THE INFLUENCE OF VARYING CALCIUM-PHOSPHORUS RATIOS ON FINISHING AND CARCASS CHARACTERISTICS OF BROILER FINISHER CHICKENS UNDER A SEMI ARID ENVIRONMENT

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ABSTRACT

An experiment was conducted to determine the influence of various ratios of calcium to phosphorus on growth performance and carcass yield of broiler finisher chickens under a semi arid environment. The experiment used a total of 150 twenty eight days old broiler chicks randomly assigned to five treatment groups of 30 birds each made up of three replicates of ten birds. They were fed five treatment diets that were isocaloric-isonitrogeneous but of varying Ca: P ratios namely; 2:1 (control), 2.5:1, 3:1, 3.5:1 and 4:1 for a period of thirty five days. The highest daily feed consumption of 132.88g was recorded for the 4:1 ratio group while the control group significantly ($P<0.05$) consumed the least (121.80g). All the four treatment groups (i.e., 2.5:1 to 4:1) significantly ($P<0.05$) gained more than the control. The trend was similar for feed conversion ratio and final body weight. The ranking order of final body weight was 3:1>4:1>3.5:1>2.5:1>2:1. Among the carcass indices, drum stick and breast were significantly heaviest in 2.5:1 and 3:1groups respectively. The study concluded that Ca: P ratio of 2:1 was inadequate for broiler finishers while 3:1 was the most favourable for finishing broiler chickens.

Keywords: calcium-phosphorus ratio, broiler-chickens, finishing characteristics.

INTRODUCTION

Generally speaking, minerals are responsible for proper Osmo-regulation in addition to maintaining nervous and muscular coordination and blood coagulation in the animal's body. Among the macro minerals, Calcium (Ca) and Phosphorus (P) are known for their ability to interact with each other. The two minerals are so much dietary essential that deficiency of Ca, for instance, leads to development of rickets, tibial dyschondroplasia (TD), increased chick's mortality and reduced body weight in older birds [1]. Inadequacy of P also results in similar anomalies and includes loss of skeletal integrity, loss of appetite subnormal growth in young birds and weight loss in older birds [2, 3]. However, when in excess, Ca impedes the availability of other minerals like P, Mg, Mn, Zn and through the formation of Ca-phytate complexes, reduces the efficacy of phytase as reported in literature [4, 5]. Furthermore, excess dietary Ca concentration may reduce the energy value of the diet through the chelation of lipids [4]. Therefore, balanced ratio between Ca and P is as important as formulating the diet itself.

The report of NRC [6] suggested 1% Ca for broilers and could be increased when accompanied by increased P so as to increase weight gain and reduce the risk of toxicity. Similarly, [7] found that bodyweight response to dietary Ca is bell shaped and shifted to right as the P level increase from 0.7% to 0.9%. Also, [8] opined that, Ca requirement for optimum weight gain was similar to or slightly higher than the recommended 1.0% level [6]. Earlier, [9] observed that Ca: P ratio of 1:1 and 2:1 were adequate for growing chickens, while up to 6:1 is required for laying hens. Furthermore, [10] cautioned that young birds should not be fed high Ca diets because Ca: P ratio will be unbalanced which results in high morbidity and mortality. It has been shown that feed conversion ratio of birds fed 0.4% more Ca than the 2:1 Ca: P ratio did not differ significantly ($P>0.05$) from that of birds fed any of the other Ca levels tested [11]. Therefore, the objective of this study was to determine the influence of various Ca: P ratio on the performance of broiler chickens thereby establishing optimum dietary ratio of calcium to phosphorus.

MATERIALS AND METHODS

Experimental site, stock and design

This study was conducted at the Teaching and Research Farm, Department of Animal Science, University of Maiduguri, Nigeria. Located on Latitude 11^o15^1N, Longitude 30^o05^1E and altitude of 345m above sea level, the city of Maiduguri is a typical semiarid zone. Diurnal room temperature of 35^oC to 40^oC and relative humidity of ≤ 35% are not uncommon during hot season (March to June). These peculiar environmental characteristics make it inevitable for poultry farmers to finish broiler stocks on wood shavings-littered floor, open-sided houses.

