ARTICLE

Response of Broiler Birds to Choline Chloride in Semi Arid Sokoto, Nigeria

Abdullahi, A.U. 1*  Aliyu, S. 2  Fauziyya I. 1  Bello, A. 3  Jafaru, Y. 1

1. Department of Animal science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria
2. College of Agriculture and Animal Science, Wurno. Sokoto state
3. Department of Veterinary Anatomy, Faculty of Veterinary Sciences, Usmanu Danfodiyo University, Sokoto

ARTICLE INFO

Article history
Received: 28 November 2019
Accepted: 17 December 2019
Published Online: 31 March 2020

Keywords:
Broiler
Growth performance
Carcass characteristics
Level of choline inclusion

ABSTRACT

A study was carried out to evaluate growth performance and carcass characteristics of broiler birds fed with varying level of choline inclusion in their diets; T1 (control), T2 (10g/10kg) and T3 (20g/10kg). A total of 225 marshall broiler chicks were randomly divided into three (3) treatment group of 75 birds each. Each group was divided into five (5) replicates of fifteen (15) birds each laid in a completely randomized design. Feed and water was supplied ad-libitum and the experiment lasted for 49 days. The total feed intake (1316.75-14442.18) (24437.13-31999.76) for starter and finisher respectively, body weight gain (6227.30-8241.20) (10956.64-14182.96) for starter and finisher respectively, feed conversion ratio (1.73-2.26) (2.21-2.48) for starter and finisher respectively. Many (thigh, wings, back) of the carcass parameters measured were not significantly (p>0.05) affected by the treatments but significant difference (p<0.05) was observed in drum stick, breast and neck. However, significant difference (p<0.05) was also observed in gizzard, liver and bile, heart, lungs, legs and head. There was significant difference (p<0.05) in primal cuts per live weight, primal cuts per dressed weight, organs per live weight and organs per dressed weight. In view of the results obtained, it can be concluded that treatment two (10g/10kg) performed better in terms of total body weight (TBW) and feed conversion ratio (FCR). Also in the carcass characteristics, treatment two performed better in terms of breast yield, drumstick, percentage of primal cuts from live weight (P/LW) and percentage of primal cuts from dressed weight.

1. Introduction

Poultry industry has mainly two branches, which are; egg and meat production. Studies have indicated that broiler enterprise has great potential for increasing protein supply in Nigeria [7]. The hot-dry season is known to have the highest ambient temperature, long duration of sunshine and high relative humidity, making it thermally stressful to animals [13,21]. Heat stress in birds increase oxidative damage to cell evidenced by decrease in weight gain, feed intake and feed efficiency [11]. Broilers are strains of birds used for the purpose of producing a large quantity of chicken meat in a short pe-
iod. Broiler chickens are raised from six to 10 weeks in poultry farms in Nigeria [1].

Nutrients are the nutritious components in foods that an organism utilizes to survive and grow. Macronutrients provide the bulk energy for an organism’s metabolic system to function, while micronutrients provide the necessary cofactors for metabolism to be carried out. Both types of nutrients can be acquired from the environment (Whitney and Sharon, 2005). Only part of birds’ nutrient requirements is provided by the natural feedstuffs in their diets. Nutrient supplements must therefore be included in feed formulations [14].

Choline, is a water soluble colourless compound with vitamin-like properties as not a metabolic catalyst but forms an essential structural component of body tissues [18]. Choline is ubiquitously distributed in all plant and animal cells, mostly in the form of the phospholipids, phosphatidylcholine (lecithin), lysophosphatidylcholine, choline plasmalogens and sphingomyelin – essential components of all membranes [26]. Choline degrades in hot alkali creating trimethylamine. Choline has ability to form salts with many organic and inorganic acids. It is well soluble in water and ethanol, but not in ether. Choline is chemically a strong alkali and hygroscopic in nature. Choline is amino ethyl alcohol and have three methyl groups on the nitrogen atom, chemically termed as (2-Hydroxyethyl) trimethylammonium. Chemical formula of choline is C₅H₁₄NO⁺ and of choline chloride is (HOCH₂CH₂N (CH₃)₃HCl) [6]. Choline chloride have 139.63 g/mole molecular weight, 247°C melting point, decompose on heating, 1.1 g/cm³ relative density at 20°C (70% choline chloride in water) and practically stable at 20-30°C [16]. Choline is an essential nutrition for the poultry. One of its functions is to furnish methyl groups that can also be furnished by betaine and methionine [22,23].

It is important for researchers to reinvestigate the use of choline in poultry diets. In the past, several studies have looked at choline and betaine for their methionine sparing effects under ideal conditions (Rafeeq et al., 2011a; Rafeeq et al., 2011b), but it may also be important to evaluate choline for its primary function of supporting growth and not just as a methionine sparing molecule. Choline may also have added benefits during heat stress, since bird physiology is altered in this condition [16]. Therefore, the need for conducting this research.

In poultry industry, nutrition represents about 70% of total costs, thus constitutes a key factor in poultry production. Choline is classified as an essential vitamin for day-old chicks; it is usually added to diets for the purpose of furnishing the body with labile methyl group for formation of creatine and methionine. In addition, it also assists in the prevention of hemorrhagic kidney in different animal models and perosis in turkeys and broilers [25]. Choline’s methyl group is available after the conversion to betaine in the liver. Choline has three essential metabolic roles, namely: As a constituent of phospholipids; secondly, it helps to prevent fatty liver; and thirdly, as a precursor for acetylcholine synthesis. Choline also has non-essential metabolic functions: As a labile methyl group, as well as prevention of perosis and fatty liver syndrome in broiler chicks (Workel et al., 2002). Choline must be a part of the human and animal diets [16].

