NUTRIENT UTILIZATION DURING INCUBATION AND JUVENILE GROWTH OF INDIGENOUS AND EXOTIC CHICKEN IN NIGERIA

UTILIZACIÓN DE NUTRIENTES DURANTE LA INCUBACIÓN Y CRECIMIENTO JUVENIL DE POLLOS INDÍGENAS Y EXÓTICOS EN NIGERIA

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PALABRAS CLAVE ADICIONALES

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SUMMARY

Nutrient utilization and early growth rate in three strains of chicken were investigated using 900 hatching eggs, 300 from each strain. The strains of chicken used were Nigerian indigenous chicken (NIC), ISA Brown (IB) and Nera Black strains (NB). Ten eggs per strain were randomly selected for breakout at embryonic day (ED) 7, 11, 15, and 18 of incubation to collect data on albumen weight in order to determine the embryonic albumen reduction rate during incubation and yolk weight to monitor its utilization. Blood samples were collected at hatch (day-old), weeks 1, 2, 3 and 4 post-hatch for triiodothyronine (T_3), thyroxine (T_4) and corticosterone level (CORT) determination. The chicks were randomly distributed into four rearing pens for a 28-day assessment of growth rate. The results showed that at day 18 of incubation (ED 18), weight of egg yolk and rate of yolk loss were similar among all the strains. Also, from ED 0 to 7 and11 to 15, albumen reduction rate in the eggs of IB was higher compared to NB and NIC, while it was lowest in NIC. From ED7 to 11, NIC showed highest reduction rate, followed by NB. Lowest reduction rate was shown in the eggs of IB. At day 7 and 28 of post-hatch growth, relative weight gain by the NIC was higher compared to NB and IB chicks. While IB and NB strains were similar at day 7, NB showed an intermediate relative weight gain at day 28. Strain did not significantly ($p>0.05$) affect body weight at all the ages. At day 14 and 21of post-hatch growth, strain did not affect relative weight gain except at day 7 and 28. At day 7 and 28 relative weight gain by the NIC chicks was higher compared to NB and IB chicks.

While IB and NB were similar at day 7, NB showed an intermediate relative weight gain at day 28. Plasma CORT level did not change from day-old until day 28 in all strains. Similarly, CORT levels did not differ among strains at each age of determination. T_3 concentration increased from day-old until day 7 post-hatch and leveled out throughout the ages of observation in all the strains. The weight differences of the embryos at ED18 and day-old-chicks at the hatching day suggest the influence of genetic differences and possibly that of inadequate incubation protocol at this stage.

RESUMEN

En tres líneas de pollos (Nigerian indigenous chicken, NIC; ISA Brown, IB y Nera Black, NB) se estudió la utilización de nutrientes durante la incubación y crecimiento juvenil, empleando 900 huevos (300 de cada línea). A los días embrionarios (ED) 7, 11, 15 y 18 de la incubación, diez huevos por línea fueron seleccionados al azar, para obtener datos sobre el peso del albumen y determinar su tasa de reducción embrionaria y peso de la yema. Se obtuvieron muestras de sangre con un día de edad (a la eclosión) y a las semanas 1, 2, 3 y 4 desde la eclosión para determinacion de triiodotironina (T_3), tiroxina (T_4) y corticosterona (CORT). Los pollos fueron distribuidos al azar en

