal feathered chicken.

Neck weight for naked neck chicken (95.5 g) was significantly higher \( (P < 0.05) \) compared with the neck weights of normal feathered (81.1 g) and frizzled-naked neck chicken (83.4 g). The normal feathered and frizzled-naked neck had similar \( (P > 0.05) \) neck weights. This observation agrees with the findings of Kgwatalala et al., (2013), who recorded a significantly higher neck weight for naked neck compared with the normal feathered birds. The main effect of the naked neck gene is the reduction of the whole feather coverage especially in the neck which is approximately 20 to 30% (Galal, 2000). The heavier neck weight associated with the Na gene could be attributed to the feather reduction associated with this gene, consequently saving more protein for muscle weight as reported by other researchers (Adedeji et al., 2006; Galal et al., 2007). According to Reddy et al., (2015), reduced feather coverage helps to improve and enhance heat dissipation and consequently alleviate the effects of heat on chickens reared in hot climates. In addition, reduced feathering saves on the amount of protein required to form feathers, and such protein that would have been used to form feather would now be used for meat tissue development.

**CONCLUSION**

The naked neck and frizzling genes have no effect on the hematological parameters which determine chicken health. From a health point of view, the indigenous naked neck genotype seems superior because its fat and cholesterol contents were low. Thus, it is strongly recommended that there should be a conscious effort to develop and commercialize the naked-neck and frizzled birds especially in developing countries.

**ACKNOWLEDGMENTS**

The authors are grateful to the management and staff of Akate Farms and Trading Company, especially to Adomako Kweku (now a lecturer at KNUST).

**REFERENCES**

Adedeji, T. A., O. A. Adebambo, S. O. Peters, L. O. Ojedapo, and A. O. Ige. 2006. Growth performance of crossbred and purebred chickens resulting from different Sire strain in a humid tropical environment. J. Anim. Vet. Adv. 5:674–678.

Adedeji, T. A., O. A. Adebambo, S. O. Peters, L. O. Ojedapo, and A. O. Ige. 2006. Growth performance of Nigerian local chickens in crosses involving an exotic broiler breeder. Trop. Anim. Health Prod. 43:643–650.

Akate Farms and Trading Company Limited. 2009. Kumasi, Ghana. Annougi, A. A., and A. S. Folornuo. 2003. Biochemical evaluation of the Gleina arborea fruit meal as swine feedstuff. Biokemistri 15:1–6.

Azbarral, I. M., H. Ranvig, and M. A. R. Howlider. 2005. Comparison of growth rate and meat yield characteristics of cockerels between Fayoumi and Sonali under village conditions in Bangladesh. Livest. Res. Rural Dev. 17.

Campbell, T. W. 1995. Avian Haematology and Cytology. Iowa State University Press, Ames, Iowa.

Esou, B. O., U. O. Enenhalom, A. B. I. Udedibie, U. Herbert, C. F. Ekpor, I. C. Okoli, and F. C. Inheukwunie. 2001. Performance and blood chemistry of weaner pigs fed raw mucinuma (Velvet bean) and meal. Trop. Anim. Prod. Invest. 4:49–55.

Fathia, M. M., A. Galal, S. El-Safty, and M. Mahmoud. 2013. Naked neck and frizzle genes for improving chickens raised under high ambient temperature: I. Growth performance and egg production. Worlds Poult. Sci. J. 69:813–832.

Galal, A. A., M. H. Ahmed, U. M. Ali, and H. H. Younis. 2007. Influence of Naked Neck gene on laying performance and some haematological parameters of dwarfing hens. Int. J. Poult. Sci. 6:807–813.

Galal, A. A. 2000. Pleiotropic effects of naked neck, frizzled and double segregation genes on some phenotypic and genetic parameters of chickens under hot environmental conditions. Egypt Poult. Sci. 20:945–960.

Genstat 2009. Genstat Discovery Twelfth Edition. Genstat Release 12.1 DE, VSN International Ltd., Genstat Co., UK.

Islam, M. S., N. S. Lucky, M. R. Islam, A. Ahadi, B. R. Das, M. M. Rahman, and M. S. I. Siddiqui. 2004. Haematological parameters of Fayoumi, Asil and local chickens reared in Sylhet region in Bangladesh. Int. J. Poult. Sci. 3:144–147.