This research is aimed at assessing the response of broiler strain (marshal) to choline chloride at starter and finisher phase in semi-arid zone (Sokoto State), through the following objectives:

1. To assess the general performance of broiler birds fed with diet supplemented with choline chloride at starter and finisher phase.
2. To assess carcass characteristics of broiler birds fed with diet supplemented with choline chloride at starter and finisher phase.
3. To assess the level of inclusion of choline chloride that gives the best result in terms of performance and carcass quality.

2. Materials and Methods

2.1 Study Area

The study was carried out at the poultry production unit of the Department of Animal Science, Usmanu Danfodiyo University, Teaching and Research Farm situated at the veterinary clinic, Aliyu Jodi road in Sokoto metropolis, which lies between latitude 11°30N and 14°00N and longitude 4°00E and 6°40E. The state covers a total land area of 32,000km² (Tureta et al., 2006), has a tropical continental climate and entirely falls within the semi-arid climatic environment. The annual rainfall is between 500 and 750mm with peak in August with mean monthly temperatures varying between 13°C in December/January and 42°C in April while the average annual temperature is 34°C (SERC, 2010). It has an estimated population of about 1,078,092 [19]. The demographic structure of the metropolis is cosmopolitan, albeit with the Hausas predominating; and Hausa is the common language. Occupation of the inhabitants includes trading; civil service while a reasonable proportion of the population works in organized private sectors [27].

2.2 Experimental Birds and their Management
Two hundred and twenty five (225) Marshall Broiler chicks at day old were used for the experiment. The chicks were bought from a reputable dealer in Sokoto. The chicks were housed in a standard open-sided tropical house type. The housing unit was thoroughly clean and disinfected. Litter material e.g. wood shavings was used to cover the floor. Feed and water was served *ad libitum*. Vaccination was administered accordingly and disease outbreaks were adequately managed. Regular washing of the feeders and drinkers was carried out and sweeping of the pens were observed.

2.3 Experimental Feed Materials and Their Sourcing

The feeds to be used was self-formulated both starter and finisher feed. The birds were fed with commercial feed for the first three (3) days and afterwards introduced to the self-formulated feed without the test ingredient for the next four (4) days (adjustment week). Then from the second (2<sup>nd</sup>) to seventh (7<sup>th</sup>) week, they were fed with the self-formulated feed containing the test ingredient (choline chloride).

2.3.1 Sourcing of the Ingredients

The feed ingredients were bought from Sokoto central market e.g maize, wheat offal and salt. Other ingredients such as soya bean meal, groundnut cake, bone meal, lysine, methionine, limestone and premix was obtained from supply stores.

2.3.2 Gross and Calculated Chemical Composition of the Experimental Diets

Table 2.4.2 shows the gross composition and the calculated chemical composition of the feed ingredients for both starter and finisher diet.

2.4 Experimental Design

Two hundred and twenty five (225) chicks were randomly divided into three (3) treatment group of75 birds each. Each group was divided into five (5) replicates of fifteen (15) birds each. The three (3) treatment groups T<sub>1</sub> (control 0g/kg), T<sub>2</sub> (10g choline/10kg feed) and T<sub>3</sub> (20g choline/10kg feed) was randomized in a completely randomized design (CRD) experiment. The birds were fed with starter diet for the first four (4) weeks and then finisher diet for the last four (4) weeks of age. The birds were housed in a deep litter system and good management was carried out. Feed and water was served *ad libitum*.

Table 1. Gross composition and calculated chemical composition of Feed Ingredients for both Starter and Finisher Diet

| Ingredients          | Starter (kg) | Finisher (kg) |
|----------------------|--------------|---------------|
| Maize                | 50           | 49            |
| Soya Bean Meal       | 18           | 22            |
| Groundnut Cake       | 20           | 12            |
| Wheat Offal          | 8            | 13            |
| Limestone            | 1.5          | 0.5           |
| Bone Meal            | 1.5          | 2.5           |
| Premix               | 0.25         | 0.25          |
| Lysine               | 0.25         | 0.25          |
| Methionine           | 0.25         | 0.25          |
| Salt                 | 0.25         | 0.25          |
| Total                | 100          | 100           |

| Calculated Chemical Composition | Starter | Finisher |
|----------------------------------|---------|----------|
| Energy (Kcal/kg)                 | 3054    | 2941     |
| Crude Protein (%)                | 23      | 21       |
| Lysine (%)                       | 0.9     | 1.1      |
| Methionine (%)                   | 0.6     | 0.6      |
| Calcium (%)                      | 1.0     | 0.9      |
| Premix (%)                       | 0.5     | 0.6      |
| Fibre (%)                        | 6.0     | 5.4      |

2.5 Data Collection

Data were collected on feed intake, body weight and feed conversion ratio and mortality. Data on carcass characteristics were primal cuts (thighs, drum sticks, wings, back and breast), the offal (heart, liver, gizzard, kidney, spleen, lungs, bile and intestine) and other organs such as the neck, head and legs. Data on weight and percentages (live weight, killed weight, plucked weight/carcass weight and their percentages) were also collected.

2.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) and where difference among means was observed, means were separated using Least Significant Difference (LSD).

3. Results

Results on the performance and carcass characteristics of the experimental birds fed with feed supplemented with choline chloride is presented on tables 4.1, 4.2 and 4.3.

3.1 Performance Characteristics at Starter Phase

Results on the performance of experimental birds fed diet...
supplemented with choline chloride at starter phase (2-4wks) is presented in table 2.