A total of 150 unsexed *Hybro* strain of broiler chicks aged 28 days were fasted overnight, and randomly allotted to five groups of 30 birds. Each group was made up of three replicates of ten (10) birds in a completely randomized design. Birds from each replicate were individually weighed to get the initial body weight to the nearest whole number. Thereafter, they were fed isocaloric-isonitrogeneous broiler finisher diets of varying Ca: P ratio namely: 2:1 (control), 2.5:1, 3:1, 3.5:1 and 4:1 (Table-1). Feeding and watering were *ad libitum* throughout the thirty five day study period.

Table-1. Composition and calculated analysis of the experimental broiler finisher diet (%).

Various Ca: P ratios in the diets					
Ingredients	**2:1**	**2.5:1**	**3:1**	**3.5:1**	**4:1**
Maize	58.00	58.00	58.00	58.00	58.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Full-fat soya	12.00	12.00	12.00	12.00	12.00
Groundnut cake	10.00	10.00	10.00	10.00	10.00
Fish meal	05.00	05.00	05.00	05.00	05.00
Blood meal	01.00	01.00	01.00	01.00	01.00
Bone meal	02.75	01.74	01.06	00.60	00.22
Limestone	00.25	01.26	01.95	02.40	02.78
Min-vit Premix*	00.50	00.50	00.50	00.50	00.50
NaCl	00.30	00.30	00.30	00.30	00.30
Methionine-DL	00.20	00.20	00.20	00.20	00.20
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculate analysis					
Crude protein	20.35	20.35	20.35	20.35	20.35
Crude fibre	03.23	03.23	03.23	03.23	03.23
Ether Extract	05.67	05.67	05.67	05.67	05.67
ME(Kcal/kg)	2977.36	2977.36	2977.36	2977.36	2977.36
Calcium	1.4726	1.4524	1.4386	1.4296	1.4220
Phosphorus	0.7275	0.5760	0.4725	0.4050	0.3480

*Composition of the broiler finisher premix used:
The mineral-vitamin premix supplied the following nutrients per Kg of feed: Vitamin A = 12000.00IU, Vitamin E = 1000mg, folic acid = 1000mg, Pathogenic acid = 15, 000mg, Vitamin B_{12} = 15000mg, B_6 = 2500mg, B_1 = 2000mg, Vitamin K = 2000mg, Choline = 50, 000mg, Manganese = 10000mg, Vitamin D_3 = 25,000IU, Nicotinic acid = 40,000mg, Biotin = 6000mg, Vitamin C = 3000mg, Copper = 15, 000mg, Cobalt = 250mg and selenium = 1000mg.

Response criteria

The major response criteria were: daily feed intake, daily weight gain, feed conversion ratio (FRC), Feed Consumption as Percent body weight and Final bodyweight. Carcass parameters were also determined. Feed intake was determined by offering a known quantity of feed (A) to each replicate, morning and evening and the left over (B) weight the following morning. The difference between A and B (A-B) gave the quantity of feed consumed. Daily weight gain was obtained by weighing birds individually from each replicate weekly. Mean of each group was taken (X) and that of the previous week (Y) was subtracted from it (X-Y). The difference between the two divided by seven days gave the daily weight gain for a particular day in a week i.e., (X-Y)/7 = daily wt gain (DWG). FCR was given by the ratio of feed intake (A) to bodyweight gain at a particular period i.e., A/DWG (g).

Feed consumption as percent bodyweight was the percent expression of the ratio of feed consumed or intake (A) to the actual live bodyweight (BW) at a particular period i.e., (A/BW) 100%. Final body weight is the weight of each bird at the end of the study period. An automatic mobile weather station (*Oregon Scientific Model WMR 928 MX*) was used to measure temperature and relative humidity daily.

