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ARTICLE

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

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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-

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riod. 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 [28].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 $C_5H_{14}NO^+$ and of choline chloride is ($HOCH_2CH_2N$ (CH_3)3HCl) [6]. Cholinechloride have 139.63 g/mole molecular weight, 247^0c melting point, decompose on heating, 1.1 g/cm³ relative density at 20°C (70% choline chloride in water) and practically stable at 20-30^0C [6]. 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 [8].

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 thr 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 32,000km^2 (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

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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^{nd}) to seventh (7^{th}) 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_1 (control 0g/kg), T_2 (10g choline/10kg feed) and T_3 (20g choline/10kg of 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

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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	T_1(0gC-C/10kg)	T_2(10gC-C/10kg)	T_3(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^{b}	1781.08^{ab}	1907.59^{a}	33.29
Body Weight per Bird per Day	245.41^{b}	254.44^{ab}	272.51^{a}	4.76
Body Weight Gain	7620.75^{ab}	8241.20^{a}	6227.30^{b}	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^{ab}	1.73^{b}	2.26^{a}	0.098

Note: ^{abc}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 T_3 and the highest was 14442.18 in T_1 (control). Furthermore, the intermediate was 14252.52 in T_2. 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 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 T_1 (control), similar trend was observed in T_2 (3088.72 – 6290.54) and T_3 (2978.07 – 5523.52).

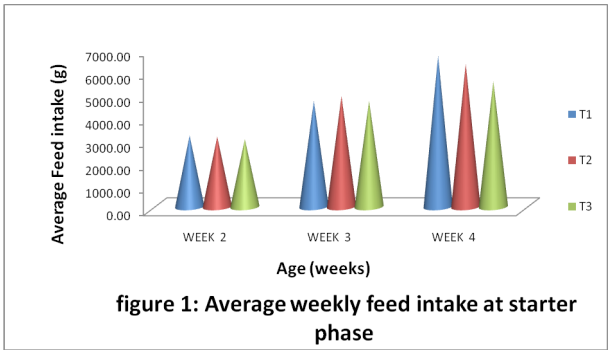

figure 1: Average weekly feed intake at starter phase

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 T_2, highest (1415.12) in T_3 and intermediate (1368.35) in T_1. 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 T_2 and T_3 respectively. Intermediate value 195.48 was obtained in T_1. 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 T_2, T_1 and T_3 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 ; T_1(3347.10-9102.63), T_2 (3344.92-9779.00) and T_3 (3506.76-7765.10) respectively.

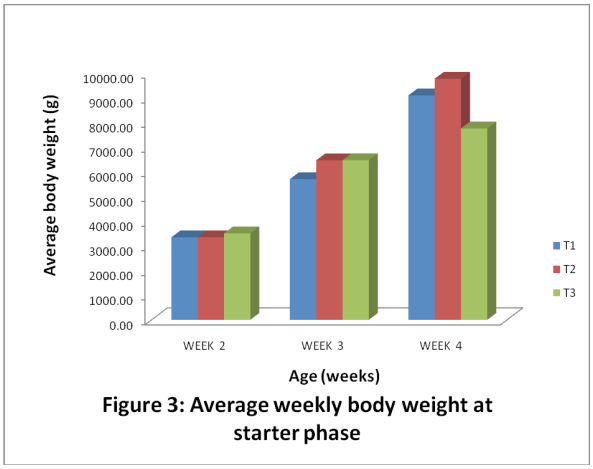

Figure 3: Average weekly body weight at starter phase

3.1.5 Body Weight Per Bird (BWB)

1717.88, 1781.08 and 1907.59 values was obtained for BWB (g/b) in T_1, $T_2$and T_3 respectively, with the highest value 1907.59 observed in T_3, intermediate 1781.08 in T_2 and lowest 1717.88 in T_1. 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

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T_3 and lowest 245.41 in T_1 (control). Intermediate value (254.44) was recorded in T_2. 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 T_3 and T_2 respectively. Intermediate (7620.75) value obtained was in T_1. 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 T_1 (1865.22-3396.49) and T_2 (1807.12-3311.00) respectively. Similar trend was also observed from only wk 2-3 in T_3 (1968.96-2966.74) and sudden decrease from wk 3-4 (2966.74-1292.00).

