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Effect Of Breed Differences On Growth Performance, Haematology And Serum Biochemical Indices Of Indigenous And Commercial Broiler Chickens.

Garba H., Egena S.S.A., Otu B.O., and Sikiru A.B.

Department of Animal Production, Federal University of Technology, P.M.B. 65, Minna, Niger State, Nigeria

Correspondence: husgabejiza@gmail.com

ABSTRACT

This study aimed to compare the feed intake, growth performance, and carcass characteristics of Fulani ecotype chickens, Noilers, and broilers (Cobb-500) to optimize feeding strategies and improve poultry production efficiency in Nigeria. A total of 300-day-old birds of mixed sexes were used, with 100 each of the Fulani ecotype, Noiler, and Broiler chickens randomly allotted into three experimental treatments. Each treatment was replicated five times with 20 birds per replicate in a completely randomized design (CRD). The birds were fed an experimental diet formulated to contain 21% crude protein and 2900 Kcal ME/kg in a single-phase feeding regime. Feed and water were provided ad libitum throughout the experimental duration of 22 weeks for Fulani ecotype (T1) and Noilers (T2), while broilers (T3 as the control) were fed for 8 weeks. The results indicated significant differences ($p<0.05$) in daily feed intake among the species, with broilers consuming the most feed, followed by Noilers, and then Fulani ecotype chickens. Carcass analysis also revealed that broilers had the highest weights and meat yield, while Noilers exhibited intermediate values, and Fulani ecotype chickens had the lowest. These findings suggest that while broilers are best suited for commercial meat production, Noilers offer a balanced option for dual-purpose production, and Fulani ecotype chickens are better adapted to low-input systems. In conclusion, understanding the distinct characteristics of these breeds is essential for developing tailored feeding practices that can enhance productivity, reduce waste, and support sustainable poultry farming in Nigeria.

Keywords: Poultry; Feed; Growth performance; Carcass; Indigenous; chicken

INTRODUCTION

Poultry is arguably one of the most popular sources of animal protein for Nigeria's evergrowing population [1]. However, the high cost of feed and poor disease resistance has made an over-reliance on commercial poultry breeds a significant risk for some farmers. Additionally, the preference of many consumers for local chicken meat, due to its superior organoleptic properties, gives local chicken breeds a comparative advantage [2]. Unfortunately, these advantages are countered by the slow growth performance of local chicken breeds. Studies have shown that commercial broilers exhibit a higher growth rate than local Nigerian chickens [3].

Poultry has been genetically improved to increase body weight gain, feed efficiency, growth rate, and breast muscle weight to meet consumer demands [4]. Selection processes have produced modern commercial chicken lines with a higher

growth rate, increased breast meat yield, better feed conversion rates, and higher body fat compared to unselected lines [5]. Therefore, harnessing the growth potential of local stock, while maintaining their established organoleptic profile, could provide a credible investment alternative. This would mitigate the risks associated with investing in commercial breeds, such as high feed consumption, poor disease resistance, high morbidity, high mortality, and lower consumer acceptance due to poor organoleptic qualities. Haematological parameters are important indices in assessing the physiological state of both humans and animals [6-9]. Blood serves as a medium for transporting nutrients absorbed from the digestive system or released from storage in adipose tissues or the liver. Significant haematological parameters with diagnostic value include packed cell volume (PCV), haemoglobin (Hb), all of which affect health, production, and adaptability to environmental conditions in livestock [10-12]. As reviewed by Mannello [15], using the wrong matrix (e.g., plasma instead of serum) can lead to improper diagnosis. Both plasma and serum are derived from whole blood that has undergone different biochemical processes after collection serum was obtained from coagulated blood.

MATERIALS AND METHODS

The research was conducted at the Teaching and Research Farm on both the Bosso and Gidan Kwano campuses of the Department of Animal Production, Federal University of Technology, Minna. Laboratory work was carried out in the departmental laboratories of Animal Production and Biochemistry at the university, as well as at the African Biosciences Laboratory in Ibadan. The Bosso campus is situated between latitudes 9° 28′ and 9° 37′ N, and longitudes 6° 23′ and 6° 33′ E, while the Gidan-Kwano campus is located at latitude 9° 51′ N and longitude 6° 44′ E. The mean annual rainfall of the study area varies from 1102.6 to 1361.7 mm. The vegetation is classified as Southern Guinea Savannah, and the area lies at an altitude of 147 meters above sea level [16].

