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Research Article

Effect of Stocking Density and Quantitative Feed Restriction on Growth Performance, Digestibility, Haematological Characteristics and Cost of Starting Broiler Chicks

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ABSTRACT

The study was conducted to investigate the effect of different stocking densities and quantitative feeding regimens on starting broiler chicks. A total of one hundred and sixty two (162) Marshall strain chicks having average initial weight of 44.23g at day old were randomly distributed and used for the trials. The treatments under stocking densities were D_1 ($0.25m^2$/bird), D_2 ($0.17m^2$/bird) and D_3 ($0.13m^2$/bird) while under the quantitative feeding regimen were 0% feeding restriction (F_1), 15% feed restriction (F_2) and 30% feed restriction (F_3). All were replicated three times making a total of 27 observations and randomly distributed into a 3 × 3 factorial arrangement in a completely randomized design. The growth performance, economic cost, nutrient digestibility and haematological characteristics were measured, data obtained were subjected to one way analysis of variance. Results showed that stocking density had no significant effect ($p>0.05$) on the daily feed intake and the body weight gain. The body weight gain decreased with increasing stocking density from 20.53g in D_1 to 19.25g in D_2. The best feed conversion ratio (FCR) value of 3.05 was recorded in D_3 compared to 3.20 recorded in D_2. Stocking density had no effect on the dry matter digestibility, crude protein digestibility, crude fibre digestibility and ether extract digestibility ($p>0.05$). The stocking density however had an effect ($p < 0.05$) on the haematological parameters like red blood cell (RBC), mean cell volume, mean cell haemoglobin concentration, blood glucose and blood corticosterone levels. The blood cholesterol was significantly highest in D_1 (94.28mG/dl) compared to the lowest value of 88.17mG/dl in D_3. Stocking density had no significant effect on the cost of feed per kg weight gain. The quantitative feed restriction significantly decreased both the daily feed intake and weight gain. A lower daily weight gain of 16.40g in F_3 compared to 22.95g in F_1. A better FCR value was recorded in the restricted groups compared to the F_1. Birds in F_3 recorded a marginally better digestibility coefficient when compared to F_1 and F_2 respectively. The packed cell volume and RBC was significantly lower in feed restricted birds compared to F_1 but the white blood cells were significantly highest in F_3 than in F_1 and F_2. The blood glucose and cholesterol level was significantly highest in F_1 than F_2 and F_3 birds. The heterophil: lymphocyte ratio (H: L) was significantly highest in F_3 than in F_1 and F_2 respectively. Feed restricted birds (F_2 and F_3) had significantly ($p < 0.05$) lower cost of feed intake/ bird (N5.32 and N6.15, respectively) compared to N7.64 in F_1 birds. Also, the cost of feed/kg weight gain was significantly lowest in F_3 at N317.20 compared to N334.53 in F_1. It was concluded that that birds in D_3 and F_3 had the best FCR and a better digestibility coefficient though higher haematological values were recorded in the D_1 and F_1 compared to other treatments. Birds in F_3 had lower haematological profiles and reduced costs of production per bird due to the quantitative feed restriction.