**Table 2.** Performance Characteristics of Experimental Birds at Starter Phase

| Parameters                        | T1(0gC-C/10kg) | T2(10gC-C/10kg) | T3(20gC-C/10kg) | SEM    |
|----------------------------------|----------------|-----------------|-----------------|--------|
| **Total Feed Intake**            | 14442.18       | 14252.52        | 13161.75        | 262.45 |
| **Average Feed Intake per Bird** | 1368.35        | 1295.68         | 1415.12         | 49.2   |
| **Average Feed Intake per Bird per Day** | 195.48          | 185.10          | 202.16          | 3.42   |
| **Total Body Weight**            | 18155.72       | 19591.92        | 17745.36        | 385.80 |
| **Body Weight per Bird**         | 1717.88<sup>a</sup> | 1781.08<sup>b</sup> | 1907.59<sup>a</sup> | 33.29  |
| **Body Weight per Bird per Day** | 245.41<sup>a</sup> | 254.44<sup>a</sup> | 272.51<sup>a</sup> | 4.76   |
| **Body Weight Gain**             | 7620.75<sup>a</sup> | 8241.20<sup>b</sup> | 6227.30<sup>ab</sup> | 375.03 |
| **Body Weight Gain per Bird**    | 719.30         | 749.20          | 648.67          | 20.26  |
| **Body Weight Gain per Bird per Day** | 102.76         | 107.03          | 92.67           | 2.89   |
| **Feed Conversion Ratio**        | 1.90<sup>a</sup> | 1.73<sup>b</sup> | 2.26<sup>b</sup> | 0.098  |

**Note:**<sup>a</sup><sup>b</sup> means in the same row with different superscripts differ significantly; (P<0.05)= *

### 3.1.1 Total Feed Intake (TFI)

Results on total feed intake of the experimental birds shows that TFI (g/3wks) was lowest (13161.75) in T1 and the highest was 14442.18 in T3 (control). Furthermore, the intermediate was 14252.52 in T2. However, there was no significant difference (p>0.05) among the treatments, thus, they are statistically similar. SEM recorded under TFI performance was 262.45.

A result of trend in ATFI (g/wk) of experimental birds under performance characteristics at starter phase from wk 2-4 is presented in appendix 1. Figures showed that ATFI (g/wk) increased in age of the birds from wk 2-4 (3133.84 - 6648.43) in T1 (control), similar trend was observed in T2 (3088.72 - 6290.54) and T3 (2978.07 – 5523.52).

### 3.1.2 Average Feed Intake Per Bird (AFIB)

Results on average feed intake per bird per week indicated that AFIB (g/b) was lowest (1295.68) in T2, highest (1415.12) in T3 and intermediate (1368.35) in T1. However, significant difference was not observed among the treatments (p>0.05) and the SEM recorded was 49.04.

### 3.1.3 Average Feed Intake Per Bird Per Day (AFIBD)

Lowest and highest value was obtained for results on AFIBD (g/b/d) 185.10 and 206.16 in T2 and T3 respectively. Intermediate value 195.48 was obtained in T1. There was no significant difference (p>0.05) observed among the treatments and 3.42 was obtained as SEM.

### 3.1.4 Total Body Weight (TBW)

Results on TBW (g/3wks) indicated that T2, T1 and T3 recorded highest (19591.92), intermediate (18155.72) and lowest (17745.36) respectively. Significant difference (p>0.05) was not observed among treatment means and SEM was 385.80.

Results of trend on AWkBW (g/b/wk) of the experimental birds under performance characteristics at starter phase from wk 2-4 is presented in appendix 3 and figure 3. It can be deduced from the figures that there was increase in body weight with increase in age of the birds from wk 2-4 across all treatments; T1(3347.10-9102.63), T2 (3344.92-9779.00) and T3 (3506.76-7765.10) respectively.

### 3.1.5 Body Weight Per Bird (BWB)

1717.88, 1781.08 and 1907.59 values was obtained for BWB (g/b) in T1, T2 and T3 respectively, with the highest value 1907.59 observed in T3, intermediate 1781.08 in T2 and lowest 1717.88 in T1. Significant difference was observed among treatment means (p<0.05). SEM recorded was 33.29.

### 3.1.6 Body Weight Per Bird Per Day (BWBD)

Results on BWBD (g/b/d) recorded highest 272.51 in
T₂ and lowest 245.41 in T₁ (control). Intermediate value (254.44) was recorded in T₃. There was significant difference (p<0.05) among the treatments and SEM value is 4.76.

3.1.7 Body Weight Gain (BWG)

Results on BWG (g/3wks) indicated that lowest (6227.30) and highest (8241.20) values were obtained in T₁ and T₂ respectively. Intermediate (7620.75) value obtained was in T₃. However, significant difference was observed between T₂ and T₃ (p<0.05) and SEM recorded was 375.03.

Results of trends on ABWG (g/b/wk) of the experimental birds under performance characteristics at starter phase are presented in appendix 5 and figure 5. Figures showed increase in ABWG with increase in age of the birds from wk 2-4 in T₁, T₂ (1865.22-3396.49) and T₃ (1807.12-3311.00) respectively. Similar trend was also observed from only wk 2-3 in T₃ (1968.96-2966.74) and sudden decrease from wk 3-4 (2966.74-1292.00).

3.1.8 Body Weight Gain Per Bird (BWGB)

Result on BWGB (g/b) was lowest (648.67) in T₃, highest (749.20) in T₂ and intermediate (719.30) in T₁ respectively. There was no significant difference (p>0.05) among the treatments and SEM was 20.26.

3.1.9 Body Weight Gain Per Bird Per Day (BWGBD)

Result on BWG (g/d) was lowest (92.67), highest (107.03) and intermediate (102.76) in T₁, T₂ and T₃ respectively. No significant difference (p>0.05) was observed among the treatments and the SEM obtained was 2.89.

3.1.10 Feed Conversion Ratio (FCR)

Results on FCR (fi/bwg) shows that significant difference (p<0.05) existed among the treatments where T₃ (2.26), T₂ (1.90) and T₁ (1.73) was highest, intermediate and lowest respectively. Significant difference existed between T₃ and T₁-T₂. The SEM recorded was 0.098.

Weekly trend on AFCR (FI/BWG/Wk) of the experimental birds under performance characteristics at starter phase is presented in appendix 7 and figure 7. Figures shows increase in FCR with increase in age of the birds across all treatments; T₁ (1.68-2.04), T₂ (1.44-1.90) and T₃ (1.51-3.57). T₂ has the best FCR across the weeks (1.44-1.57-1.90).