The indigenous birds used in the study included Fulani ecotype and Noiler chickens. The parent stock of the Fulani ecotype was sourced from nearby villages within the Bosso Local Government Area of Niger State, Nigeria, and was used to generate the chicks for the study. The Noiler and Broiler chickens were procured from Amo Hatchery, Ibadan. Maize, maize offal, and protein concentrate used in feed compounding were sourced from the open market and agro mill shops. Drugs and vaccines were obtained from an agroveterinary store within Minna metropolis. Feeders, watering troughs, wood shavings, and wire mesh used for constructing the pens were all sourced from within Minna. The heat source for brooding the birds was provided by electric bulbs and charcoal pots. The single-phase experimental diet fed to the birds was formulated to contain 21% crude protein and 2900 Kcal/kg ME (Table 3.1). The feed was provided ad libitum for 22 weeks to the birds in experimental treatments T1 (Fulani ecotype) and T2 (Noiler). Treatment T3 (Arbor Acre) was fed the diet only for the last 8 weeks of the experiment. A total of 300-day-old unsexed chicks were used in the study. One hundred chicks each of the Fulani ecotype, Noiler, and Arbor Acre breeds were randomly allotted to the four treatments, with five replicates per treatment, each containing twenty birds per replicate, in a Completely Randomized Design (CRD) arrangement.

MATERIALS AND METHODS

Experimental Location

The research was conducted at the Teaching and Research farm at both campuses (Bosso and Gidan Kwano) of the Department of Animal Production, Federal University of Technology, Minna. Laboratory works were conducted in the departmental laboratories of Animal Production and Biochemistry of the

university, and at the African Biosciences laboratory Ibadan. Bosso campus is situated between latitude 9° 28′ and 9° 37′ N, longitude 6° 23′ and 6° 33′ E; while Gidan-Kwano campus is situated at latitude 9° 51 'N and longitude 6° 44 'E. The mean annual rainfall of the study area varies from 1102.6 to 1361.7 mm. The vegetation is Southern guinea savannah, and it lies at an altitude of 147 m above sea level (Njoku *et al*., 2021).

Experimental Materials

The indigenous birds used in the study include the Fulani ecotype, Noiler chickens and Broiler chickens. Parent stock of the Fulani ecotype was sourced from nearby villages within Bosso Local Government Area of Niger State, Nigeria, and used to generate the chicks used for the study. The Noiler and Broiler chicken chickens were procured from Amo hatchery, Ibadan. Maize, maize offal, and protein concentrate used in feed compounding were sourced from the open market and agro mill shops. Drugs, and vaccines were sourced from an agro veterinary store within Minna metropolis. Feeders and watering trough, wood shavings, and wire mesh used in constructing the pens were all sourced from within Minna. Heat source for brooding the birds was via electric bulb, and charcoal pots.

Experimental Materials The birds used in this study include the Fulani ecotype, Noiler, and Broiler birds. Maize, maize offal, and broiler concentrates were used for diet formulation. Other materials used were feeding and drinking troughs, wood shavings, and wire mesh to construct the pens. Heat sources for brooding birds (electric bulb and charcoal heat source) were also used during the study.

Source of Experimental Materials

Parent stock of the Fulani ecotype fowl was sourced from the open market within Bosso Local Government Area of Niger State, Nigeria, to generate the birds used in this study, while the Noiler and Broiler chicken birds were procured from Amo hatchery, Ibadan. The feed ingredients used in the study (Maize, maize offal, and broiler concentrates) were sourced from the open markets and an agro mill shop within the Bosso local government area of Niger State. Drugs and vaccines were sourced from an accredited agro-veterinary store within the Minna metropolis.

Experimental Diet and Design

A total of 300-day-old birds of mixed sexes were used in this study. One hundred each of the Fulani ecotype, Noiler and Broiler chicken birds were randomly allotted into three experimental treatments. Each treatment was replicated five times with twenty birds (20) per replicate in a completely randomized design (CRD). The birds were grouped into three treatments with Fulani ecotype as treatment 1 (T_1), Noiler birds as treatment 2 (T_2) and Broiler birds as treatment 3 (T_3 as the control). The birds were fed an experimental diet formulated to contain 21 % crude protein and 2900 Kcal ME/kg (Table 1) in a singlephase feeding regime. Feed and water were served *ad libitum* throughout the experimental duration of 22 weeks for T1 and T2, while T3 was fed for 8 weeks.