Average parameter for each week was then calculated.

At end of the experimental period i.e., ninth week of life, three birds from each replicate were selected on the basis of bodyweight true-to-type for the group they represent. They were staved over night and slaughtered the following morning. The birds were thereafter defeathered, dressed and piecessed into cut-up parts and organs. Each part of a chicken was weighed individually on an electronic sensitive balance to the nearest two decimal

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places. Indices of assessment were dressing percentage, cut-ups as a percent dressed weight and organs weight.

Data analysis

All data collected were subjected to analysis of variance of completely randomized design (CRD) according to [12]. Where necessary, means were separated using Standard Error of Means (SME) and Least Significant Difference (LSD) in accordance with [13]. All statements of significance were based on $p<0.05$.

RESULTS AND DISCUSSIONS

Feed consumption varied significantly ($P<0.05$) between the control group on one hand and the treatment groups on the other (Table-2). The trend of feed consumption appeared to be increasing with increasing dietary Ca: P ratio, with 2:1 being the least (121.80g) and 4:1 being the highest consumer (132.88g). It can therefore be said that higher Ca: P ratios stimulated higher appetite than lower ratios. This observation was at variance with that of [14] who observed non-significant of Ca and P or their concentration on feed consumption of chickens. The result, however, partly agreed with that of [15, 16, 17, and 18] who reported significant ($P<0.05$) inverse linear relationship between levels of dietary calcium and feed intake and increasing the amount of available P decreases feed intake. The 2:1, 2.5:1 and 4:1 ratios did not differ significantly from one another, while 4:1 ratio consumed significantly ($P<0.05$) more feed than either the control or 3.5:1 group.

During the third week of the study (7th week of age), there was a general drop in feed consumption across the entire groups from an average of 125g to 109g. This represents a drop of about 13%. During this time, average diurnal temperature was about 37^0C with a relative humidity of 31% (Figure-1). The temperature was above the upper critical point of thermo neutral zone (18^0C-26^0C) for maximum broiler development; this was perhaps responsible for the 13% decline in feed intake. It can as well be said that at such a temperature, the ratio of Ca: P exerted very little or no effect on feed consumption.

Mean body weight over the study period showed that 4:1 group was significantly ($P<0.05$) heavier than 2:1, 2.5:1 and 3:1. This trend appeared to have followed feed consumption trend with 4:1 being the highest and 2:1 being the least. Same trend was observed for daily weight gain (Table-2). The four treatment groups (2.5:1, 3:1, 3.5:1 and 4:1) recorded significantly ($P<0.05$) higher weight gain than the control group. This implied that, higher Ca: P ratios support higher rate of gain in finishing broiler chickens. This may be attributed to higher feed consumption and invariably, higher Ca and P consumption. This result disagreed with the earlier report of [19] which showed that Ca: P ratio of 1.2:1 provided better growth rate than 1:1 or 2:1 and [9] which observed that Ca: P ratio of 1:1 and 2:1 were adequate for growing chickens but concurred with [20] which recommended higher ratios than 2:1 for better gain. The result similarly supported, partly, the report of [8] which indicated a Ca requirement for optimum weight that was similar to or slightly higher than the [20] recommendation of 1.0%.

Table-2. Productive performance of *Hybro* strain of broiler chickens finished on varying dietary Ca: P ratios for 35 days.

	Various Ca: P ratios in the diets					
Ingredients	**2:1**	**2.5:1**	**3:1**	**3.5:1**	**4:1**	**SEM**
DFC (g)	121.80^{c}	127.82^{ab}	128.01^{ab}	126.41^{bc}	132.88^{a}	6.80
IBW (g)	833.00	851.50	866.00	848.67	812.00	NS
ABW (g)	1790.67^{c}	1874.22^{b}	1869.22^{b}	1896.39^{ab}	1939.39^{a}	62.63
DWG (g)	35.08^{b}	42.53^{a}	48.07^{a}	44.50^{a}	43.54^{a}	7.94
FCR	3.89^{a}	3.18^{ab}	2.85^{b}	3.11^{ab}	3.44^{ab}	0.88
AFC as % BW	6.80	6.82	6.85	6.67	6.85	NS
FBW (g)	2383.67^{c}	2610.67^{b}	2705.00^{a}	2637.33^{ab}	2639.00^{ab}	74.15
Mortality (%)	00	7.14	00	3.45	00	NTS

