Comparative developmental trajectory of four strains of chicken embryo during incubation and their post-hatch growth*¹Oke, O. E., ¹Obanla, L. O., ¹Onagbesan, O. M. and¹Daramola, J. O.,¹Department of Animal Physiology, Federal University Of Agriculture, Abeokuta, Nigeria. ²Department of Animal Nutrition, Federal University Of Agriculture, Abeokuta, NigeriaCorresponding author: emaake7@yahoo.co.uk **Abstract**

This study evaluated egg traits, embryonic growth, and early growth rate in four strains of chicken. A total of 1200 hatching eggs, 300 each from four strains of chicken were used for this study. The strains included Nigerian indigenous chicken (NIC), Arbor acre, Hubbard, and Marshall broiler strains. Embryonic weights, yolk and albumen utilization were monitored throughout the incubation period. The chicks were randomly distributed into four rearing pens for a 28-day assessment of growth rate. Blood samples were collected at hatch (day-old), week 1, 2, 3 and 4 post-hatch for thyroxine (T_4) level determination. This study showed that the embryos percentage weight gains were similar in the NIC and the broiler strains at embryonic (ED) 18. There was no difference ($P>0.05$) in the rate of albumen utilization among the strains. At hatching, there was no difference ($P>0.05$) in the metabolic rate among the strains of chicken as shown by the levels of plasma T_4 until later in the growth phase. The day-old chick weight and the weights in subsequent weeks post-hatch were smaller in the NIC than the broiler strains possibly as a result of low hatching weight and growth rate of the NIC in the first two weeks post-hatch. The early growth difference could not be explained by physiological parameters such as T_4 . However, the differences in post-hatch physiological and metabolic parameters may be due partly to genetic differences. It was concluded that embryonic development in the broiler strain was not superior to that of the NIC.

Key words: Growth rate, metabolic rate, albumen utilization**Introduction**

Chicken performance is known to be related to embryonic developmental parameters. However, strain or genotype differences with regard to embryo physiological parameters and juvenile growth have received little attention (Tona *et al.*, 2010). The process from the time of egg formation to hatching is very complex, and the hatching results may be influenced by many factors. Current incubation

requirements and practices have been summarized by Wilson (1991). These practices include setting eggs large end up, turning once per hour and providing a temperature of 37.5°C, and a relative humidity of 60% during the first 19d of incubation. During the last two days the temperature should be decreased to 37.0°C, and the humidity increased to 75%. At this time it is no longer necessary for eggs to be turned. Despite following all the precise

incubation requirements for the successful hatch of fertile eggs, it is necessary to understand how some biological factors limit the hatchability of eggs of Nigerian indigenous chicken and the chicks' performance. Lauren *et al.* (2005) established that incubation protocol influences post-hatch performance.

Indigenous poultry birds are well adapted to harsh environment of free range and they produce eggs and meat at least possible cost. The birds require no extra care and housing which makes them suitable for backyard poultry farming (Parmar *et al.*, 2006). Broilers are fast growing birds that reach a market weight of 1.6-2 kg in 8-10 weeks. Comparative study of indigenous chickens with the exotic strains of broiler is necessary for proper understanding of how to boost production under the prevailing extensive condition and their possible inputs for the development of commercial chicken type. The resource is economically important to the people of Nigeria. This is necessary because rearing of indigenous chicken demands the use of very little resources and brings financial reward in a short while. The Food and Agricultural Organization recognizes these fact and views rural poultry as an important tool for poverty alleviation in Africa.

There is a dearth of information on the growth trajectory, hormonal profile and the possible causes of mortality of the indigenous chicken during incubation in Nigeria. The local chickens are also being improved alongside different lines. It is not clear whether the eggs should be incubated using the same protocol as established for either broiler or layer type of chickens. Moreover, there is a paucity of data on the comparative study of these exotic strains with the local chicken in order to ascertain the underlying genetic or physiological reasons for the difference in performance.

The null hypothesis for this study is that the difference may not only be due to genetic reasons but also to other physiological and incubation conditions.

Proper understanding can be obtained through the study of their developmental trajectory and the comparative measurement of different parameters with the exotic strains. This will enable the development of an incubation and selection protocol to match their required performance. The objective of the present study was to evaluate the embryonic development of the local chicken in comparison with the exotic strains under similar incubation protocol normally practiced for the exotic strains and their post-hatch growth.

Materials and Methods

The experiment was conducted in a deep litter house in the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. It falls within the rainforest vegetation zone of South-Western Nigeria at Latitude 7°13'49.46"N, Longitude 3°26'11.98"E and altitude of 76m above sea level. The climate is humid with a mean annual rainfall of 1037mm. The annual mean temperature and humidity is 34.7°C and 82%, respectively.