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cuatro jaulas de cría para la evaluación del crecimiento durante 28 días. Los resultados demuestran que al día 18 de la incubación (ED18), el peso de la yema y la tasa de su consumo fueron similares en todas las líneas estudiadas. Además desde ED0 a ED7 y desde ED11 a ED15, la tasa de reducción del albumen en los huevos IB fue mayor que la de NB y NIC, siendo la de NIC la más baja. Desde el ED7 al ED11 NIC mostró la mayor velocidad de reducción seguida de NB, siendo la menor la de huevos IB. En los días 7 y 28 de crecimiento, la ganancia relativa de peso fue mayor en los pollos NIC, resultando similares entre sí los de IB y NB al día 7; NB demostró un crecimiento relativo intermedio al día 28. La línea no afectó significativamente al peso corporal en nuinguna etapa. En los días 14 y 21 de los pollos, la línea no afectó a la ganancia relativa de peso pero, a los 7 y 28 días de edad, la ganacia relativa de peso fue superior en los pollos NIC. IB y NB tuvieron incrementos relativos de peso similares al día 7 pero el de NB al día 28 fue intermedio. En ninguna línea el nivel plasmático de CORT varió desde el día 1 al 28, tampoco hubo diferencias entre líneas. La concentración de T_3 aumentó desde el día 1 hasta el 7, estabilizándose después en todas las edades y cepas. Las diferencias de peso entre los embriones al ED18 y los pollos de un día, el día de la eclosión, sugieren la posibilidad de diferencias genéticas y posiblemente un inadecuado protocolo de incubación en esta etapa.

INTRODUCTION

The post-hatch performance of chicken is determined by genotype, environmental and feed-related factors (Bruggeman *et al.*, 2006). Besides, when chickens are selected for various post-hatch characteristics, they may also differ in their embryonic developmental trajectories (Clum *et al.*, 1995). Avian embryos develop and grow from nutrients stored in the egg over a wide range of time (Schmidt *et al.*, 2003). Amounts and forms of nutrients deposited in the egg determine the success of embryo development and hatching of a healthy chick. Although, not derived from egg, oxygen and carbondioxide play a supportive role during incubation. However, adequate oxygen and carbondioxide concentrations in the surrounding air and its free passage through shell porosities are essential (Decuypere *et al.*, 2001). Developmental limitations and embryo mortality are aggravated when any inadequacy in these conditions prevails.

A lot of research findings and reports have been published among which are yolk assimilation during embryonic development of chick (Jull and Heywang, 1930); effect of egg size on embryonic growth (Hazzan and Nordskog, 1971), Comparison of different strains of exotic chicken embryo physiology and chick juvenile growth (Tona *et al.*, 2010), effect of high incubation temperature on layer chicken embryo (Tona *et al.*, 2012) and all the likes. These researches have been able to examine various strains of exotic chickens. However, there is a dearth of information on the optimum incubation condition, hormonal profile and growth trajectory of the indigenous chicken in Nigeria.

Layer chickens have been intensively selected for egg production (Sato *et al.*, 2009). Extensive experiments have investigated the physiological difference between chicken types, but these studies are usually limited in the NIC. Although, studies on embryonic development of exotic strains of chickens have been conducted in the temperate regions, none of the Nigerian studies has reported the embryonic development of the NIC strains vis-avis the post-hatch juvenile growth. The question to be asked is whether the currently used incubation protocols used for exotic strains are suitable for the NIC. Thus, a comparison of embryonic nutrient utilization and post-hatch performance among these strains of chickens might be 9a pointer focusing to areas of developing NIC for high performance and developing suitable incubation requirements for different strains. This study therefore aimed to compare some physiological parameters during embryonic development and post-hatch juvenile growth in the Nigerian indigenous normal feathered chicken with two commercial strains of layer chickens (NB and IB) of high performance in order to establish if the incubation conditions presently used for the indigenous chickens are adequate and also to establish if the exotic laying chickens have similar growth trajectories with the NIC.

MATERIALS AND METHODS

EXPERIMENTAL SITE

The experiment was conducted at the Research Farm of the Federal University of Agriculture Abeokuta (FUNAAB), Abeokuta, Nigeria. The climate is humid with a mean annual rainfall of 1037 mm. The annual mean temperature and humidity are 34 °C and 82 % respectively level (Amujoyegbe *et al.*, 2008).