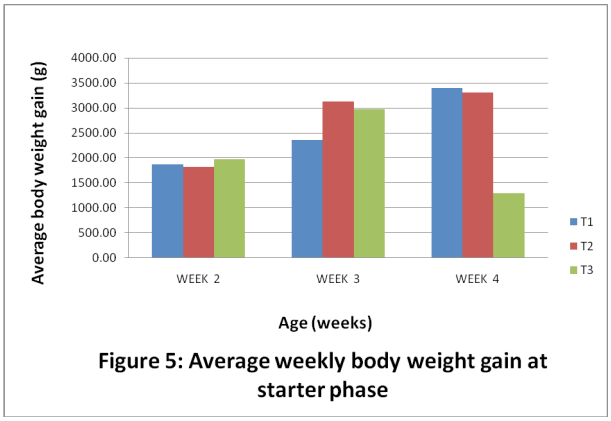

Figure 5: Average weekly body weight gain at starter phase

3.1.8 Body Weight Gain Per Bird (BWGB)

Result on BWGB (g/b) was lowest (648.67) in T_3, highest (749.20) in T_2 and intermediate (719.30) in T_1 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 T_3, T_2 and T_1 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 T_3(2.26), T_1 (1.90) and T_2 (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; T_1 (1.68-2.04), T_2 (1.44-1.90) and T_3 (1.51-3.57). T2 has the best FCR across the weeks (1.44-1.57-1.90).

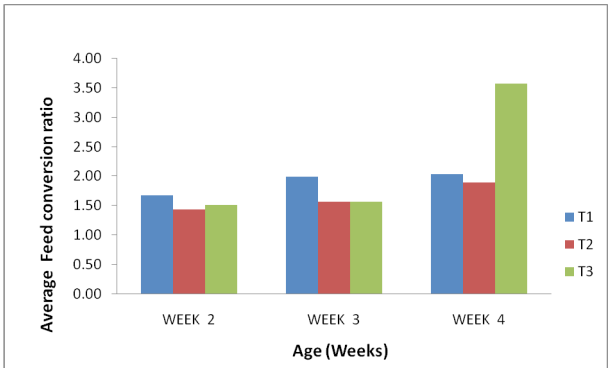

Figure 7: Average weekly feed conversion ratio at starter phase

3.2 Performance Characteristics at Finisher Phase

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

Table 3. Performance Characteristics of Experimental Birds at Finisher Phase

Parameters	T_1(0gCC/kg)	T_2(10gC-C/10kg)	T_3(20gC-C/10kg)	SEM
Total Feed Intake	31214.32^{a}	31999.76^{a}	24437.13^{b}	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	58814.22^{ab}	61798.52^{a}	50887.42^{b}	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	14182.96^{a}	13610.70^{ab}	10956.64^{b}	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 T_3, T_2 andT_1 respectively. T_1 and T_2 were statistically the

same and significant difference existed between T_2 and T_3. 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 T_1 (control), similar trend was observed in T_2 (9679.78 – 12363.01) and T_3 (7587.51-9520.01). However, ATFI (g/wk) decreased in age of the birds from wk 6-7 in T_1 (11366.22 – 10568.17), T_2 (12363.01 -9956.97) and T_3 (9520.01-7329.60).

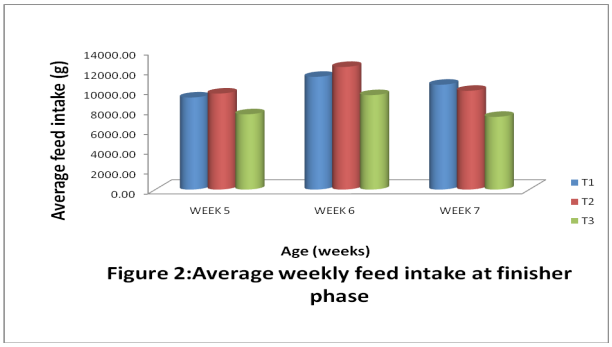

Figure 2:Average weekly feed intake at finisher phase

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 T_3, T_2 andT_1 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 T_3, T_2 and T_1 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 T_2 and T_3. Lowest (50887.42), highest (61798.52) and intermediate (58814.22) values was obtained in T_3, T_2 and T_1 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 showed increase in ABW with increase in age of birds from wk 5-7 in T_1 (14170.47-23285.58) and T_2 (17052.20-23389.70). However, similar trend was also observed in T_3 (13483.28-18727.40) only from wk 5-6, while from wk 6-7 there was slight decrease (18727.40-18721.74).