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INTRODUCTION

The advent of great breakthrough in animal breeding coupled with better animal production and nutritional management practices had led to the selection of broiler chickens with rapid growth rate that reach the slaughter weight within a short time period (Mohammad et al., 2012). Most of these birds are imported from the temperate to the tropical regions for adaptation and productivity. These birds came in with inherent associated problems that accompanied high growth rate which included metabolic and cardiovascular abnormalities/disorders like "flip over syndrome" (sudden death syndrome), abdominal fluid buildup (ascites) and other skeletal abnormalities (Yu et al., 1990; Urdaneta and Leeson, 2002; Jang et al., 2009). Most tropical poultry farmers used to overcrowd their stocks which negatively mask growth performance characteristics resulting in loss of stock and higher mortality and hence, loss in the economics of poultry production business (Olomu and Offiong, 1980; Oluyemi and Roberts, 2000). These overcrowding are mostly done in an attempt to cover the costs incurred in housing, feeding and medication of poultry birds, also, most farmers do not have the knowledge of adequate stocking density to use (Muniz et al., 2006; Adebiyi et al., 2011). The increased feed intake as a result of greater accesses to feed (*ad libitum* feeding) has its inherent attendant problems leading to subsequent problems of increased abdominal fat deposition which is an uneconomical undesirable product (Nielson et al., 2003; Abel et al., 2014). The fat depositions in meat also lead to some cardiovascular heart challenges associated with increased cholesterol intake. Lots of meat rejects in the processing industry had been reported and there are and subsequent economic losses in the poultry industry. The fatty meat obtained due to fat accumulations in meat had denied the populace in the nation of lean meat leading to reduced protein intake in the respective food basket (Olomu and Offiong, 1980; Onifade, 1997). Therefore, the objective of this research is to determine the effect of different stocking density and feed restriction regimen at the starter phase of the broiler chicks on feed efficiency, growth performance, digestibility and haematological characteristics at the end of the rearing period.

MATERIAL AND METHODS

Housing

The experiment was carried out in the deep litter section of the Animal House in the Food and Technology, Department of the Federal Institute of Industrial Research, Oshodi (FIIRO) Lagos State, Nigeria. The treatments consisted of the stocking density as a factor was at three levels of 0.25 (4 bird/m^2), 0.17 (6 birds/m^2) and 0.13m^2 per bird (8 birds/m^2), while the feed restriction regimens was at 100% –*ad libitum* as control, 15% restriction of *ad lib* and 30% restriction respectively. The housing was well ventilated to avoid any heat buildup.

Birds and Diet

One hundred and sixty-two (162) day old *Marshall* broiler chicks obtained from a reputable hatchery were used for the study. They were reared from 1- day old and fed the experimental broiler starter diet in Table 1. The birds on stocking density 0.25, 0.17 and 0.13m^2 per bird were properly separated in wooden pens covered with a 4mm wire mesh to prevent crossing from one pen to another and for easy data collection. Proper medication and vaccination programs were carried out and good bio-security measures were adhered too. The birds were weighed on arrival at the farm (initial weight) and weekly thereafter. Using a Completely Randomized Design (CRD) layout, the birds were assigned to the treatments with each treatment replicated three times. The experimental birds were weighed before the commencement of the trial and randomly allotted according to the bodyweight uniformity to the treatments and replicate pens constructed at 1 x 1m^2 dimensions on deep litter floor. Birds were given 24 hours of free access to clean water daily and a lighting regimen of 22hrs of light and 2 hrs of dark. All birds were scientifically handled and high welfare standard maintained.

Table 1: Composition of experimental starter diet (g kg^{-1}).

Ingredients	Starter diet
Maize	532.00
Soybean meal	320.00
Groundnut cake	47.00
Wheat offal	45.00
Fish meal	20.00
Bone meal	25.00
Oyster shell	5.00
Methionine	1.00
*Vit-Min Premix	2.50
Common salt (Nacl)	2.50
TOTAL	**1000.00**
Determined Analysis (g kg^{-1})	
Dry matter	891.50
Crude Protein	226.70
Crude Fat	40.50
Crude Fibre	38.61
Ash	30.90
Calculated Analysis (g kg^{-1})	
ME (MJ/kg)	11.97
ME: Protein ratio	124.36
Calcium	9.60
Av. Phosphorus	5.10
Lysine	12.80
Methionine	4.60

Starter diet fed at 0, 15 and 30% of *ad libitum* feed restriction quantitatively; *provided g kg^{-1} of diet- Vitamin A (12,000IU); Vitamin D_3 (2.500IU); Vitamin E (30,000IU);Vitamin K_3 (2,000mG); Vitamin B2-Riboflavin (3mG); Vitamin B3-Nicotinic acid (10mG);VitaminB5(15mcg)- Pantothenic acid (15,000mG); Manganese(80,000mG); Zinc(50mG); Copper(5mG); Iodine(1,000mG); Cobalt (Co) (0.2mG); Selenium (Se) (0.1mG), Folic acid (1,500mG), Biotin (50 mcg); Choline chloride (300,000mG)