---a, b, c Means within the same row bearing different superscripts differ significantly ($P<0.05$)
Where: SME = Standard Error of Means
NS = Not Significant ($P>0.05$)
NTS = Not Tested Statistically
DFC = Daily Feed Consumption,
IBW = Initial Body Weight,
ABW = Average Body Weight,
DWG = Daily Weight Gain,
FCR = Feed Conversion Ratio,
AFC = ad libitum feed consumption as percent Body Weight
FBW = Final Body Weight

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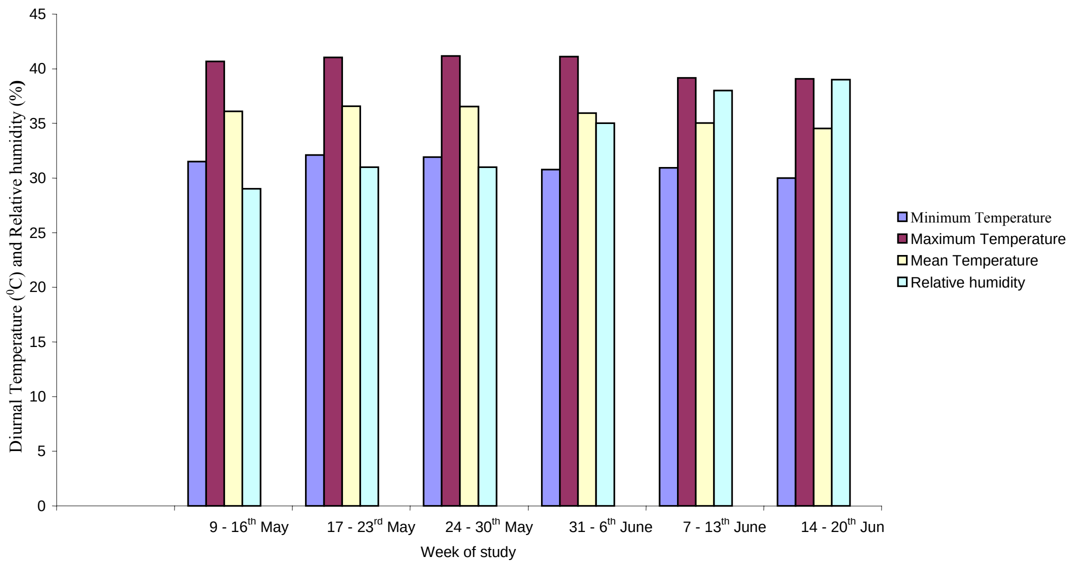

Figure-1. Minimum, maximum and mean diurnal temperature (^{0}C) and relative humidity (%) over the study period.

Birds in the 3:1 group tended to convert the feed consumed more efficiently, into meat, than any other group. Of course, no significant (P>0.05) difference was observed among 3:1, 3.5:1 and 4:1 groups compared to 2.5:1, the 3:1 treatment group was significantly (P<0.05) better than the control (Table-2) in terms of FCR. This finding reaffirmed the report of [17] which observed improved feed efficiency with increasing level and ratio of Ca to P. It also buttressed the work of [11] which reported that birds fed diet with 0.2% more Ca than the 2:1 NPP had significantly better FCR than birds fed the 2:1 ratio.