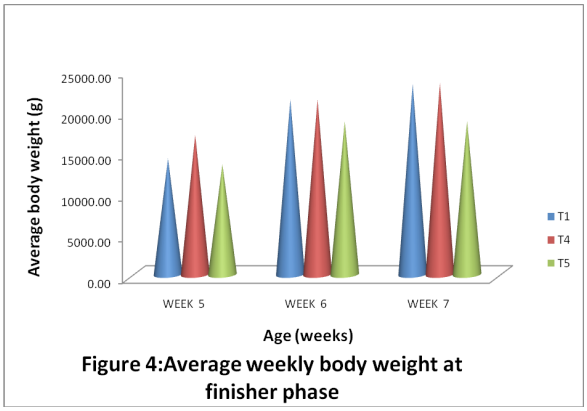

Figure 4:Average weekly body weight at finisher phase

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 T_1, T_2 and T_3 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 T_1, T_3 and T_2 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 T_1 and T_3 with lowest (10956.64), highest (14182.96) and intermediate (13610.70) was recorded in T_3, T_1 and T_2 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 T_1 (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 T_2 (7273.20-2033.08) and T_3 (5673.18-).

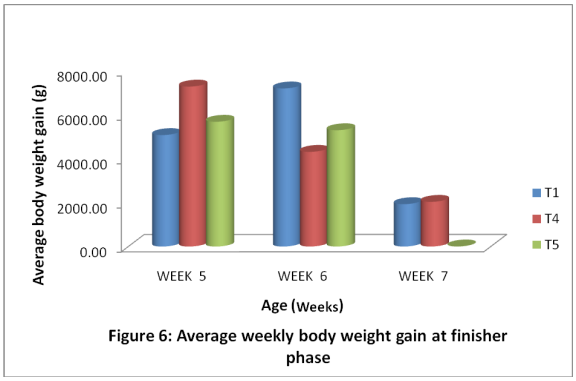

Figure 6: Average weekly body weight gain at finisher phase

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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 T_3, T_1 and T_2 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 T_3, T_1 and T_2 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 T_1, T_2 and T_3 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 T_1 (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 T_2 (1.33-5.39) and T_3 (1.31-9.18).

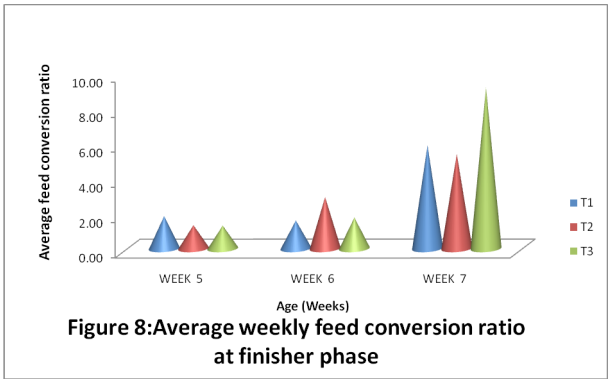

Figure 8:Average weekly feed conversion ratio at finisher phase

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 T_2 and T_3 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 T_2, T_1 and T_3 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 T_3, T_2 and T_1 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 T_1, T_2 and T_3 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 T_3, T_1 and T_2 for birds fed with feed supplemented with 20g, 0g and 10g 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 T_1, T_3 and T_2 for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively.

Neck (g)

Highest (80.15), intermediate (79.40) and lowest (70.30) values were obtained in T_3, T_2 and T_1 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 T_1, T_2 and T_3 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-

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isher phase is presented in figure 9 below.

Table 4. Carcass Characteristics of Experimental Birds at Finisher Phase

Parameters	T_1(0g) control	T_2(10g) CC	T_3(20g) CC	SEM
Drum Stick	188.80^{b}	208.15^{a}	203.60^{a}	3.21
Thigh	251.80	260.30	251.40	4.28
Breast	718.00^{a}	660.90^{ab}	611.65^{b}	15.83
Wings	166.50	161.50	168.45	2.23
Back	167.70	166.20	167.60	2.29
Neck	70.30^{b}	79.40^{a}	80.15^{a}	1.80
Total Primal	1563.10	1536.45	1482.85	21.00
Gizzard	49.10^{a}	39.40^{b}	42.70^{b}	1.49
Liver and Bile	45.50^{a}	41.70^{b}	48.55^{a}	1.28
Heart	8.00^{b}	7.05^{b}	10.00^{a}	0.40
Lungs	8.30^{b}	11.10^{a}	11.55^{a}	0.47
Crop	10.40	10.80	11.50	0.46
Spleen	1.70	1.45	6.55	1.56
Legs	64.10^{b}	65.60^{b}	81.15^{a}	2.26
Head	43.40^{b}	42.35^{b}	49.20^{a}	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^{ab}	350.65^{b}	410.40^{a}	9.72
Live Weight	2157.30	2091.20	2119.95	26.62
Killed Weight	2090.50	2027.45	2053.20	25.46
Dressed Weight	1661.70	1617.55	1574.10	20.99
Primal per Live Weight	72.43^{a}	73.47^{a}	69.97^{b}	0.46
Primal per Dressed Weight	94.05^{b}	94.99^{a}	94.18^{b}	0.16
Organs per Live Weight	17.61^{b}	16.76^{b}	19.36^{a}	0.41
Organs per Dressed Weight	22.87^{b}	21.67^{b}	26.09^{a}	0.66