RESULTS

The Table 1 summarizes the growth performance characteristics of four experimental chicken groups-Fulani Ecotype (T1), Noiler Chickens (T2), and Broiler Chickens (T3)-revealing significant differences across all parameters ($P<0.05$). Initial body weight ranged from 37.80g in T3 to 45.34g in T1, with T2 having the lowest value. Final body weight showed substantial variation, with T4 reaching the highest value of 2991.21g and T2 the lowest at 1266.00g. Body weight gain was also highest in T4 (2220.21g) and lowest in T2 (562.74g). Daily feed intake was greatest in T4 (99.05g) and

lowest in T3 (15.37g), while T1 exhibited higher intake than both T2 and T3.

These results indicate that broilers (T4) displayed the highest growth performance in terms of both weight gain and feed intake, while Guinea Fowl (T2) and Noiler Chickens (T3) had lower values for these parameters, with significant differences observed among all groups.

The Table 2 presents the haematological parameters of four chicken groups—Fulani Ecotype (T1), Guinea Fowl (T2), Noiler Chickens (T3), and Broiler Chickens (T4). Significant differences ($P<0.05$) were found in mean cell volume (MCV), mean cell haemoglobin (MCH), and eosinophil percentage, while other parameters showed no significant variation ($P>0.05$). MCV ranged from 85.67 fl in T4 to 126.27 fl in T3, with T3 having the highest value. MCH was highest in T3 (43.67 pg) and lowest in T4 (28.00 pg). Eosinophil count varied significantly, with T2 showing the maximum (3.33%) and T1 the minimum (1.67%).

The haemoglobin levels ranged from 13.00 g/dl (T4) to 18.67 g/dl (T2), and packed cell volume (PCV) ranged from 39.00% (T4) to 54.67% (T2), though these differences were not statistically significant. Other parameters, such as total white blood cell count, platelet count, and red blood cell count, also showed no significant differences. In summary, Guinea Fowl (T2) and Noilers (T3) exhibited higher values in MCV, MCH, and eosinophil count, while Broilers (T4) had lower values in some of these parameters. The results indicate that there were notable variations in certain haematological indices, which could reflect differences in the physiological adaptation of these chicken types.

Table 3 summarizes the serum biochemical profile of four chicken groups—Fulani Ecotype (T1), Guinea Fowl (T2), Noiler Chickens (T3), and Broiler Chickens (T4)—showing significant differences across most parameters ($P<0.05$). Aspartate transaminase (AST) ranged from 52.67 IU/l in T4 (Broilers) to 205.33 IU/l in T1, with Broilers having the lowest value. Alanine transaminase (ALT) was lowest in T4 (31.33 IU/l) and highest in T2 (67.67 IU/l). Alkaline phosphatase (ALP) was highest in T4 (606.33 IU/l) and lowest in T1 (444.67 IU/l).

Total protein showed no significant variation, ranging from 4.33 g/dl in T2 to 5.67 g/dl in T3, while albumin remained constant across all groups at 3.00 g/dl. Glucose levels were highest in T2 (15.00 µmol/l) and lowest in T1 (10.00 µmol/l). Cholesterol was significantly lower in T3 (2.33 mg/dl) compared to the other groups (3.00 mg/dl). The findings suggest that Broiler chickens (T4) had the lowest AST and ALT values but the highest ALP levels, while Guinea Fowl (T2) showed elevated glucose and ALT. Noiler Chickens (T3) had lower cholesterol, indicating physiological differences in liver function and metabolism among the groups.

DISCUSSION

The study on feed intake among different poultry species Fulani ecotype chickens, Noilers, and broilers revealed significant differences ($p<0.05$) in their daily feed consumption. These variations can be attributed to several factors, including genetic makeup, growth rates, metabolic needs, and overall body size. Fulani ecotype chickens, which are indigenous breeds known for their adaptability to harsh environmental conditions and low-input systems, typically have lower feed intake compared to commercial breeds like broilers. This is due to their smaller body size and slower growth rates. Their feed intake is also influenced by their ability to forage and their lower metabolic requirements.