Although the best FCR was recorded for the 3:1 group birds in the 3.5:1 group consumed less feed as percent of their bodyweight (Table-2). This group consumed 6.67% of their body weight as feed, while all the other four groups consumed ≥ 6.80%. The 3:1 group also recorded the heaviest final bodyweight of 2700g while the control group was the least with 2384g. This showed that the Ca: P ratio of 3:1 yielded the heaviest birds. In other words, this ratio favoured efficient carbohydrate and fat metabolisms in finishing broiler chickens.

Carcass analysis (Table-3) revealed that, the group that was finished on Ca: P ratio of 3:1 was significantly (P<0.05) heavier than the control before slaughter. Other treatment groups did not differ among themselves. On slaughter, each bird drained about 50ml of blood with no significant variation in blood volume among groups. The dressed carcasses from all the experimental groups were heavier than the control (2:1) group. Dressing percentage revealed no significant difference among various groups. However, the significantly (p<0.05) heavier dressed birds produced by the Ca: P of >2:1 may mean that the 2:1 ratio was not adequate in finishing broiler chickens.

Most cut-up parts, except breast and drumstick, did not vary significantly (P>0.05) among groups (Table-3). The 3:1 group significantly (P<0.05) recorded heavier breast (546.46g) amounting to 28.61% of dress than the other four groups. This implied that 3:1 favoured better yield of finished broiler. The drumstick was heaviest in the 2.5:1 group. This significantly heavier drumstick might have been as a result of longer tibial bones recorded by the group. Therefore the Ca: P ratio of 2.5:1 may not only favour elongation of tibial bone but, invariably, heavier drumstick.

Among the visceral organs, only abdominal fat was found to vary significantly (Table-3). The control group significantly (P<0.05) recorded higher abdominal fat than 3.5:1 group. The 49.43g fat recorded by the control group was higher than the 46.68g reported by [21] but below the 64.77g reported by [22]. Although no significant (P>0.05) difference was visible when Ca: P ratio of 2:1 was compared with the ratios of 2.5:1, 3:1 and 4:1 (Table-3), the general picture was that higher Ca: P ratios did not favour higher fat deposition. This is a beneficial trait in broiler industry.

Mortality recorded as shown in Table-2 indicated that 2.5:1 had the highest mortality of 7.14% followed by 3.5:1 with 3.45% mortality. No mortality was recorded in the other three groups. Postmortern examination of carcasses from the two groups concluded that the birds died of heat stress. No infection or other causes than heat stress was implicated. The mortality might not have been as a result of treatment effects but rather individual susceptibility to heat stress. This was buttressed by the fact that, the mortalities were recorded during the 2nd week of the study when ambient temperature was over 40C^0 (Figure-1).

Table-3. Carcass parameters of *Hybro* Strain of broiler chickens finished on varying Ca: P ratio.