The brooding temperature was initially maintained at 34.5^{o}C using hanging ambient thermometers (*XPT* model) at the first week and reduced thereafter as the weeks go by. The pen was open sided with good ventilation. Wood shavings were used as litter material on the floor, this helped to prevent birds from cold floor temperatures and helping to absorb the fecal droppings from the chicks thus preventing body and feed contamination, thereby maintaining a healthy micro-environment. The diets were formulated to meet the requirement of the broiler starter chicks according to the National Research Council (NRC, 1994). The quantitative nature of the feed-in mash form- was such that the quantity of feed per day was measured out and given *ad libitum* (as control 0), 15% of the *ad libitum* and also 30% of the control feed were all weighed out daily and given. Where there was leftover, it was collected, weighed and subtracted from the intake and computed for the growth performance data analysis.

Digestibility Analysis

Three birds per treatment were put into the digestibility cage having a flat aluminum tray for easy collection of fecal

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droppings. An acclimatization period of three days, followed by four days of the fecal droppings collection was done. Care was taken to avoid feather and feed falling into the fecal materials. The fecal droppings were collected daily and stored at 4°C in a refrigerator, it was later pooled and analysed. The content of the dry matter, crude protein, crude fibre, ether extract, ash and nitrogen-free extract (NFE) in the feed and freeze-dried fecal droppings was estimated according to AOAC (2001).

Statistical Analysis

Data collected were arranged in a 3 × 3 factorial experimental layout in a completely randomized design. The significant ($P < 0.05$) differences among each treatment were separated using the Tukey- Krammer *post hoc* test for multiple comparisons as contained in Minitab statistical package (2005) and SAS, (2007).

The model used in the experiment was as shown below Statistical model: –

$Y_{ijk} = \mu + T_i + I_j + (TI)_{ij} + \varepsilon_{ijk}$ Where,

Y_{ijk} = Output parameter
μ = overall mean
T_i = i^{th} effect of stocking density (i= 0.25, 0.17 and 0.13m^2/bird)
I_j = j^{th} effect of quantitative feed restriction (j= control 0, 15%, 30% feed restriction)
$(TI)_{ij}$ = Interaction effect of stocking density and quantitative feed restriction
ε_{ijk} = Random error

RESULTS AND DISCUSSION

Stocking density had no significant effect ($p>0.05$) on the body weight, weight gain, feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) among the treatment means (Table 2). This result agrees with the report of Fairchild (2005) and Tong et al., (2012) who reported that stocking density had no significant effect on the growth performance, however, this was at variance with Shanawany (1988) and Thaxton et al., (2006) who reported a higher feed conversion ratio due to a higher stocking density used. Quantitative feed restriction significantly ($p < 0.05$) affected the daily weight gain where birds on F_3 treatment had a significantly lowest weight gain of 16.40g compared to 22.95g in F_1 birds, this reduction in weight gain could be as a result of lower feed intake per bird due to the feed restriction treatments (Zhan et al., 2007). Also, the FCR was significantly lowest in restricted birds F_2 with a value of 3.06 compared to 3.22 observed in F_1. This report clearly corroborated (confirm) that of Mohammad et al., (2012) and Tumova et al., (2002), however, it is in contrast to Ramlah et al., (1996) who reported that quantitative feed restriction had no effect on the growth performance of birds. Birds in F_2 had a significantly higher protein efficiency ratio (PER) value of 1.48 compared to 1.40 and 1.37 in F_3 and F_1 respectively. There was no mortality recorded.