Noilers, a hybrid breed developed for dualpurpose use (meat and eggs), tend to have a moderate feed intake. They are bred

to grow faster and larger than indigenous chickens like the Fulani ecotype, but not as **intensively as broilers** [17]. Consequently, their feed consumption rate is higher than that of Fulani ecotype chickens but lower than that of broilers. The balance between growth rate and feed efficiency is a key characteristic of Noilers. Broilers, on the other hand, are commercial meat chickens bred specifically for rapid growth and high feed efficiency. As a result, their daily feed intake is significantly higher than that of the other species. Broilers are designed to convert feed into body mass very efficiently, resulting in high feed consumption to support their fast growth rates and large body size.

The significant differences in daily feed intake among these poultry species reflect their varying physiological and metabolic needs. Broilers, with their fast growth rates and larger body sizes, require more feed compared to the other breeds [18]. This contrasts with the slower-growing Fulani ecotype chickens, which consume less feed daily. Genetic predisposition plays a crucial role in feed intake. Broilers have been selectively bred for high feed efficiency and rapid growth, while indigenous breeds like Fulani ecotype chickens have adapted to survive on less feed. The nutrient composition of the feed can also affect intake. Broilers may have higher protein and energy requirements to support their growth, leading to increased feed consumption.

Fulani ecotype chickens are more likely to forage when allowed, potentially reducing their reliance on provided feed compared to the more confined broilers and Noilers.

Understanding these differences is crucial for optimizing feeding strategies and improving the efficiency of poultry production systems in Nigeria. By tailoring feeding practices to the specific needs of each breed, farmers can enhance growth performance, reduce waste, and improve overall productivity. Additionally, these insights can guide breeding programs and nutritional research to further enhance poultry efficiency and sustainability [19]. The carcass characteristics of the selected poultry species in Nigeria (Table 1) showed significant ($p<0.05$) differences between the treatments in live weight, slaughter weight, plucking weight, dressed percentage, breast percentage, and wing percentage. However, there were no significant ($p>0.05$) differences in dressed weight, thigh percentage, drumstick, and back percentage.

Broiler chickens had the highest values for all parameters except plucked weight, where Noiler chickens had the highest values. Generally, broiler chickens have higher weights compared to indigenous species like Fulani ecotype chickens. Noiler chickens, which are hybrids of indigenous and commercial breeds, show intermediate values for most parameters, indicating their potential as dual-purpose birds for meat and egg production [20]. Indigenous species like Fulani ecotype chickens exhibit lower weights and different carcass compositions compared to commercial breeds, reflecting their adaptation to local environments and traditional management systems [21]. The variation in percentages of different cuts reflects genetic differences in body conformation and market preferences.

Broiler chickens are bred for high breast meat yield, while indigenous species may have different proportions of meat cuts that are preferred in local cuisines.

The haematological parameters of the experimental chickens revealed that while most parameters, such as haemoglobin, packed cell volume (PCV), and red blood cell count, showed no significant differences, notable variations were observed in mean cell volume (MCV), mean cell haemoglobin (MCH), and eosinophil count. The significantly higher MCV and MCH in Noiler chickens (T2) suggest enhanced

oxygen-carrying capacity and better overall physiological function compared to other groups.

The serum biochemical analysis indicated significant differences in liver enzyme activity and metabolic indicators among the chicken breeds. Broiler chickens (T3) had the lowest aspartate transaminase (AST) and alanine transaminase (ALT) levels, suggesting less hepatic stress compared to other groups, while their high alkaline phosphatase (ALP) levels may be linked to rapid growth and bone metabolism. Noiler chickens (T2) had lower cholesterol levels, which may indicate better lipid metabolism or energy utilization efficiency. These findings suggest breed-specific metabolic differences, with broilers optimized for rapid growth and Noilers exhibiting traits favourable for dual-purpose production.

Parameter	T1	T2	T3	SEM	P-value	LS
Initial body weight (g)	45.34^{c}	39.56^{b}	37.80^{c}	0.74	0.00	*
Final body weight (g)	1526.70^{b}	2648.49^{c}	2991.21^{d}	169.92	0.00	*
Body weight gain (g)	729.00^{a}	1863.85^{b}	2220.21^{c}	166.32	0.00	*
Daily feed intake (g)	24.54^{b}	15.37^{a}	99.05^{c}	8.02	0.00	*

^{abc}Means denoted by different superscripts along the same row differ (P<0.05) significantly. *Significant (P<0.05); SEM: Standard Error of Mean; LS: Level of Significance. T1: Fulani Ecotype; T2: Noiler Chickens; T3: Broiler Chickens