3.2 Performance Characteristics at Finisher Phase

Results on performance of experimental birds fed with feed supplemented with choline at finisher phase are presented in table 3.

Table 3. Performance Characteristics of Experimental Birds at Finisher Phase

| Parameters | T₁(0gCC/kg) | T₂(10gC-C/10kg) | T₃(20gC-C/10kg) | SEM |
|------------|-------------|-----------------|-----------------|-----|
| Total Feed Intake | 31214.32ᵃ | 31999.76ᵇ | 24437.13ᶜ | 1192.80 |
| Average Feed Intake per Bird per Week | 2952.69 | 3088.77 | 2697.07 | 85.90 |
| Average Feed Intake per Bird per Day | 421.81 | 441.25 | 385.30 | 12.27 |
| Total Body Weight | 58814.22ᵃ | 61798.52ᵇ | 50887.42ᶜ | 1923.67 |
| Body Weight per Bird per Week | 5555.97 | 5945.22 | 5634.80 | 130.41 |
| Body Weight per Bird per Day | 793.71 | 849.32 | 804.97 | 18.63 |
| Body Weight Gain | 14182.96ᵃ | 13610.70ᵇ | 10956.64ᶜ | 605.08 |
| Body Weight Gain per Week | 1344.96 | 1300.45 | 1217.18 | 41.90 |
| Body Weight Gain per Day | 192.14 | 185.78 | 173.88 | 5.99 |
| Feed Conversion Ratio | 2.21 | 2.48 | 2.22 | 0.12 |

Note: ⁡ᵃᵇᶜ means in the same row with different superscripts differ significantly; (P<0.05)= *

3.2.1 Total Feed Intake

Results on TFI indicated significant difference (p<0.05) among the treatments where lowest (24437.13), highest (31999.76) and intermediate (31214.32) was recorded in T₃, T₂ and T₁ respectively. T₁ and T₂ were statistically the
same and significant difference existed between T₂ and T₃. SEM recorded was 1192.80.

Weekly trend of ATFI (g/wk) of the experimental birds under performance characteristics at finisher phase is presented in appendix 2 and figure 2. Figures shows increase in ATFI with increase in age of the birds from wk 5-6 (9297.91-11366.22) in T₁ (control), similar trend was observed in T₂ (9679.78-12363.01) and T₃ (7587.51-9520.01). However, ATFI (g/wk) decreased in age of the birds from wk 6-7 in T₁ (11366.22-10568.17), T₂ (12363.01-9956.97) and T₃ (9520.01-7329.60).

3.2.2 Average Feed Intake Per Bird (AFIB)

Results on AFIB (g/b) showed that lowest (2697.07), highest (3088.76) and intermediate (2952.69) were obtained in T₃, T₂ and T₁ respectively. However, significant difference (p>0.05) was not observed among the treatments and SEM recorded was 85.90.

3.2.3 Average Feed Intake Per Bird Per Day (AFIBD)

Results on AFIBD (g/b/d) indicated that lowest (385.30), highest (441.25) and intermediate (421.81) in T₃, T₂ and T₁ respectively. There was no significant difference (p>0.05) among the treatments and SEM recorded was 12.27.

3.2.4 Total Body Weight

Results on TBW indicated that significant difference (p<0.05) existed among the treatments. Significant difference existed between T₂ and T₃. Lowest (50887.42), highest (61798.52) and intermediate (58814.22) values was obtained in T₁, T₂ and T₃ respectively. SEM recorded was 1923.67.

Weekly trend of AWKBW (g/b/wk) of the experimental birds under performance characteristics at finisher phase is presented in appendix 4 and figure 4. Figures can be deduced from the figures that BWG increased in age of the birds from wk 5-6 in T₁ (5067.84-7187.71) and immensely decreased from wk 6-7 (7187.71-1927.41). In contrast, BWG decreased in age of the birds from wk 5-7 in T₂ (7273.20-2033.08) and T₃ (5673.18-).

3.2.5 Body Weight Per Bird (BWB)

Results on BWB indicated no significant difference (p>0.05) existed among the treatments. The lowest (5555.22), highest (5945.22) and intermediate (5634.80) were obtained in T₁, T₂ and T₃ respectively. SEM recorded was 130.41.

3.2.6 Body Weight Per Bird Per Day (BWBD)

Results on BWBD showed that lowest (793.7), highest (849.32) and intermediate (804.97) were obtained in T₁, T₂ and T₃ respectively. However, no significant difference (p>0.05) among the treatments and SEM recorded was 18.63.

3.2.7 Body Weight Gain (BWG)

Results on BWG showed that significant difference (p<0.05) was observed among the treatments between T₁ and T₃ with lowest (10956.64), highest (14182.96) and intermediate (13610.70) was recorded in T₂, T₁ and T₃ respectively. SEM recorded was 605.08.

Weekly trend of ABWG (g/b/wk) of the experimental birds under performance characteristics at finisher phase is presented in appendix 6 and figure 6. It can be deduced from the figures that BWG increased in age of the birds from wk 5-6 in T₁ (50.84-7187.71) and immensely decreased from wk 6-7 (7187.71-1927.41). In contrast, BWG decreased in age of the birds from wk 5-7 in T₂ (7273.20-2033.08) and T₃ (5673.18-).
3.2.8 Body Weight Gain Per Bird (BWGB)

Results on BWG shows that lowest (1217.18), highest (1344.96) and intermediate (1300.45) values was obtained in T3, T1 and T2 respectively. However, significant difference (p<0.05) was not observed among the treatments and SEM recorded was 41.90.

3.2.9 Body Weight Gain Per Bird Per Day (BWGBD)

Results on BWG indicated that no significant difference (p>0.05) existed among treatment means with lowest (173.88), highest (192.14) and intermediate (185.78) values in T3, T1 and T2 respectively. SEM recorded was 5.99.