EGG COLLECTION AND INCUBATION

900 hatching eggs (300 per strain) from 2 strains of exotic chickens (IB and NB) were collected from commercial farms in Nigeria. Hatching eggs from the NIC were obtained from Abeokuta, Nigeria. Age of the birds was not put into consideration. It was ensured that the eggs were devoid of physical defects as these might interfere with embryo development and hatchability. The eggs were stored for 3 days in the cold room at the temperature of 18 °C prior to setting in the incubator. The incubating eggs from each strain were replicated twice at 150 eggs per replicate. The eggs were numbered for identification and set in the same incubator. The eggs were positioned in the setting crates with broad end facing up (Alabi *et al.*, 2012) to ensure ease of gas exchange (CO_2 and O_2) between the eggs and the environment.

INCUBATION PROTOCOL

Single Stage Western® Incubator was used for setting of the eggs at a temperature of 37.8 °C and 60 % relative humidity (R.H.) with oxygen concentration of 20 %. At day 19 R.H. was increased to 70 %. Towards day 21 when chicks were likely to hatch, R.H. was reduced to 60 %. This was to allow chicks to dry off before being taken out of the hatcher. Turning of eggs was automatically done by the incubator at an angle of 90° hourly until day 18. Turning ensures even distribution of nutrients and prevents adherent of embryo to egg shell.

INCUBATION PHASE PARAMETERS

Ten eggs per strain were randomly selected for breakout at ED7, 11, 15, and 18 of incubation to collect data on: yolk weight (Yw) and albumen weight (Aw) to determine the albumen reduction rate (RAR) during incubation.

RAR= (Initial Aw–Final Aw)100/Initial Aw

POST-HATCH PHASE

The newly hatched chicks were removed from the hatcher and identified with their corresponding eggs. The chicks were weighed using a Mettler top-loading weighing balance.

At hatch, 60 Pullet chicks (20 per replicate) from each of NB and IB, and 60 from the NIC chicks (20 per replicate) were tagged for identification. They were brooded for four (4) weeks in an open sided brooder house supplied with heat depending on weather condition. The amount of heat supplied was based on the response of the chicks to the heat. The brooder house was partitioned and the chicks from each strain were assigned pens.

FEEDING MANAGEMENT AND WEIGHT GAIN DETERMINATION

The chicks were fed *ad libitum* with mash (Crude Protein of 19 % and Metabolisable Energy of 2,650 per kilogramme) (as shown in **table I**) and clean water. Data were collected at day 7, 14, 21 and 28 for weight gain of individual birds using a Mettler top-loading weighing scale.

BLOOD SAMPLES COLLECTION

At day 0, 7, 14, 21, and 28 of post-hatch growth, 10 chicks per strain were selected and blood samples were aspirated from wing vein or jugular vein using 2 mL syringe. The blood samples were put in to heparinized tubes to avoid blood clotting. The blood samples were centrifuged at 3000 revolution per minute for 10 minutes to separate blood plasma. The plasma samples were labeled for identification and later frozen at the temperature of –20 °C until ready for analysis to determine the levels of corticosterone, tri-iodothyronine (T_3) and thyroxine (T_4) using radio immunoassay (RIA) technique as described by Darras *et al*. (1992). The analysis was carried out in K.U. Laboratory of Livestock Genetics, Immunology and Physiology, Leuven, Belgium.

STATISTICAL DESIGN AND ANALYSIS

The data were analyzed using a completely randomized design. The model is shown below:

$$Y_{ij} = \mu + T_i + \Sigma_{ij}$$

where:
Y_{ij}= observed value of dependent variable;
μ= population mean;
T_i= effect of i^{th} strain of chicken;
Σ_{ij}= residual error.

All the data collected were subjected to Analysis of Variance using SAS (1999) statistical package while significant means were compared using Duncan's Multiple Range Test.

RESULTS

COMPARISON OF EGG YOLK WEIGHT (G), % YOLK WEIGHT AND % YOLK LOSS DURING INCUBATION

Yolk weight was compared among the strains of chicken at day 0 (pre- incubation) and day18 of incubation, as shown in **table I**. The **table II** shows that strain had significant effect ($p<0.05$) on egg yolk weight and percentage yolk weight prior to incubation (i.e. day 0). Prior to incubation egg yolk weights were similar between IB and NB chicken strains but greater in values than the egg yolk of the local chicken strain. The Local and IBhad similar percentage yolk weight, while NB showed the lowest weight which was similar with IB. At day 18 of incubation, egg yolk weights, percentage yolk weights, and percentage yolk loss were similar among all the strains.