Table 2: Haematological parameters of the experimental chicken investigated ^{abc}Means denoted by different superscripts along the same row differ (P<0.05) significantly. *significant (P<0.05); NS: Not significant (P>0.05); SEM: Standard Error of Mean. LS: Level of Significance; %: percentage. T1: Fulani

Parameters	T1	T2	T3	SEM	P-value	LS
Haemoglobin (g/dl)	13.67	16.67	13.00	1.01	0.15	NS
Packed cell volume (%)	41.67	49.00	39.00	2.98	0.24	NS
Mean cell volume (fl)	9.00^{ab}	126.27^{c}	85.67^{a}	5.92	0.02	*
Mean cell hemoglobin (pg)	29.67^{a}	43.67^{b}	28.00^{a}	2.09	0.00	*
Mean cell hemoglobin concentration (g/dl)	29.67	29.33	30.33	0.22	0.38	NS
Total white blood cell (X10$^{9/l}$)	168.33	175.00	160.00	19.54	0.46	NS
Platelat count (X10$^{9/l}$)	382.67	354.33	353.33	18.72	0.94	NS
Neutrophil (%)	40.33	18.33	33.00	3.68	0.20	NS
Lymphocytes (%)	53.67	74.00	56.33	4.06	0.32	NS
Monophils (%)	4.00	5.67	8.00	0.76	0.31	NS

Eosinophils (%)	1.67[a]	2.00[a]	2.00[a]	0.22	0.01	*
Basophils (%)	0.33	0.00	0.67	0.22	0.20	NS
Red Blood Cell ($X10^{9/l}$)	4.33	4.00	5.00	0.22	0.34	NS
Red blood distribution width count (%)	12.00	11.67	12.00	0.11	0.60	NS

Ecotype; T2: Noiler Chickens; T3: Broiler Chickens

Parameters	**T1**	**T2**	**T3**	**SEM**	**P-value**	**LS**
Aspartate transaminase (IU/l)	205.33[b]	188.33[d]	52.67[a]	18.20	0.00	*
Alanine transaminase (IU/l)	35.67[b]	42.00[c]	31.33[a]	4.28	0.00	*
Alkaline phosphatase (IU/I)	444.67[a]	511.0[b]	606.33[d]	17.54	0.00	*
Total protein (g/dl)	5.33[b]	5.67[b]	5.00[ab]	0.19	0.06	NS
Albumin (g/dl)	3.00	3.00	3.00	0.00	0.60	*
Globulin (g/dl)	2.33	2.33	2.00	0.11	0.00	NS
Glucose (µmol/l)	10.00[a]	12.67[b]	11.67[b]	0.57	0.00	*
Cholesterol (mg/dl)	3.00[b]	2.33[a]	3.00[b]	0.11	0.05	*

[abc]Means denoted by different superscripts along the same row differ (P<0.05) significantly. *significant (P<0.05); NS: Not significant (P>0.05); SEM: Standard Error of Mean. LS: Level of Significance. T1: Fulani Ecotype; T2: Noiler Chickens; T3: Broiler Chickens.

CONCLUSION

This study highlights the significant differences in feed intake, growth performance, and carcass characteristics among various poultry species, including Fulani ecotype chickens, Noilers, and broilers. These differences are largely influenced by genetic factors, growth rates, metabolic needs, and body size. Broilers, bred for rapid growth and high feed efficiency, exhibited the highest feed consumption and carcass weights, making them suitable for commercial meat production. Noilers, as a hybrid breed, demonstrated intermediate feed intake and carcass characteristics, showing potential as dual-purpose birds for both meat and egg production. In contrast, Fulani ecotype chickens, with their slower growth rates and lower feed intake, are well-adapted to low-input systems and preferred by consumers for their organoleptic properties. Understanding these variations is crucial for optimizing feeding strategies, improving productivity, and guiding breeding programs to enhance the sustainability of poultry farming in Nigeria.

REFERENCES

1. Mohammed AB, Mohammed SA, Ayanlere AF, Afolabi OK. Evaluation of poultry egg marketing in Kuje Area Council Municipality of FCT Abuja, Nigeria. Greener J Agric Sci. 2013;3(1):68-72.

2. Debora CFS, Alex MVA, Alex AG. Quality characteristics of broiler chicken meat from free-range and industrial poultry system for the consumers. J Food Sci Technol Mysore. 2017;54(4).