Table 2 Effect of stocking density and quantitative feed restriction on performance and economic cost of starting broiler chicks

	Stocking Density (m^2/bird)				Quantitative Feed Restriction			
Parameters	0.25	0.17	0.13	SEM	0%	15%	30%	SEM
Initial liveweight/bird (g)	254.26	253.82	253.55	1.80	253.48	253.51	254.64	1.89
Final liveweight/bird (g)	541.70	523.29	524.92	16.90	574.77^a	530.90^{ab}	484.21^b	10.79
Daily weight gain/bird (g)	20.53	19.25	19.38	1.21	22.95^a	19.81^{ab}	16.40^b	0.76
Daily feed intake/bird (g)	63.61	61.51	59.05	3.32	73.63^a	59.27^b	51.28^c	0.52
Feed conversion ratio (FCR)	3.10	3.20	3.05	0.13	3.22	3.06	3.18	0.12
Daily protein intake/bird (g)	14.42	13.94	13.39	0.76	16.69^a	13.44^b	11.63^c	0.12
Protein efficiency ratio (PER)	1.42	1.40	1.39	0.06	1.37	1.48	1.40	0.05
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Cost of feed/kg of diet (N)	103.76	103.76	103.76	0.00	103.76	103.76	103.76	0.00
*Cost of daily feed intake/bird (N)	6.59	6.38	6.33	0.34	7.64^a	6.15^b	5.32^c	0.15
*Cost of feed/kg weight gain (N)	321.64	332.03	316.15	12.96	334.53	317.20	329.50	13.58

[abc]Means within same row by factor with different superscripts differ significantly ($P < 0.05$); SEM- Standard Error of Means;*Calculated in Nigerian currency Naira (N)

Table 3: Effect of stocking density and quantitative feed restriction on digestibility trials of starting broiler chicks

	Stocking Density(m^2/bird)				Quantitative Feed Restriction			
Parameter (%)*	0.25	0.17	0.13	SEM	0%	15%	30%	SEM
DMD	84.57	84.78	84.96	0.29	84.72	84.81	84.77	0.31
CPD	91.52	91.49	91.81	0.16	91.38	91.72	91.71	0.17
CFD	31.16	29.54	28.96	1.66	27.52	30.39	31.74	1.54
EED	97.56	97.68	97.61	0.08	97.51	97.57	97.76	0.07

[ab] Means within same row by factor with different superscripts differ significantly ($P < 0.05$); SEM- Standard Error of Means;*DMD= Dry Matter Digestibility; CPD= Crude Protein Digestibility; CFD= Crude Fibre Digestibility; EED=Ether Extract Digestibility

The economic cost evaluation showed that the cost of daily feed intake per bird and cost of feed per kg weight gain was not significantly ($p>0.05$) affected by the stocking density. The quantitative feed restriction however significantly ($p < 0.05$) lowered the cost of feed intake/bird by N5.32 and N6.15 in F_3 and F_2 while F_1 recorded N7.64, this lowered value in F_3 could be as a result of lowered feed consumed by the birds when compared to those in F_1 (Table 2).

The stocking density and quantitative feed restriction had no significant effect ($p>0.05$) on the digestibility parameter measured (Table 3), however, there are marginal differences where birds on higher stocking densities (D_2 and D_3) recorded lower values in crude fibre digestibility (29.54 and

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Table 4 Effect of stocking density and quantitative feed restriction on hematological profile of starting broiler chickens