Table I. *Composition of layer diet used.* (Ingredientes de la dieta empleada).

Ingredient (%)	
Maize	46.50
Soybeans	14.40
Groundnut cake	6.80
Fishmeal	1.70
Wheat offal	25.20
Bone meal	2.40
Oyter shell	2.00
*Premix	0.25
Salt	0.25
Lysine	0.25
Methionine	0.25
Total	100
Calculated feed analysis	
ME (kcal/kg)	2650.22
CP (%)	19.04
CF (%)	4.15
Ether extract (%)	3.75
Calcium (%)	1.47
Phosphorus (%)	0.46
Lysine (%)	1.06
Methionine (%)	0.55

*Supplied per kg diet: Biotin= 40 mg; Zn= 58 mg; Fe= 5800 mg; Vit A= 1,000,000 i.u; Folic acid= 500 mg; Se= 120 mg; I= 60 mg; Nicotinic acid= 2800 mg; Cu= 700 mg; Mn= 4800 mg; Vit K= 1,500 mg; Riboflavin= 500 mg; Co= 300 mg.

COMPARISON OF ALBUMEN WEIGHT AND RELATIVE ALBUMEN REDUCTION DURING INCUBATION (%)

Table III shows the albumen weight and relative albumen reduction (%) in the incubating egg of the 3 strains of chicken.

Table II. *Comparison of egg yolk weight and yolk weight loss during incubation.* (Comparación del peso y pérdida de yema durante la incubación).

Strain	N	Yw (D0)	%Yw* (D0)	Yw (ED18)	%Yw* (ED18)	% Yw loss
NIC	10	14.00±1.21^{b}	28.74±2.31^{a}	8.78±2.38	21.07±6.45	37.30±0.47
NB	10	16.41±1.59^{a}	25.87±2.48^{b}	10.27±1.47	19.95±3.96	37.28±6.94
IB	10	16.78±1.58^{a}	26.55±2.42^{ab}	10.70±2.15	21.81±4.29	35.83±13.73

^{a,b}Means(±SD) within a column with different superscripts differ significantly (p<0.05).
N= observations; Yw= yolk weight (g); *in % of egg weight; D0= before incubation; ED= embryonic day.

It shows significant effect of chicken strains on the albumen reduction rate in the eggs at different incubation durations. From embryonic day (ED) 0 to 7 and11 to 15, reduction rate in the eggs of IB strain was higher compared to NB and NIC, while NIC showed the lowest. From ED7 to 11 NIC showed highest reduction rate, followed by NB. Lowest reduction rate was shown in the egg of IB.

Comparison of post hatch juvenile body weight (g) and relative weight gain (%)

The post hatch juvenile chicks body weight and relative weight gain as affected by strain is shown in **table IV**. Strain did not significantly (p>0.05) affect body weight at all the ages. At day 14 and 21 strain did not affect relative weight gain except at day 7 and 28. At day 7 and 28 relative weight gain by the NIC chicks was higher compared to NB and IB chicks. While IB and NB were similar at day 7, NB showed an intermediate relative weight gain at day 28.

Comparison of corticosterone (CORT), triiodothyronine (T_3) and thyroxine

(T_4) concentrations (ng/mL) at hatch and post-hatch juvenile growth among three strains of chicken

The concentrations of corticosterone (CORT), T_3 and T_4 at hatch and during juvenile development of the NIC, NB, and IB are shown in **table V**. Plasma CORT level did not change from day-old until day 28 in all strains. Similarly, CORT levels did not differ among strains at each age of determination. T_3 concentration increased from day-old until day 7 post-hatch and leveled out throughout the ages of observation in all

Table III. *Albumen weight and its relative reduction during incubation*. (Peso del albumen y su reducción relativa durante la incubación).