A total of 1200 eggs (300 eggs each from three exotic broiler strains (Arbor acre, Hubbard, and Marshall broiler) and one local chicken) were used for this study. The hatching eggs for the three exotic strains were purchased from commercial farms in Nigeria. The hatching eggs from the NIC chicken (normal feather) were purchased from the Department of Animal Breeding and Genetics of the Federal University of Agriculture, Abeokuta. Prior to incubation, the eggs were individually numbered and weighed.

The model of the incubator used was Western[®]. It is a single stage incubator. Eggs were incubated at the temperature of 37.8°C and relative humidity of 60% with oxygen concentration of 21%. On day 19, the humidity was raised to about 70% for hatching and towards the end of day 21 when all chicks would have hatched; the humidity was reduced to 60%. This allowed the chicks to dry off before being taken out. The turning angle of the incubator was 90°. Five (5) eggs from each strain were broken carefully to weigh the albumen, yolk and developing embryo at day 7, 11, 15, and 18 of incubation. Relative embryos weight to the initial weight of the egg was taken. At day 18 of incubation, the eggs were candled and those with the evidence of living embryo were transferred from the turning tray in the incubator to the partitioned hatching baskets in the hatcher.

Blood Sampling and Analysis

Blood samples were obtained from the chicks from each of the strains via the wing vein puncture at hatch, day 7, 14, 21 and 28 post hatch using gauge needle and syringe. The blood samples were collected in heparinised tubes, centrifuged (10 min, 3000 rev/min) and plasma samples were stored at -20°C until thyroxine (T_4) was analyzed. Plasma (thyroxine) T_4 concentrations were measured in plasma samples by radioimmunoassay (RIA) as described by Darras *et al.* (1992). All samples were run in the same assay in order to avoid inter-assay variability.

All data collected were analyzed using the General Linear Model procedure of SAS (1999). Significantly different means were compared using DMRT (Duncan, 1955).

Results and Discussion

Table 1 shows the albumen weight changes

during incubation in four strains of chicken. At embryonic day ED 0, Arbor acre broiler strain had higher ($P<0.05$) albumen weight than Marshall and the NIC. The lowest value was recorded for the NIC. Throughout the incubation period, there was no statistical difference in albumen weight at each developmental stage among the strains. Also, percentage relative albumen weight among the strains of chicken were similar. The albumen use was completed at day 18 of incubation in all the strains. Overall, the data shows significantly higher ($P<0.05$) albumen decrease between day 0 and 7 and between day 15 and 18. The lowest change was at day 7 to 11.

Table 2 gives an overview of the embryonic body weight and relative growth rate among four strains of chicken. The data shows differential embryo body weight and relative growth rate among strains at different stages of development during incubation. At embryonic day 7 (ED7), the embryo of the Hubbard strain had significantly higher body weight ($P<0.05$) than those of the other strains. The weight of the Nigerian indigenous chicken embryo (0.70g) was comparable to that of the Arbor acre strain (0.68g) and the Marshall Strain (0.80g). At the ED 11, the weight gain of the NIC (3.46g) was still comparable to the Marshall strain (3.92) but the weight gains were higher ($P<0.05$) in Arbor acre and Hubbard than in the NIC. However, the relative growth was higher in Arbor acre than Marshall, Hubbard and the NIC. At the ED 15, the weight gain in the NIC was comparable with that of the Arbor acre strain but significantly lower than those of Hubbard and Marshall. On body weight basis, the Hubbard strain had the highest body weight and a numerically higher relative growth than Arbor acre, Marshall and the NIC. At ED 18, the body weight of

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Table 1: Albumen weight changes (g) among four strains of chicken during incubation

Strains	Day				
	0	7	11	15	18
Arbor acre	38.40±4.18 ^a	13.54±1.67(64.09±8.17)	11.34±1.73(16.27±7.77)	4.06±1.65 (62.67±17.02)	0.00±0.00
Marshall	33.92±1.92 ^b	12.16±2.13(64.06±6.90)	9.64±1.25 (18.97±16.61)	4.28±1.47 (53.21±24.50)	0.00±0.00
Hubbard	35.38±1.26 ^{ab}	13.24±2.17 (62.61±5.61)	11.18±1.89 (12.82±23.88)	2.76±1.31 (75.91±8.45)	0.00±0.00
NIC	29.92±3.14 ^c	10.78±1.61 (63.56±7.47)	9.52±1.93 (10.37±22.16)	4.54±1.39 (49.01±23.00)	0.00±0.00

a, b, means with different superscripts differ significantly along the column (p<0.05)

NIC was similar to the weight of Marshall and Arbor acre but significantly lower than that of the Hubbard. At this stage, there was no significant difference in the relative growth among the strains. Overall relative growth was highest during ED7-ED11. Except in the Hubbard strain, growth trajectory decreased significantly (P<0.05) in the NIC, Arbor acre and Marshall strains between ED11-ED15. Between ED15 and ED18, relative growth decreased significantly (P<0.05) in all the strains.