3.2.10 Feed Conversion Ratio (FCR)

Results on FCR shows that lowest (2.21), highest (2.48) and intermediate (2.22) values was obtained in T1, T2 and T3 respectively. Furthermore, no significant difference (p>0.05) among the treatments thus, they are statistically the same. SEM recorded was 0.12.

Results of trend on AFCR (FI/BWG/Wk) of the experimental birds under performance characteristics at finisher phase are presented in appendix 8 and figure 8. Figures showed FCR decreased in age of the birds from wk 5-6 in T1 (1.86-1.60) and immensely increased from wk 6-7 (1.60-5.89) for birds under control. In contrary, there was increased FCR in age of the birds from wk 5-7 in T2 (1.33-5.39) and T3 (1.31-9.18).

3.3 Carcass Characteristics at Finisher Phase

Results on carcass characteristics of experimental birds that consumed feed supplemented with choline at finisher phase is presented in table 4.3.

4. Primal Cuts

Drum Stick (g)

Results on DS indicated that significant difference (p<0.05) existed among treatments where T2 and T3 are statistically similar while significant difference existed between T2-T3 and T1. SEM recorded was 3.21. Highest (208.15), lowest (188.80) and intermediate (203.60) values was obtained in T2, T3 and T1 for birds that consumed feed supplemented with 10g, 0g and 20g of choline respectively.

Thigh (g)

Results on thigh indicated that no significant difference (p>0.05) among the treatments. Thus, they are statistically similar with SEM 4.28. Lowest (251.80), highest (260.30) and intermediate (251.40) values was recorded in T2, T3 and T1 for birds that consumed 20g, 10g and 0g of choline respectively.

Breast (g)

Results on breast indicated that significant difference (p<0.05) was observed among treatment means thus, they are statistically different and significant difference existed between T2 and T3, SEM recorded was 15.83. Highest (718.00), intermediate (660.90) and lowest (611.65) values were recorded in T1, T2 and T3 for birds fed with feed supplemented with 0g, 10g and 20g of choline respectively.

Wings (g)

Results on wings shows that highest (168.45), intermediate (166.50) and lowest (161.50) was obtained in T3, T2 and T1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. However, there was no significant difference (p>0.05) among the treatments and SEM was 2.23.

Back (g)

Results on back shows that no significant difference (p>0.05) observed among treatment means and SEM obtained was 2.29. Highest (167.70), intermediate (167.60) and lowest (166.20) values was recorded in T1, T3 and T2 for birds fed with feed supplemented with 0g, 10g and 20g of choline respectively.

Neck (g)

Highest (80.15), intermediate (79.40) and lowest (70.30) values were obtained in T3, T2 and T1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. However, significant difference (p<0.05) was observed between treatments 2-3 and treatment 1. SEM recorded was 1.80.

Total Primal (g)

Results on TP obtained was highest (1563.10), intermediate (1536.45) and lowest (1482.85) in T1, T2 and T3 for birds fed with feed supplemented with 0g, 10g and 20g of choline respectively. No significant difference (p>0.05) was observed among treatment means and SEM recorded was 21.00.

Result on performance of primal cuts at the end of fin-
lisher phase is presented in figure 9 below.

Table 4. Carcass Characteristics of Experimental Birds at Finisher Phase

| Parameters          | T1(0g) control | T2(10g) CC | T3(20g) CC | SEM  |
|---------------------|----------------|------------|------------|------|
| Drum Stick          | 188.80         | 208.15     | 203.60     | 3.21 |
| Thigh               | 251.80         | 260.30     | 251.40     | 4.28 |
| Breast              | 718.00         | 660.90     | 611.65     | 15.83|
| Wings               | 166.50         | 161.50     | 168.45     | 2.23 |
| Back                | 167.70         | 166.20     | 167.60     | 2.29 |
| Neck                | 70.30          | 79.40      | 80.15      | 1.80 |
| Total Primal        | 1563.10        | 1536.45    | 1482.85    | 21.00|
| Gizzard             | 49.10          | 39.40      | 42.70      | 0.47 |
| Liver and Bile      | 45.50          | 41.70      | 48.55      | 1.28 |
| Heart               | 8.00           | 7.05       | 10.00      | 0.40 |
| Lungs               | 16.76          | 11.10      | 11.55      | 0.47 |
| Crop                | 10.40          | 10.80      | 11.50      | 0.46 |
| Spleen              | 1.70           | 1.45       | 6.55       | 1.56 |
| Legs                | 64.10          | 65.60      | 81.15      | 2.26 |
| Head                | 43.40          | 42.35      | 49.20      | 1.01 |
| Intestines          | 124.20         | 108.50     | 131.70     | 6.24 |
| Abdominal Fat       | 20.40          | 22.70      | 22.50      | 0.96 |
| Total Organs        | 379.10         | 350.65     | 410.40     | 9.72 |
| Live Weight         | 2157.30        | 2091.20    | 2119.95    | 26.62|
| Killed Weight       | 2090.50        | 2072.45    | 2053.20    | 25.46|
| Dressed Weight      | 1661.70        | 1617.55    | 1574.10    | 20.99|
| Primal per Live Weigh| 72.43         | 73.47      | 69.97      | 0.46 |
| Primal per Dressed Weight | 94.05     | 94.99      | 94.18     | 0.16 |
| Organs per Live Weight | 17.61     | 16.76      | 19.36      | 0.41 |
| Organs per Dressed Weight | 22.87     | 21.67      | 26.09      | 0.66 |

Note: * means in the same row with different superscripts differ significantly, (P<0.05)= *

5. Organs

**Gizzard (g)**

Results on gizzard indicated that significant difference (p<0.05) was observed among treatment means thus, they are statistically different. T2 and T3 were statistically the same and significant difference existed between T1 and T2-T3 and SEM obtained was 1.49. The highest (49.10), intermediate (42.70) and lowest (39.40) was recorded in T1, T1 and T2 for birds fed with feed supplemented 0g, 20g and 10g of choline respectively.