	Stocking Density(m^2/bird)				Quantitative Feeding Regimen			
Parameter	0.25	0.17	0.13	SEM	0%	15%	30%	SEM
Packed cell volume (%)	31.84	29.51	29.14	1.27	32.73^a	30.86^a	26.90^b	0.94
Red blood cell (10_6mm_3)	3.79^a	3.57^b	3.34^c	0.09	3.82^a	3.57^b	3.31^c	0.42
White blood cell (10^3/mm)	25.35	25.25	25.30	0.73	24.33^b	24.33^b	27.23^a	0.36
Haemoglobin conc (g/dl)	10.80	10.75	10.41	0.28	11.12	10.63	10.21	0.22
MCV (femtolitres, fl)	90.12^a	88.61^{ab}	86.53^b	0.72	89.51	88.39	87.36	0.91
MCH (u/mG)	30.14	29.69	29.43	0.70	30.51	28.97	29.78	0.66
MCHC (%)	33.92^a	31.17^{ab}	29.77^b	0.86	32.28	31.77	30.81	0.79
Total Serum Protein (mG/dl)	43.71	42.03	40.96	1.19	40.87	42.05	43.78	1.16
Serum albumin (mG/dl)	25.63	25.03	25.38	0.73	24.37	25.33	26.35	0.70
Serum globulin (mG/dl)	17.24	17.00	15.58	1.14	15.67	16.72	17.43	1.07
Albumin: globulin ratio	1.54	1.51	1.66	0.12	1.57	1.56	1.57	0.12
Serum creatinine (mG/dl)	1.00	1.00	0.96	0.05	1.11^a	0.96^{ab}	0.87^b	0.09
Blood glucose (mG/dl)	190.11^a	189.53^a	184.13^b	2.84	180.36^c	188.27^b	195.25^a	1.46
Corticosterone (mG/dl)	8.39^b	9.93^a	11.26^a	0.79	7.76^c	9.97^b	11.86^c	0.59
Blood Cholesterol (mG/dl)	94.28^a	92.24^{ab}	88.17^b	1.79	95.61^a	91.24^{ab}	87.82^b	1.53
Heterophil: Lymphocyte ratio	0.53	0.52	0.61	0.03	0.48^b	0.57^{ab}	0.61^a	0.22

^{abc} Means within same row by factor with different superscripts differ significantly (P < 0.05); SEM.– Standard Error of Means

28.96% respectively) compared to 31.16% in D_1. Also, the crude protein digestibility values were marginally lower in F_1 (91.38%) compared to 91.72 and 91.71% in F_2 and F_3 respectively. The main effect of the stocking density and the quantitative feeding regimens on the haematological blood profiles (Table 4) showed that the stocking density significantly lowered the red blood cell values from 3.79 mm^3 in D_1 to 3.57 and 3.34 mm^3 in D_1 and D_3 respectively, this reduction in the blood values could be due to stress of decreased space unit per bird. The blood cholesterol values were significantly ($p < 0.05$) highest in the birds raised under D_1 (99.28mG/dl) compared to 88.17mG/dl in D_3 birds. Heterophil: lymphocyte ratio (H: L ratio) was however significantly highest in D_3 (0.61) compared to 0.53 in D_1, this could be due to stress caused by higher number of birds per space in D_3 compared to that in D_1 .The quantitative feeding regimens showed that the pack cell volume was significantly lowest in the lowest feeding regimens D_3 with a value of 26.90% compared to the highest value of 32.73 and 30.86% in D_1 and D_2 respectively. The white blood cell (WBC) was significantly highest in F_3, this could be due to response of the birds to the low feed intake quantitatively which is a form of stress, this triggered up the immune response of the birds physiologically (Yu et al., 1990; Zulkifli and Siegel, 1995). The serum creatinine was significantly highest in F_1 with a value of 1.11mG/dl compared to 0.87mG/dl, this could be due to the higher feed intake and growth rate compared to restricted feed birds in F_2 and F_3, however, the blood cholesterol was lowest in F_3.

CONCLUSION

It is hereby concluded that stocking density had no significant effect on the growth performance and digestibility coefficients of the starting broiler chicks but significantly affects some of the haematological parameters. The quantitative feed restrictions had a significant effect on the growth performance leading to reduced feed intake and weight gain. It also affected the haematological blood profiles. It however positively leads to reduced cost of production and a better feed conversion ratio.

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CONFLICT OF INTEREST

There was no conflict of interest from any of the co–authors concerning this work. It was unanimously packaged.

REFERENCES

Abel FAS, Eruvbetine D, Sogunle OM, Elemo GN, Owolabi FO, Onyibe J, Akinola SO, Adeyemi OA (2014). Response of finishing broiler chickens to different stocking densities and quantitative feeding regimens. Int. J. of Applied Res.Tech. 3 (7): 11 – 17. – Esxon Publishers USA.