3. Ajayi FO, Agaviezor BO. Fertility and hatchability performance of pure and crossbred indigenous chicken strains in the high rainforest zone of Nigeria. Int J Livest Prod. 2016;7:141-144.

4. Wang SZ, Hu XX, Wang ZP, et al. Quantitative trait loci associated with body weight and abdominal fat traits on chicken chromosomes 3, 5 and 7. Genet Mol Res. 2012;11:956-965.

5. Baeza E, Le Bihan-Duval E. Chicken lines divergent for low or high abdominal fat deposition: A relevant model to study the regulation of energy metabolism. Animal. 2013;7:965-973.

6. Khan TA, Zafar F. Hematological study in response to varying doses of estrogen in broiler chicken. Int J Poult Sci. 2005;4(10):748-751.

7. Animashaun RA, Omoikhoje SO, Bamgbose AM. Rabbits fed concentrates and Syndrella nudiflora forage. Sci Assoc Nigeria, Institute Agric Res Train. Ibadan, Nigeria. 2006:29-32.

8. Bhatti JA, Younas M, Abdullahi ME, Baber M, Nawoz H. Feed intake, weight gain and hematology in NiliRavi buffalo heifers fed on motgrass and barseem fodder substituted with

saltbush (Atriplex amnicola). Pak Vet J. 2009;29(3):133-137.

9. Maidala A, Garba AR, Maidala A, Doma UD, Egbo LM. Hematological and serum biochemical indices of broiler chickens fed differently processed African locust bean seeds (Parkia biglobosa). Nig Soc Anim Prod. 2014;16-19 Mar: Babcock Univ, Ilishan-Remo, Ogun State, Nigeria.

10. Medugu CI, Kwari ID, Igwebuike J, Nkama I, Mohammed ID, Hamaker B. Carcass and blood components of broiler chickens fed sorghum or millet as replacement for maize. Agric Biol J N Am. 2010;1(3):326-329.

11. Adenkola AY, Ayo JO. Effect of ascorbic acid on rectal temperature fluctuations in indigenous turkeys during hot dry season. Int J Poult Sci. 2009;8(5):457-461.

12. Adenkola AY, Idoga ES, Tughgba T. Comparative assessment of erythrocyte osmotic fragility and hematological parameters of broiler and local chicken during the hot-dry season in Makurdi, Nigeria. Proceedings of 36th Annual Conference of Nigerian Society of Animal Production. 2011:117-119.

13. Jaffe AS, Ravkilde J, Roberts R, Naslund U, Apple FS. It's time for a change to a troponin standard. Circulation. 2000;102:1216-1220.

14. Sacks DB, Bruns DE, Goldstein DE, Maclaren NK, McDonald JM. Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Clin Chem. 2002;48:436-472.

15. Mannello F. Serum or plasma samples? The "Cinderella" role of blood collection procedures. Preanalytical methodological issues influence the release and activity of circulating matrix metalloproteinases and their tissue inhibitors, hampering diagnostic trueness and leading to misinterpretation. Arterioscler Thromb Vasc Biol. 2008;28:611-614. doi:10.1161/ATVBAHA.107.159608.

16. Usman HI. Effects of time of intercropping soybean on weed suppression and performance of upland rice in southern guinea savanna of Nigeria [PhD thesis]. Federal University of Technology Minna; 2011:24.

17. Dogara MU, Kalla DJU, Mancha YP, Shuaibu A. Evaluation of egg production and egg quality traits of Noiler chickens. Niger J Anim Sci. 2021;23(2):100-113.

18. Buzala M, Janicki B. Effects of different growth rates in broiler breeder and layer hens on some productive traits. Poult Sci. 2016;95(9):2151-2159.

19. Zampiga M, Calini F, Sirri F. Importance of feed efficiency for sustainable intensification of chicken meat production: implications and role for amino acids, feed enzymes, and organic trace minerals. World's Poult Sci J. 2021;77(3):639-659.

20. Fayeye TR, Adeshiyan AB, Olugbami AA. Egg traits, hatchability and early growth performance of the Fulaniecotype chicken. Livest Res Rural Dev. 2005;17:48.

21. Bello KO, Adeola AA, Akerele D, Adeyeye OA, Irekhore OT, Famakinde SA. Optimisation and multiplication of large Fulani eco-type chicken for sustainable production and genetic security in Nigeria. In: Food Security and Safety: African Perspectives. 2021:255-269.