**Liver and Bile (g)**

Results on L&B shows that significant difference (p<0.05) was observed among the treatments where highest (49.50), intermediate (48.55) and lowest (41.70) values were recorded in T1, T1 and T2 for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively. However, significant difference (p<0.05) was observed among treatment means and SEM recorded was 0.47.

**Heart (g)**

Highest (10.00), intermediate (8.00) and lowest (7.05) values were recorded in T3, T1 and T2 for birds fed with feed supplemented with 20g, 0g and 10g of choline respectively. However, significant difference (p<0.05) was observed among treatment means and SEM recorded was 0.40.

**Lungs (g)**

Results on lungs indicated that highest (11.55), intermediate (11.10) and lowest (8.30) values were recorded in T3, T2 and T1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. Significant difference (p<0.05) existed among the treatments and SEM recorded was 0.47.

**Crop (g)**

Results on crop indicated that no significant difference (p>0.05) was observed among treatment means thus, they are similar statistically and SEM recorded was 0.46. Highest (11.50), intermediate (10.80) and lowest (10.40) was recorded in T3, T2 and T1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. However, no significant difference (p>0.05) was observed among treatment means and SEM recorded was 0.47.

**Spleen (g)**

Results on spleen indicated that highest (6.55), intermediate (1.70) and lowest (1.45) values were obtained in T1, T3 and T2 for birds fed with feed supplemented with 20g, 0g and 10g of choline respectively. However, no significant difference (p>0.05) was observed among treatment means and SEM recorded was 1.56.

**Legs (g)**

The highest (81.15), intermediate (65.60) and lowest (84.10) values were recorded under T3, T2 and T1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. However, significant difference (p<0.05) was observed among treatment means and 2.26 was recorded under SEM.

**Head (g)**

Results on head recorded highest (49.20), intermediate (43.40) and lowest (42.35) values under T3, T1 and T2 for birds that consumed feed supplemented with 20g, 0g and 10g of choline respectively. In addition, significant difference (p<0.05) was observed among treatment means,

Figure 9: Performance of Primal Cuts at Finisher Phase
were T₂ and T₁ are statistically similar. 1.01 was recorded under SEM.

**Intestines (g)**

Results on intestines indicated that no significant difference (p>0.05) existed among treatment means and 6.24 was recorded under SEM. Highest (131.70), intermediate (124.20) and lowest (108.50) was obtained in T₃, T₁ and T₂ for birds fed with feed supplemented with 20g, 0g and 10g of choline respectively.

**Abdominal Fat (g)**

There was no significant difference (p>0.05) observed among treatment means for abdominal fat thus, they are statistically the same and SEM recorded was 0.96. Highest (22.70), intermediate (22.50) and lowest (20.40) was recorded under T₂, T₃ and T₁ for birds fed with feed supplemented with 10g, 20g and 0g of choline respectively.

**Total Organs (g)**

Results on TO indicated that there was significant difference (p<0.05) among the treatments, T₃ and T₁ are statistically similar as well as T₁ and T₂. Highest (410.40), intermediate (379.10) and lowest (350.65) values were obtained under T₁, T₂ and T₃ for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively.

**Live Weight (g)**

The results on LW as shown by the table indicated that no significant difference (p>0.05) was observed among the treatment means, thus, they are statistically the same with SEM 26.62. Highest (2157.30), intermediate (2119.95) and lowest (2019.20) values were recorded under T₁, T₂ and T₃ for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively.

**Killed Weight (g)**

Highest (2090.50), intermediate (2053.20) and lowest (2027.45) values were recorded under T₁, T₃ and T₂ for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively. However, there was no significant difference (p>0.05) among the treatments and SEM recorded was 25.46.

**Plucked Weight (g)**

Results on PW indicated that highest (2017.90), intermediate (1978.80) and lowest (1950.75) values were recorded under T₁, T₃ and T₂ for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively. In addition, there was no significant difference (p>0.05) among the treatment means and SEM recorded was 25.45.

**Dressed Weight (g)**

There was no significant difference (p>0.05) observed among the treatment means and SEM recorded was 20.99. Highest (1661.70), intermediate (1617.55) and lowest (1574.10) values were obtained under T₁, T₂ and T₃ for birds fed with feed supplemented with 0g, 10g and 20g of choline respectively.

**Primal Per Live Weight (%)**

Results on P/LW shows that significant difference (p<0.05) existed among the treatment means with T₁ and T₂ statistically the same but statistically different from T₃, while the SEM recorded under it was 0.46. Highest (73.47), intermediate (72.43) and lowest (69.97) values were obtained in T₁, T₂ and T₃ for birds fed with feed supplemented with 10g, 0g and 20g of choline respectively.

**Primal Per Dressed Weight (%)**

Results on P/DW indicated that significant difference (p<0.05) was observed among the treatments where T₁ and T₂ were statistically the same and the SEM recorded was 0.16. Highest (94.99), intermediate (94.05) and lowest (94.18) were obtained in T₁, T₁ and T₂ for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively.

**Organs Per Live Weight (%)**

Results on O/LW indicated that highest (19.36), intermediate (17.61) and lowest (16.76) values were recorded under T₁, T₂ and T₃ for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively. However, significant difference (p<0.05) was observed among treatment means and 0.41 was recorded under SEM.

**Organs Per Dressed Weight (%)**

Results on O/DW indicated that significant difference (p<0.05) was observed among treatments where T₁ and T₂ were statistically the same and the SEM recorded was 0.66. Highest (26.09), intermediate (22.87) and lowest (21.67) values were obtained in T₁, T₂ and T₃ for birds fed with feed supplemented with 20g, 0g and 10g of choline respectively.