Adebiyi OA, Adu OA, Olumide MD (2011). Performance characteristics and carcass quality of broiler chicks under high stocking density fed Vitamin E supplemented diet. Agric. J. 6 (5): 264 – 268.

AOAC–Association of Official Analytical Chemists International (2001): Official Methods of Analysis. 17th Edition.

Estevez I (2007). Density Allowances for broilers: Where to set the limits? Poult. Sci.. 86: 1265 – 1272.

Fairchild BD (2005). Environmental factors to control when brooding chicks. The University of Georgia Cooperative Extension Service. Bulletin No 134. Georgia Printers. Pages 1–5.

Jang IS, Kang SY, Ko YH, Moon YS, Sohn SH (2009). Effect of qualitative and quantitative feed restriction on growth performance and immune function in broiler chickens. Asian– Australian J. of Ani. Sci. 22 (3): 388 – 395.

Minitab Statistical Package, Statistical Analysis Software, 2005.

Mohammad AR, Zakaria J, Zakaria H (2012). The effect of quantitative feed restriction during the starter period on compensatory growth and carcass characteristics of broiler chickens. Pakistan J. Ani. Nut. 11 (9): 719 – 724.

Muniz EC, Fascina VP, Pires PP, Carrijo AS, Guimaries EB (2006). Histomorphology of bursa of fabricius: Effect of stocking density on commercial broilers. Brit. J. Poult. Sci. 8: 217 – 220.

ISSN: 2308–2801

National Research Council (NRC) (1994). Nutrient Requirement in Poultry. 9th Edition. National Academy Press. Washington D.C. USA. Pages 12–15.
Nielson BL, Litheland M, Noddegaard F (2003). Effect of qualitative and quantitative feed restriction on the activity of broiler chicken. Applied Ani. Beh. Sci. 83: 309 – 323.
Olomu JM, Offiong SA (1980). The effects of different protein and energy and time of change from starter to finisher ration on the performance of broiler chicken in the tropics. Poult. Sci. 59: 828 – 835.
Oluyemi J , Roberts FA (2000). Poultry production in warm wet climates. 2nd Edition
Spectrum Books Limited, Ibadan, Nigeria, Onifade AA (1997). Growth performance, carcass characteristics, organs measurement and haematology of broiler chickens fed a high fibre diet supplemented with antibiotics or dried yeast. Molecular Nut. Food Res. 41 (6): 370 – 374.
Ramlah AH, Halim AS, Siti–Sara AR (1996). Effects of early feed restriction on the performance of broilers. Asian Australian J. Ani. Sci. 9: 63 – 67.
Shanawany MM (1988). Broiler performance under high stocking densities. Brit. Poult. Sci. 29 (1): 43 – 52.
Thaxton JP, Dozier WA, Branton SL, Margan GW, Miles DM, Roush WB, Lott BD, Vizzier–Thaxton Y (2006). Stocking density and physiological adaptive responses of broilers. Poult. Sci. 85: 819 – 824.
Tong HB, Lu J, Zou JM, Wang Q, Shi SR (2012). Effects of stocking density on growth performance, carcass yield and immune status of a local chicken breed. Poult. Sci. 91(3): 667 – 673.
Tumova E, Skrivan M, Skrivanova E, Kacerovska L (2002). Effect of early feed restriction on growth in broiler chickens, turkeys and rabbits. Czech J. Ani. Sci. 47: 418 – 428.
Urdenta RM, Leeson S (2002). Quantitative and qualitative feed restriction on growth characteristics of male broiler chicken. Poult. Sci.. 81: 769 – 788.
Yu MU, Robinson FE, Clandinin MT, Bodnar L (1990). Growth and body composition of chickens in response to different regimens of feed restriction. Poult. Sci. 69: 2074 – 2081.
Zhan XA, Wang M, Ren H, Zhao RQ, Li JX, Tan ZL (2007). Effect of early feed restriction on metabolic programming and compensatory growth in broiler chickens. Poult. Sci. 68: 654 – 660.
Zulkifli I, Siegel PB (1995).The good and bad of stress. Poult. Digest. 54: 18 – 24.

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