	Various Ca: P ratios in the diets					
Parameter	**2:1**	**2.5:1**	**3:1**	**3.5:1**	**4:1**	**LSD**
Live body weight	2468.10±17.04^{b}	2590.00±10.20^{ab}	2688.30±24.04^{a}	2676.05±15.30^{ab}	2609.46±30.35^{ab}	123.50
BDW	2518.00±6.00	2542.00±.09	2640.50±8.40	2622.00±3.00	2560.50±2.90	NS
Dressed weight	1715.00±0.95^{b}	1778.40±5.50^{ab}	1910.04±6.10^{a}	1875.38±5.50^{ab}	17890.50±7.50^{ab}	89.00
Dressing percentage	69.53±3.35	69.69±7.17	70.15±2.50	70.48±6.25	68.68±5.75	NS
Cut up parts						
Head	50.73±2.54	51.00±7.20	51.39±3.10	55.34±6.78	47.21±6.81	NS
Neck	91.51±14.71	105.62±12.01	118.39±10.05	96.52±15.24	99.08±6.81	NS
Shanks	84.80±4.43	9431±14.60	81.77±14.60	88.90±19.01	82.22±13.85	NS
Breasts	482.39±30.61^{b}	479.92±26.68^{b}	546.46±19.25^{a}	456.91±11.40^{b}	484.93±2.08^{b}	79.50
B % DW	28.13±4.20	30.54±4.25	25.13±2.05	24.36±3.10	27.08±5.30	NS
Thorax	188.03±47.90	202.40±10.54	186.2716.72	147.06±15.90	228.92±29.73	NS
Back	206.34±20.10	210.41±2321	202.37±27.13	189.03±28.23	200.05±19.35	NS
Wings	201.37±9.21	233.47±7.17	199.04±11.20	193.04±6.20	206.23±13.24	NS
Thighs	304.59±27.62	343.32±26.69	306.04±33.30	294.77±21.74	285.87±38.56	NS
Drum sticks	215.38±29.11^{ab}	257.05±19.13^{a}	215.87±24.93^{b}	222.76±10.49^{b}	219.45±25.90^{b}	33.00
Visceral organs						
Gizzard	66.88±9.91	69.15±3.98	67.25±7.07	62.53±9.79	58.94±11.28	NS
Abdominal fat	49.43±11.55^{a}	33.08±13.80^{ab}	34.54±11.45^{ab}	19.88±6.28^{b}	29.80±9.20^{ab}	24.58
Liver	7.98±4.48	52.02±6.89	42.44v6.78	46.74±6.50	42.29±7.61	NS
Heart	9.85±0.22	10.34±2.75	9.38±3.00	8.31±1.40	6.98±2.00	NS
Proventriculus	6.00±0.46	9.75±1.05	5.90±0.77	6.34±0.93	5.39±0.85	NS
Empty crop	4.27±0.12	3.64±0.20	4.07±0.50	3.13±0.15	3.50±0.18	NS

---a, b, c Means within the same row bearing different superscripts differ significantly ($P<0.05$)
Where: BDW = Blood-Drained Weight, B % DW = Breast as percent Dressed Weight
LSD = Least Significant Difference
NS = Not Significant ($P>0.05$)

CONCLUSIONS

The ratio of calcium to phosphorus has strong influence on the performance of broiler finisher chickens. From the findings of this study it was concluded that neither higher (>3:1) nor lower (<2.5:1) ratio was appropriate for finishing broiler chickens. At Ca: P ratio of 3:1, chickens had a voluntary feed intake of about 6.85% of their body weight with the best FCR of ≤ 2.85. At this (3:1) ratio also, the chickens were significantly heavier (2705g) than those on lower ratios (2384g). The study also concluded that the Ca: P ratio of 2:1 was not adequate in finishing broiler chickens. The ratio of 3:1 favoured breast and drumstick yields which constituted the major retail value of dressed chickens, but exerted minimal influence on visceral organs. The study recommended a Ca: P ratio of 3:1 as optimum for finishing broiler chickens under a semi-arid environment.

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REFERENCES

[1] Underwood E. J. and Suttle N.F. 2001b. Phosphorus. In: Underwood, E. J and N.F. Suttle (Eds). The mineral nutrition of livestock, 3rd Ed. Wallington, U.K. CABI.

[2] Christensen J.W., B.I. Neielsen, J.F. Young and Noddegaard F. 2003. Effects of calcium deficiency in broilers in the use outdoor areas, foraging activity and

production parameters. Applied Animal Behavioral Science. 82: 229-240.

[3] Narcy A., M. P. Letourneau-montminy, M. Magnin, P. Lescoat, C. Jondreville, D. Sauvant and Nys Y. 2009. Phosphorus utilization in broilers. Proceedings of the 17th European Symposium on Poultry Nutrition, 23rd-27th August, Edinburgh, U.K. pp. 1-20.

[4] Driver J.P., G.M. Pesti, R.I. Bakalli and Edwards H.M.J. 2005. Calcium requirement of the modern broiler chicken as influenced by dietary protein and age. Poultry Science. 84: 1629-1639.

[5] Selle P.H., A.J. Cowieson and Ravindran V. 2009. Consequences of calcium interaction with Phytate and Phytase for Poultry and Pigs. Livestock Science. 124: 126-141.