Result on weights of the experimental birds at the end of finisher phase is presented in figure 11 below.
7. Discussion

7.1 Performance Characteristics at Starter Phase

7.1.1 Feed Intake

Although, there was no significant difference (p>0.05) among the treatments, there was reduction in feed intake across the different level of choline inclusion in diet; this could be as a result of choline inclusion in the diet. Thus, the more the choline, the lesser the feed intake. It agrees with Swain and Johri (2000) who recorded that choline supplementation alone did not elicit any response in the feed intake and feed utilization of broilers. Blair et al. [5] who found that choline had no effect on the feed consumption of broilers in the presence or absence of additional Methionine. The result contradict Shrivastav et al. [26] who stated the feed intake and feed efficiency ratio increased significantly with the increasing level of choline from 1500-2000mg/kg diet.

7.1.2 Body Weight

There was no significant difference (p>0.05) among treatments with response to different level of choline inclusion with respect to body weight. This was in accordance with Saarinen et al. (2000) who observed choline supplementation did not significantly affect growth performance of broiler chicks fed Methionine adequate or inadequate diets, their observation agrees with that of Swain and Johri (2000) who reported that dietary choline, at different inclusion level, had no significant effect on body weight and body weight change in broiler chicks. Which also contradict Hassan et al. [10] who observed that different levels of choline supplement had meaningful effect on average live body weight.

7.1.3 Feed Conversion Ratio

Significant difference (p<0.05) observed among treatments with response to different level of choline inclusion could be as a result of decreased in feed intake across the levels and significant body weight gain increment. This was in accordance with Hassan et al. [10] who found that supplementation of 0.3g/kg of choline increased feed conversion ratio by 3.3% compared to control diet.

7.2 Performance Characteristics at Finisher Phase

7.2.1 Feed Intake

Significant difference (p<0.05) that existed among treatment means could be as a result of increase in choline synthesis at finisher phase. This conforms with Fouladi et al. (2008) who found that using 500 or 1000mg/kg of choline chloride supplement of broiler diets significantly increased feed intake during 22-42 day-old age. This contradicts with Summer [29] who indicated no positive effects of dietary choline on broiler feed intake during the last three weeks of experimental study.

7.2.2 Body Weight

Significant difference (p<0.05) in body weight with response to different level of choline inclusion could be as a result of positive effect of feed intake and body weight gain. This conforms with Fouladi et al. (2008) who found that using 500-1000mg/kg of choline chloride supplement of broiler diets significantly increased live body weight during 22-42 day-old. Also Baranova [3] observed that inclusion of choline to the diet mixture improved growth rate with the inclusion rate of 500-700mg/kg of diet. Hassan et al. [10] also observed that different level of choline supplementation had meaningful effect on average live body weight. On the contrary, Rafeeq et al. (2011a) and Swain and Johri (2000) reported dietary choline at different level of inclusion had no significant effect on body weight and body weight change in broiler chicks.

Feed conversion ratio

No significant difference (p>0.05) was observed at different level of choline inclusion. This was in contrast with Waldroup et al. (2006) who noted that the supplementation of 1000mg/kg diet statistically improved feed conversion ratio over the chicks fed unsupplemented diets at 35, 42, 49 and 52 days of age. And Fouladi et al. (2008) who found that using 500-1000mg/kg of choline chloride supplement of broiler diets significantly increased feed conversion ratio during 22-42 day-old.

7.3 Carcass Characteristics at Finisher Phase

Significant difference (p<0.05) existed across different level of choline inclusion with respect to breast yield. This
was in accordance with Waldroup and Frits (2005) who reported an improvement in breast yield due to choline supplementation (1000g choline/ton diet) at 42 days of age and not at 49 days of age in broiler chicks. Moreover, Waldroup et al. (2006) also observed that supplementation of 1000g choline/ton to the broiler diets resulted in significant improvements in breast yield at 42, 49 and 56 days of age.

7.4 Conclusion and Recommendation

7.4.1 Conclusion

It is concluded from the experiment that 10gCC/10kg performed better in terms of total body weight (TBW) and feed conversion ratio (FCR). Also in the carcass characteristics, treatment two performed better in terms of breast yield, drumstick, percentage of primal cuts from live weight (P/LW) and percentage of primal cuts from dressed weight.

7.4.2 Recommendation

Based on the result obtained from the research, it is therefore recommended from the experiment that 10g/10kg of choline chloride should be used. It is also recommended that more research should be carried out with lower levels of choline chloride.

References

[1] Adenaike, A.S., U., Akpan, J.E., Udoh, M., Wheto, S.O., Durosaro, A.J., Sanda, C.O.N., Ikeobi. Comparative Evaluation of Growth Functions in Three Broiler Strains of Nigerian Chickens. Pertanika Journal of Tropical Agricultural Science, 2017, 40(4): 611-620.

[2] Alagawany, M., M., El-Hindawy, A., Attia, M., Farag, M.A., El-Hack. Influence of Dietary Choline Levels on Growth Performance and Carcass Characteristics of Growing Japanese Quail. Advances in Animal and Veterinary Sciences, 2015, 3(2): 109-115.

[3] Baranova, G. Choline in Diets for Broiler Chickens. Ptitsevodstvo, 1991, 9: 15-17.

[4] Biswas, S., S., Giri. Importance of Choline as an Essential Nutrient and Its Role in the Prevention of Various Toxicities. Prague Medical Report, 2015, 116: 5.

[5] Blair, M.E., L.M., Potter, B., Bliss, J.R., Shelton. Methionine, Choline and Sulphate Supplementation of Practical Type Diets for Young Turkey. Journal of Poultry Science, 1986, 65(1): 130-137.

[6] Chaudhari, K.I., D.C., Prajapati, P.M., Lunagariya, K.K., Sorathiya, S.N., Patel, R.P., Patel and A.L., Nayak. An Importance of Choline Chloride for Poultry and Cattle: An Overview. International Journal of Science and Technology, 2017, 6(5): 2804-2810.