Table 3 shows the yolk weight at the 18th day of incubation and the relative change in the yolk weight in four strains of chicken. The remaining yolk in the NIC was statistically similar to that of the Marshall and Arbor acre but lower than that in the

Hubbard (p<0.05). There was no difference in the relative change in the yolk weight at 18th day among the strains. Table 4 shows the growth rate in four strains of chicken in successive weeks after hatching (%). In the first week of growth, the growth rate was significantly different (P <0.05) among the strains. The rate in Marshall strain was higher than that of the Arbor acre while Arbor acre was higher than that of Hubbard strain and the growth in the NIC was the lowest (P <0.05). In the second week of growth however, the growth rate in the NIC was comparable to that of the Hubbard strain. The rate in Arbor acre and Marshall strains were comparably higher than those of the NIC and Hubbard. In the third week, Arbor acre strain growth rate was similar to

Table 2: Embryo weight (g) and percentage weight gain (in brackets) during incubation in four strains of chicken

Strains	Day			
	7	11	15	18
Arbor acre	0.68±0.04 ^b	4.30±0.16 ^a (534.29±42.38 ^a)	12.68±1.91 ^{bc} (196.02±5.50 ^b)	26.28±4.78 ^{ab} (113.176±63.76)
Marshall	0.80±0.07 ^{ab}	3.92±0.61 ^{ab} (394.52±98.64 ^b)	14.04±1.47 ^b (268.85±92.43 ^{ab})	26.70±1.70 ^{ab} (92.35±28.44)
Hubbard	0.94±0.17 ^a	4.14±0.17 ^a (352.67±86.50 ^b)	17.76±1.63 ^a (329.47±42.46 ^a)	29.26±3.14 ^a (66.58±29.90)
NIC	0.70±0.10 ^b	3.46±0.23 ^b (404.17±92.33 ^b)	10.32±1.18 ^c (198.29±26.64 ^b)	20.20±4.11 ^b (96.32±37.42)

a, b, c: means with different superscripts differ significantly on the same column (p<0.05)

Table 3: Yolk weight at day 0 and 18 and relative change (RC) in yolk weight (%) during incubation in four stains of chicken

Strains	Day		
	0	18	RC
Arbor acre	17.88±2.05 ^a	10.55±0.90 ^b	40.71±4.43
Marshall	15.22±0.99 ^b	9.82±2.12 ^b	34.68±18.11
Hubbard	14.64±2.39 ^b	13.28±1.33 ^a	23.91±14.38
NIC	14.50±1.35 ^b	9.14±1.75 ^b	35.93±16.50

^{a, b:} Means with different superscripts differ significantly along the columns (P <0.05)

that of Hubbard strain and but higher than that of the Marshall strain. The rate in the Hubbard strain and that of the Marshall strain was also similar. The NIC had lower growth rate compared to the broiler strains. In the fourth week however, the growth rate in the NIC was comparable to that of Marshall strain but lower (P <0.05) than those of Arbor acre and Hubbard strains.

Plasma Thyroxine (T₄)

Thyroxine levels at day-old and successive weeks after hatching among four strains of chicken are shown in Table 5. At day-old, there was no significant difference in the levels of T₄ among the strains of chicken considered but numerically, the NIC was higher than Arbor acre, Hubbard and

Marshall. Also in the first week of growth, there was no significant difference in the levels of T₄ among the strains. There was a significant difference (P<0.05) among the strains of chicken in the second week of growth. The level in the NIC was comparable to those of Hubbard and Arbor acre broiler strains. The level in Marshall strain was lower than that of Hubbard. The level of T₄ was also significantly different among the strains of chicken in the third week. At this time, the level in the NIC was comparable to those of Arbor acre and Marshall but lower than in the Arbor acre and Marshall. The levels in the Hubbard and Arbor acre were also similar. In the fourth week, the level of T₄ in NIC was

Table 4: Mean (±SD) growth rate in four strains of chicken in successive weeks after hatching (%)

Strains	Week				
	0	1	2	3	4
Arbor acre	40.23±3.10 ^b	110.81±20.92 ^b	112.19±15.27 ^a	77.07±31.64 ^a	54.48±13.71 ^a
Marshall	35.07±2.21 ^c	138.09±23.27 ^a	115.78±19.57 ^a	63.54±10.09 ^b	49.13±13.64 ^{ab}
Hubbard	48.59±4.09 ^a	84.73±15.32 ^c	83.70±12.34 ^b	69.23±8.37 ^{ab}	52.88±9.97 ^a
NIC	31.89±3.69 ^d	61.19±23.46 ^d	84.57±21.18 ^b	50.79±13.89 ^c	42.70±16.53 ^b

^{a, b, c, d:} Means with different superscripts differ significantly (P <0.05) along the same column.