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

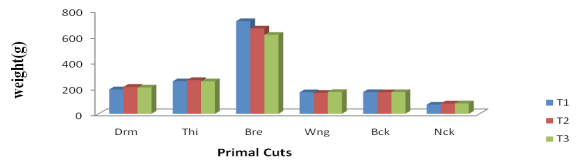

Figure 9: Performance of Primal Cuts at Finisher Phase

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 T_1, T_3 and T_2 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 T_1, T_3 and T_2 for birds fed with feed supplemented with 0g, 20g and 10g of choline respectively. SEM recorded under L&B was 1.28.

Heart (g)

Highest (10.00), intermediate (8.00) and lowest (7.05) values were recorded in T_3, T_1 and T_2 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 T_3, T_2 and T_1 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 T_3, T_2 and T_1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively.

Spleen (g)

Results on spleen indicated that highest (6.55), intermediate (1.70) and lowest (1.45) values were obtained in T_3, T_1 and T_2 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 (64.10) values were recorded under T_3, T_2 and T_1 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 T_3, T_1 and T_2 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,

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were T_2 and T_1 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 T_3, T_1 and T_2 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 T_2, T_3 and T_1 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, T_3 and T_1 are statistically similar as well as T_1 and T_2. Highest (410.40), intermediate (379.10) and lowest (350.65) values were obtained under T_3, T_2 and T_1 for birds fed with feed supplemented with 20g, 10g and 0g of choline respectively.

Result on the performance of organs at the end of finisher phase is presented in figure 10 below.

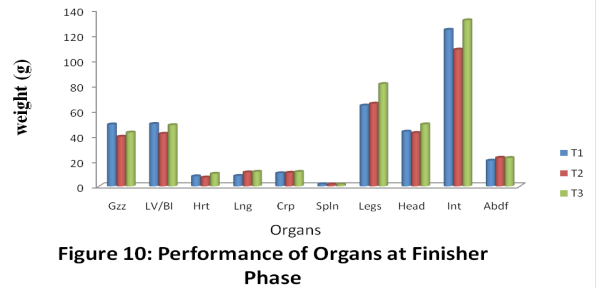

Figure 10: Performance of Organs at Finisher Phase

6. Weights and Percentages

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 T_1, $T_3$and T_2 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 T_1, $T_3$and T_2 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 T_1, $T_3$and T_2 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 T_1, T_2 and T_3 for birds fed with feeed 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 T_1 and T_2 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 T_2, T_1 and $T_3$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 T_3 and T_1 are statistically the same but statistical difference existed between T2 and T1-T3 and the SEM recorded was 0.16. Highest (94.99), intermediate (94.05) and lowest (94.18) were obtained in T_2, $T_3$and T_2 for birds fed with feed supplemented with 10g, 20g 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 T_3, T_2 and T_1 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 T_1 and T_2 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 T_3, T_1 and T_2 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.

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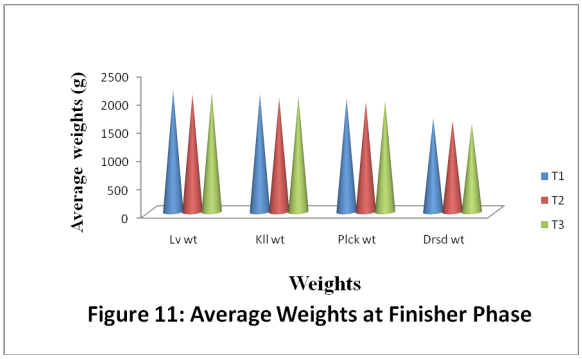

Figure 11: Average Weights at Finisher Phase

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

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was in accordance with Waldroup and Fritis (2005) who reported an improvement in breast yield due to choline supplementation (1000g choline/ton diet) at 42 days of age and not at 49days 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.

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