Jain, N. C. 1993. Essential of Veterinary Haematology. Lea and Febiger, Philadelphia, pp. 134–160.

Kgwatalala, P. M., A. M. Bolowe, K. Thutwa, and S. J. Nsoso. 2013. Carcass traits of the naked-neck, dwarf and normal strains of indigenous Tswana chickens under an intensive management system. Agric. Biol. J. N. Am. ISSN Print: 2151-7517, ISSN Online: 2151-7525, https://doi.org/10.5251/abjna.2013.4.4.413-418 © 2013, ScienceHui.

Khawaja, T., S. H. Khan, A. Parveen, and J. Iqbal. 2016. Growth performance, meat composition and haematological parameters of first generation of newly evolved hybridized pure chicken and their crossbred parents. Veterinarski Arhiv 86:135–148.

Khawaja, T., S. H. Khan, N. Mukhtar, A. Parveen, and T. Ahmed. 2013. Comparative study of growth performance, meat quality and haematological parameters of three-way crossbred chickens with reciprocal F1 crossbred chickens in a subtropical environment. J. Appl. Anim. Res. 41:300–308.

Kumar, N., Z. N. Belay, A. M. Shenkutie, and H. Taddele. 2014. Comparative study of performance of Rhodes Island red and Bovans white under intensive management in Mekelle, Ethiopia. Int. J. Livest. Res. 4:92–98.

Kral, I., and P. Suchy. 2000. Haematological studies in adolescent breeding cockerels. Acta Vet Brno 69:189–194.

Ladokun, A. O., A. Yakubu, J. B. Otite, J. N. Omeje, O. A. Sokumbi, and E. Onyefuji. 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. 7:55–58.

Machebe, N. S., A. G. Ezekwe, and M. O. Amaechegonwu. 2010. Physiological response of breeding gilts to varying protein diets. Int. J. Sci. Nat. 1:136–139.

Madubuike, F. N., and B. U. Ekenyem. 2006. Haematological and serum biochemistry characteristics of broiler chicks fed varying dietary levels of Ipomoea asarifolia leaf meal. Int. J. Poult. Sci. 5:09–12.

Margaret, A. W. 2001. Avian Plasma Proteins. Accessed April 2014. http://www.exoticpetvet.net.

Oke, U. K., U. Herbert, C. O. Ebuzoeme, and E. N. Nwachukwu. 2007. Effect of genotype on the haematology of Nigerian local chickens in a humid tropical environment. In Proc. 32nd Annual Conference of Nigerian Society for Animal Production (NSAP). Calabar, Nigeria 18th-21st March, pp. 18-21.

Olayeni, T. B., L. O. Ojedapo, O. S. Adeleji, T. A. Adeleji, and S. A. Ameen. 2006. Effects of feeding varying levels of castor fruit meal \( (Ricinus communis) \) on performance characteristics of layers. J. Anim. Vet. Adv. 5:515–518.

Parveen, A. S. H. Khan, T. Khawaja, N. Iftikhar, and S. Khan. 2017. Growth performance and haemato-biochemical parameters of different breeds of rural chickens. J. World Poult. Res. 7:114–122.
Patra, B. N., R. K. S. Bais, R. B. Prasad, and B. P. Singh. 2002. Performance of naked neck (Na) versus normally feathered colour broilers for growth, carcass traits and blood biochemical parameters in tropical climate. Asian Australas J. Anim. Sci. 15:1776–1783.

Pollock, C., J. W. Carpenter, and A. Natalic. 2001. Exotic Animal Formulary. Elsevier Sauders, p. 273.

Reddy, M. V., V. C. Preetam, A. R. Reddy, U. R. Kumar, V. R. Reddy, K. Gautham, D. Harceesh, and P. G. Vishnu. 2015. Phenotypic characterization of Indian naked neck chicken under tropical climatic conditions. Asian J. Anim. Vet. Adv. 10:527–536.

Ritchie, B. W., G. J. Harrison, and L. R. Harrison. 1994. Avian Medicine: Principles and Application. Wingers Publishing Inc., Lake Worth, FL.

Sonaiya, E. B., R. D. S. Branckaert, and E. F. Gueye. 1999. The scope and effect of family poultry research and development. In Research and Development options for family poultry. First-INFPD/FAO Electronic Conference on Family Poultry.