	NIC		NB		IB	
Stage	AW (g)	RAR (%)	AW (g)	RAR (%)	AW(g)	RAR (%)
AS	29.69±2.80^{b}	-	42.48±7.40^{a}	-	40.67±5.30^{a}	-
ED7	9.96±1.44	66.46±0.01^{c}	11.85±2.46	70.13±0.05^{b}	9.95±2.77	75.30±0.43^{a}
ED11	9.17±1.78^{b}	8.50±0.22^{a}	11.45±1.22^{a}	3.53±0.05^{b}	9.91±1.05^{b}	0.69±0.40^{c}
ED15	4.31±1.72	54.06±0.08^{c}	5.11±1.76	55.33±0.06^{b}	4.25±1.46	57.05±0.10^{a}
ED18	0.00±0.00	100.00±0.00	0.00±0.00	100.00±0.00	0.00±0.00	100.00±0.00

^{a,b}Means (±SD) within a row with different superscripts differ significantly (p<0.05).
AS= at setting; ED= embryonic day; AW= albumen weight; RAR= relative albumen reduction (%).

***Table IV.** Body weight (g), and relative weight gain (%) of juvenile chicks from three strains.* (Peso corporal (g) de los pollos y ganancia relativa de peso (%) entre líneas de pollos).

	NIC		NB		IB	
	BW (g)	RWG (%)	BW(g)	RWG (%)	BW(g)	RWG (%)
DOC	31.65±4.33[b]	-	34.94±4.49[a]	-	34.45±2.93[a]	-
Day7	53.43±8.52	70.32±25.88[a]	53.91±8.24	55.55±24.01[b]	52.89±6.33	54.05±18.44[b]
Day14	98.60±24.23	83.23±24.22	96.90±16.18	79.97±15.73	98.02±13.34	85.39±14.63
Day21	146.65±37.74	48.86±14.78	144.17±24.79	49.04±9.37	149.09±21.56	52.07±9.99
Day28	211.86±41.77	47.94±22.64[a]	203.25±31.04	41.85±12.25[ab]	204.01±36.43	36.40±12.58[b]

[a,b]Means (±SD) within a row with different superscripts differ significantly ($p<0.05$).
DOC= day-old chick; BW= body weight (g); RWG= relative weight (g).

the strains. Similarly, T_3 levels did not differ among strains at each age of determination. At each age of observation, strain did not significantly ($p>0.05$) affect T_4 concentration except at day 14 in which Local strain had significantly ($p<0.05$) higher T_4 compared to that of the NB and IB. NB showed similar value as the IB.

DISCUSSION

The rate of reduction of albumen during incubation was not the same in the strains

***Table V.** Corticosterone, triiodothyronine and thyroxine hematic concentrations (ng/mL) at hatch and juvenile growth of chicken from three strains.* (Concentraciones hemáticas de triiodotironina, tiroxina y corticosterona (ng/mL) a la eclosión y crecimiento juvenil en 3 líneas de pollos).

Hormone/Developmental stage	NIC	NB	IB
Corticosterone			
At hatch	28.32±8.69	21.40±13.41	26.15±10.33
At 7 day post-hatch	23.35±18.46	17.08±13.35	14.79±8.08
At 14 day post-hatch	28.35±19.85	35.96±17.54	36.89±16.42
At 21 day post-hatch	14.94±10.96	14.72±8.10	16.49±8.57
At 28 day post-hatch	22.91±14.07	13.80±11.28	15.03±12.67
Triiodothyronine			
At hatch	0.32±0.15	0.32±0.15	0.32±0.12
At 7 day post-hatch	1.80±0.76	1.73±0.10	1.44±0.37
At 14 day post-hatch	1.34±0.25	1.82±0.54	1.88±0.44
At 21 day post-hatch	1.25±0.49	1.89±1.39	2.11±1.00
At 28 day post-hatch	1.58±0.50	1.87±0.51	1.90±0.50
Thyroxine			
At hatch	3.79±1.76	4.21±1.04	3.70±1.25
At 7 day post-hatch	1.91±0.93	3.76±1.93	3.66±1.30
At 14 day post-hatch	5.58±2.15[a]	3.80±1.27[ab]	3.51±1.59[b]
At 21 day post-hatch	5.83±1.69	6.86±1.90	5.01±1.86
At 28 day post-hatch	3.58±1.20	3.96±1.71	2.72±1.80