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similar to that of Hubbard strain. The levels in Marshall and Hubbard were also similar. Also Arbor acre and Marshall ranked similar ($P<0.05$) and had the highest level of T_4 . The level of T_4 increased with age up to the fourth week in the Arbor acre and Marshall whereas in the NIC and Hubbard, T_4 level decreased at the fourth week.

Discussion

This study demonstrates that there is a natural process of albumen use that may be related to the growth of the embryo. Tona (2001) observed that lower use of albumen may be the cause of lower hatchability and viability of embryos. The similarity in the rate of use of albumen in the NIC and broiler strains during incubation suggests that the lower hatching weight of the NIC may not be related to albumen consumption. Finkler *et al.* (1998) suggested that albumen volume is an important determinant of hatchling size. Interestingly, in this present study, there was no significant difference in the rate of albumen utilization among the strains of chicken compared. This implies that the difference in hatching size of the chicks cannot be associated with albumen

utilization during incubation.

Embryo development could be expressed in terms of yolk-free embryo weight (Hill, 2001). The weight in the NIC was comparable to one or more of the broiler strains throughout the experimental period. This may imply that the NIC used in this trial had similar potential for growth as those of the broiler strains. Schmalhausen (1930) hypothesized that posthatch growth and organ function will be impaired if growth rates during embryonic development deviates from optimum.

Due to the fact that the end of 7 day of rearing is often considered as the true starting point for production and that the chick body weight between 7 to 10 day has been shown to linearly related to the body weight at slaughter age (Tona *et al.*, 2003), performance up to four weeks of age was considered to be a good indicator of the difference in the NIC and the broiler strains in this study. Data from this study showed that day-old chicks weights were significantly different among the four strains considered. This contrasts with the study reported by Tona *et al.* (2004) despite the difference in initial egg weight used.

Table 5: Mean ($\pm$ SD) plasma thyroxine (T_4) levels (ng/ml) in four strains of chicken in successive weeks after hatching

Strains	Week				
	0	1	2	3	4
Arbor acre	2.1776 $\pm$ 1.49	2.9230 $\pm$ 1.07	6.5630 $\pm$ 1.74 ^{ab}	7.9886 $\pm$ 2.20 ^{ab}	10.8352 $\pm$ 4.29 ^a
Marshall	1.8230 $\pm$ 1.92	2.8380 $\pm$ 0.61	4.6208 $\pm$ 0.94 ^b	5.8996 $\pm$ 1.92 ^b	8.4408 $\pm$ 1.51 ^{ab}
Hubbard	2.2952 $\pm$ 1.57	2.3546 $\pm$ 0.47	7.7102 $\pm$ 1.65 ^a	9.7098 $\pm$ 2.83 ^a	5.7684 $\pm$ 1.20 ^{bc}
NIC	3.7924 $\pm$ 1.76	2.8560 $\pm$ 1.19	5.5840 $\pm$ 2.15 ^{ab}	5.0598 $\pm$ 0.99 ^b	3.5786 $\pm$ 1.20 ^c

a,c Means with different superscripts differ significantly on the same columns ($p<0.05$)

This may be due to the genetic make-up of the birds (Adegbola and Olatoke, 1988). There is no consistency in the day-old chick weight and early performance up to seven days in the three strains of the broilers. This is comparable with the report of Tona *et al.* (2003) who reported that juvenile growth in broiler chicks did not follow a consistent pattern. NIC however showed a consistency in its post-hatch growth. The growth trajectory observed in this study is probably due to the difference in physiological processes in the different strains. The early growth difference could not be explained by physiological parameter (T_4). However, the differences in post-hatch metabolic parameters may be due partly to genetic differences.

The plasma T_4 levels observed in the broiler strains in this study is in line with the reports of Tona *et al.* (2003), Decuypere *et al.* (1979) and Careghi *et al.* (2005). These authors reported that thyroid hormones increased from day-old until day 7 post-hatch. The observation in the NIC is however at variance with this. The differences in the thyroid hormone levels suggest differential metabolic rate among strains at different stages of development. Arbor acre and Marshall strains had significantly higher levels than the NIC at week 4. This may indicate that the NIC are able to cope better with the environmental stress than the exotic birds.

Conclusion

This study showed that the embryonic development in the broiler strain was not superior to that of the Nigerian indigenous chicken. The difference in the growth trajectory comes later in the growth phase. The significant differences between the strains seem partly genetic. The rate of albumen consumption during incubation in

NIC was similar to those of extotic broilers. Therefore, the data from this study have shown that the NIC strain can provide an compete well with the exotic strains of broiler during incubation. The post-hatch growth rate was smaller in the NIC than those of the broiler strains up to three weeks of age. Beyond this point, the NIC had a catch-up growth.

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