[7] Corbin, K.D., S.H., Zeisel. Choline Metabolism Provides Novel Insights into Nonalcoholic Fatty Liver Disease and its Progression. Current Opinion in Gastroenterology, 2012, 28: 159. DOI: 10.1097/MOG.0b013e32834e7b4b

[8] Gholami, J., A.A., Qotbi, A., Seidavi, A., Meluzzi, S., Tavaniello, G., Maiorano. Effects of Administration of Betaine and Choline on Hatchability Results, Growth and Carcass Characteristics and Immune Response of Broiler Chickens. Italian Journal of Animal Science, 2015, 14. DOI: org/10.4081/ijas.2015.3694

[9] Harms, R.H., R.D., Miles. Effect of Supplemental-Methionine and Potassium Sulfate on the Choline Requirement of the Turkey Poultry. Journal of Poultry Science, 1984, 63(7): 1464-1466.

[10] Hassan, R.A., Y.A., Attia, E.H., El-Ganzory. Growth, Carcass Quality and Serum Constituents of Slow Growing Chicks as Affected by Betaine Addition to Diets Containing 1. Different Levels of Choline. International Journal of Poultry Science, 2005, 4(11): 840-850.

[11] Hossain, M.E., G.B., Das, M.M., Hasan, A.H., Shaikat, A.S.M., Bari. The Effect of Choline Chloride Supplementation on Performance Parameters and Carcass Characteristics of Broiler. Iranian Journal of Applied Animal Science, 2014, 4(2): 373-378.

[12] Huang, Z., J., Rui, X., Li, X., Meng, Q., Liu. Use of 11C-Choline Positron Emission Tomography/Computed Tomography to Investigate the Mechanism of Choline Metabolism in Lung Cancer. Molecular Medicine Reports, 2015, 11: 3285-3290. DOI: 10.3892/mmr.2015.3200

[13] Igono, M.O., Y.O., Aliu. Environmental Profile and Milk Production of Friesian-Zebu Crosses in Nigerian Guinea Savannah. International Journal of Biometeorology, 1982, 26: 115-120.

[14] Igwe, I.R., C.J., Okonkwo, U.G., Uzoukwu, C.O., Onyenegecha. The Effect of Choline Chloride on the Performance of Broiler Chickens. Annual Research and Review in Biology, 2015, 8(3): 1-8.

[15] Jiang, X., A.A., West, M.A., Caudill. Maternal Choline Supplementation: A Nutritional Approach for Improving Offspring Health. Trends in Endocrinology and Metabolism, 2014, 25: 263-73. DOI: 10.1016/j.tem.2014.02.001

[16] Khosravinia, H., P.S., Chethen, B., Ukmakantha, R., Nourmohamadi. Effects of Lipotropic Products on Productive Performance, Liver Lipid and Enzymes Activity in Broiler Chickens. Poultry Science Journal, 2015, 3: 113-120
[17] Kim, Y.I., J.W., Miller, K.A., Costa, M., Nadeau, D., Smith, J., Selhub, S.H., Zeisel, J.B., Mason. Severe Folate Deficiency Causes Secondary Depletion of Choline and Phosphocholine in Rat Liver. Journal of Nutrition, 1994, 124: 2197.

[18] McDonald, P., R., Edward, C.A., Morgan, J.F.D., Greenhalgh. Animal Nutrition. Sixth Edition. Published by Dorling Kindersley (India) Pvt. Ltd. Noida, India, 2011.

[19] Nigeria Population Commission (NPC). Projected figures. Federal Republic of Nigeria, 2012.

[20] NRC. Nutrient Requirement of Poultry, 9th Revised Edition. Subcommittee on Poultry Nutrition, National Research Council. National Academy Press Washington D.C. United States of America, 1994.

[21] Oladele, S.B., S., Ogundipe, J.O., Ayo, K.A.N., Esievo. Effects of Season and Sex on Packed Cell Volume, Haemoglobin and Total Proteins Indigenous Pigeons in Zaria, Northern Nigeria. Veterinary Archive, 2001, 71: 277-286.

[22] Pesti, G.M. The Nutrition of Labile Methyl Group Donors in Broiler Chickens. Pages 145-150 in: Proceedings of the Maryland Nutrition Conference, College Park, MD, 1989.

[23] Pesti, G.M., A.E., Harper, M.L., Sunde. Choline/Methionine Nutrition of Starting Broiler Chicks. Three Models for Estimating the Choline Requirement with Economic Considerations. Poultry Science, 1980, 59: 1073-1081. DOI:10.3382/ps.0591073

[24] Rama Rao, S.V., G.S., Sunder, M.R., Reddy, N.K., Prahraraj, M.V., Raju, A.K., Panda. Effect of Supplementary Choline on the Performance of Broiler Breeders Fed on Different Energy Sources. British Poultry Science, 2001, 42:362. DOI:10.1080/00071660120055340

[25] Ross R.G., S.K., Hunter, L., Mccarthy, J., Beuler, A.K., Hutchison, B.D., Wagner. Perinatal Choline Effects on Neonatal Pathophysiology Related to Later Schizophrenia Risk. American Journal of Psychiatry, 2013, 170: 290-298.

[26] Shrivastav, A.K., B.B., Dash, T.S., Johri. Effect of Dietary Levels of Choline in Relation to Sulphur AminoAcid for Growth and Immune Response in Quail Broilers. Indian Journal of Poultry Science, 2004, 39(1): 9-14.

[27] Sokoto State Government (SOSG). Ministry of Information, Sokoto, Nigeria. Diary, 2012: 12.

[28] Sonbol, S.M.. Interrelationship between Methionine and Choline Levels on the BroilerPerformance and Blood Constituents. Egypt Journal of Applied-Science, 1990, 5(1): 209-219.

[29] Summers, D.J.. Effect of Choline or BetaineSupplementation on Broilers Exposed to DifferentTemperature Treatments. Thesis Master of Science, The University of Tennessee, Knoxville, 2013.