[a,b]means (±SD) within rows, data not sharing a common letter are different ($p<0.05$).

of chicken in this study. The reason for this may be attributed to genetic differences and evaporation loss, although each of the strains had similar embryo weights until day 15 of incubation. The similarity in the percentage yolk losses among the strains during embryonic development suggests that similar amount of yolk content were utilized by the strains. Finklera *et al.* (1998) indicated that differences in yolk seem not to result in greater tissue formation during embryonic development.

The superiority of the NIC chicken in post-juvenile relative weight gain over the other two strains at day (d)7 and 28 was seen except at d14 and 21 when they were similar. This could be attributed to genetic difference. Similar results were observed among chickens from different ecological zone by Adedokun and Sonaiya (2001) where weights of the eco-type chickens observed from different ecological zones varied and were similar at different growth trajectory during post-juvenile development. The superior body weights and relative body weights in the NIC at day 28 in this study reveals that the NIC has higher ability to catch up with the exotic strains and also overtake them despite the fact that the NIC was smaller than the exotic strains at hatch.

Corticosteroids are known to be elevated by corticotrophin-releasing hormone and stimulate thyroid metabolism in the chicken embryo, which is related to the hatching process (Decuypere *et al.*, 1990). The production of glucocorticoids is increased by stress. Therefore, corticosterone can be used as a biomarker of stress. The similarity in corticosterone concentrations among the strains at each of the developmental stage in the present study indicates similarity in their ability to tolerate stress from the environment with little effect on performance. The finding is similar to the report of De Smit *et al.* (2005) where two lines of broilers had similar corticosterone levels. In contrast an ascites susceptible chicken which struggled to maintain metabolic rate showed a higher concentration of corticosterone.

The reason for higher plasma concentration level of T_4 compared with T_3 probably was due to the fact that elevated level of T_4 concentration is a substrate for T_3 production (Decuypere *et al.*, 1990). This pattern conforms to the result of Tona *et al.* (2004). The similarity observed in the thyroid hormones (T_3 and T_4) levels among the strains except at day 14 of T_4 is an indication that the strains of chicken had similar metabolic rate. This result is similar to De Smit *et al.* (2005) in which two lines of broiler maintained the same T_3 levels, hence similar metabolic rate. Generally, plasma T_3 levels of these strains at day 7 were higher than at hatch. It shows that it increased from hatch to day 7 and then leveled out. This means that the metabolic rate of each strain at hatch was lower than at day 7. In contrast, plasma T_4 levels at these two stages of development were similar in the strains. This result is in contrast with the finding of De Smit *et al.* (2005) where T_4 concentration level at day 7 was higher compared to the concentration at hatch at the same time in all the strains.

It could be concluded that the differences in albumen reduction rate during incubation indicated that the NIC embryo had higher conversion rate of albumen into body tissues than in the IB and NB strains at ED7 and 15. Moreover, the NIC chicks showed superiority in post-juvenile relative weight gain over the other two strains at day (d) 7 and 28, except at d14 and 21 when they were similar. This suggests that different strains may have different growth trajectory at different periods of post-juvenile development. This is in accordance with the findings of Tona *et al.* (2012) who observed different growth trajectories in different strains of broiler. There is however a dearth of information on the comparison of this parameter in the NIC and the exotic strains. Also, the three strains of chicken seemed to have similar tolerance to stress as reflected in their similar concentrations of plasma corticosterone. The Similarity in the blood plasma concentrations of thyroid hormones of the strains suggests that the NIC, NB and IB chicken have similar metabolic rates during post-hatch juvenile growth (0 to 28 days).

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