[6] National Research Council (NRC). 1994. Nutrient Requirement of Poultry. The Nutrient Requirement of Farm animals. 9th Ed. National Academy of Science, Washington, DC, USA.

[7] Hurwitz S. I. Plavnik, A. Shapiro, E. Wax, H. Talpaz and Bar A. 1995. Calcium metabolism and requirement of chickens as affected by growth. Journal of Nutrition. 125: 2679-2686.

[8] Bar A. D. Shinder, S. Yosefi, E. Vax and Plavnik I. 2003.Metabolism and requirements for calcium and phosphorus in the fast-growing chickens as affected by age. British Journal of Nutrition. 89: 51-61.

[9] Van Eekeren N, A. Maas, H.W. Saatkamp and Verschhuur M. 1999. Small scale poultry production in the tropics. Agrodoyh 42nd revised English Ed. Wageningen Publishers, The Netherlands.

[10] Jacob J.P., H.R. Wilson, R.D. Miles, G.D. Butcher and Mather F.B. 1998. Factors affecting chicken production in backyard chicken flocks. University of Florida, Institute of Food and Agricultural Sciences, Florida, USA.

[11] Cesar Coto, F.S., S. Yan, Z. Cerrate, P. Wang, J. T. Sacakli, C.J. Hallery, A. Wiernusz, A. Martinez and Woldroup P.W. 2008. Effects of dietary levels of calcium and Non phytate phosphorus in broiler Starter diets on live performance, Bone development and growth plate conditions in male chicks fed a corn-based diet. International Journal of Poultry Science. 7(7): 638-645.

[12] Steel R.G.D. and Torrie J.H. 1980. Principles and Procedure of Statistics; a biometrical approach. Mc-Graw Hill books Co. New York, USA.

[13] SAS Institute. 1991. SAS users guide: Statistical Version 6th Ed. SAS Institute Inc., Cary, N.C.

[14] Mathur C.R., C.V. Reddy and Siddiqui, S.M. 1982. Determination of calcium and phosphorus requirements of caged layers. Indian Journal of Animal Science. 52: 768-771.

[15] Roland D.A., M. Farmer and Marple D. 1985. Calcium and its relationship with excess feed consumption, body weight, egg size, fat deposition, shell quality and fatty liver haemorr- hagic syndrome. Poultry Science. 64: 2341-2350.

[16] Rouesh W., B. Mylet, J.L. Rosemberger and darr J. 1986. Investigation of calcium and available phosphorus requirements for laying hens by response surface methodology. Poultry Science. 65: 964-9670.

[17] Edwards H.M. Jnr. A. Michael, A. Elliot and Soonchernying S. 1992. Effects of dietary calcium on Tibial dyschondroplasisa, interaction with light, cholecalceferol, protein and synthetic zeolite. Poultry Science. 71: 2041-2055.

[18] Robertson K.D., M.F. Ledwaba and R.A. Charbeneau. 2005. Studies on the efficacy of 25-hydroxycholecalceferol to prevent tibial dyschondroplasia in Ross broilers fed marginal calcium to market age. International Journal of Poultry Science. 4: 85-90.

[19] Pottas P.M. 1975. The comprehensive review on calcium and phosphorus 1: Broiler Nutrition. Poultry Science. 65: 1074-1079.

[20] National Research Council (NRC). 1984. National Research Council. Nutrient Requirement of Poultry, 8th Revised Edition. National Academy Press, Washington, D.C., USA.

[21] Adamu S.B., A.R. Muhammad and Aliyu J. 2008. Appropriate Switch-over age from broiler starter to broiler finisher diet under a hot dry environmental condition. League of Researchers in Nigeria. 9(2): 173-179.

[22] Adamu S.B. and Muhammad A. A. 2008. Effects of various protein sources on performance and cost-benefit analysis of broiler finisher chickens Sahel. Journal of Veterinary Science. 7: 26-31.