

Heat balance, haematology and serum chemistry of layers under varying stocking density reared in locally fabricated metal-type cage system

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Abstract

One hundred and thirty five 18weeks old Bovans Nera Black strain pullets were used in a 10week study to determine their heat balance and blood profile under varying stocking density in locally fabricated metal-type cage system. The cages were stocked 2, 3 and 4birds/cell. Daily ambient temperature and relative humidity of the cage and rectal temperature of the birds were taken and heat balance calculated. Record of Packed cell volume (PCV), Haemoglobin concentration (Hb), Red blood cell (RBC), White blood count (WBC) and differential of the birds were taken at beginning and end of the study for the haematological indices while blood glucose, total protein, Albumin and blood urea were taken for the bio-chemical measurements. Ambient temperature, relative humidity, and heat balance showed no significant ($P>0.05$) difference with cage stocking density. Cage stocking density had significant ($P<0.05$) effect on rectal temperature of layers. Bird stocked 3/cell recorded the least (41.14°C) rectal temperature while those stocked 4/cell recorded the highest (41.27°C). All the haematological parameters of the birds were not significantly ($P>0.05$) influenced by stocking density of the cage type. Bio-chemical measurements were not significantly ($P>0.05$) different among layers under varying stocking density of the cage except total protein ($P<0.05$). Layers stocked 4/cell recorded highest (5.22g/dl) total protein while those stocked 3/cell had the least value (4.37g/dl). However, the values were within the normal range recommended for healthy chicken. The study concluded that locally fabricated metal-type battery cage could be used to rear layers and stocking density of 3birds/cell is ideal without compromising the welfare of the birds.

Keywords: heat balance, haematology, serum chemistry, stocking density, metal-type battery cage, layers

Introduction

Nowadays, enhancement of productivity and survivability of farm animals is a major goal of Animal husbandry management strategies. One approach to reach this goal is to reduce stress and increase adequate adaptation to stressors in laying hens (Cheng *et al.*, 2003). To this end, various manipulation of environment/housing system that provides comfort to laying birds, good profit margin to producers, adequate supply of animal protein and food security for the teeming population in

developing countries have remained the focus of Animal Scientists/Researchers, farmers and other stakeholders.

Certain features of battery cages, such as the small space allowance, low ceiling and wire floor had been criticized to result in physical discomfort in layers production (Robins and Phillips, 2011). Also low of space allowance had been reported to restrict comfort behaviour such as wing-flapping, stretching and shaking (Nicole, 1987) and of other behaviour patterns in poultry (Dawkins and Hardie, 1989) but the

battery cage system has the highest contribution (80%) to global egg production and 92-95% of Europe and other developed country systems poultry production (ACMF, 2009; Robins and Phillips, 2011). To this end, different conditions and designs for poultry houses and cages had been developed. The equivocal agreement and condition is that they should be designed to provide comfort and protection for the birds; permit a flow of fresh air (good air quality) and protection from environmental extremes, predators, pathogens and prevent waste of resources. Also good aeration and air circulation to minimize levels of carbon monoxide, ammonia, other gases and dust is critically important.

Nigeria Poultry Farmers have therefore continued to invest heavily on importation of battery cages without due consideration to available technology to motivate economic growth and enhanced local production. Various designs and makes from Europe and America are available in the Country with unprecedented high purchasing cost as housing remained the third of major components of efficient poultry production after feed and quality bird (Ogundipe, 1998). There is therefore the need to determine some welfare indicators and the haematological traits of laying birds under different stocking densities in locally fabricated metal-type battery cage.

Materials and Methods

Experimental site

This experiment was conducted at the poultry unit of Teaching and Research Farm Directorate (TREFFAD), University of Agriculture Abeokuta, Nigeria. This area is situated in the rainforest vegetation zone of South-Western Nigeria and latitude

7°13'22.44"N, longitude 3°25'48.57"E and altitude of 98m above sea level. The climate is humid with a mean rainfall of 1003mm, the annual mean temperature and humidity is 34.7°C and 82%, respectively (Google Earth, 2010).

Experimental birds and cage design

A total of one hundred and thirty five 18 weeks old Bovan Nera Black strain pullets purchased from a reputable commercial farm were used in the study. The cages were the 3-tier locally fabricated type of 5 cell compartments. Each cell has a standard dimension of 45cm by 30cm by 60cm. The material was made up of 5mm silver coated iron metal rod arranged parallel in a rectangular shape. The housing was an open sided type covered with mesh net. The wall was dwarf type with concrete floor.

Experimental layout

The birds were arranged in 3 treatments (2, 3 and 4birds/cell) and each treatment replicated thrice. The arrangement system was as follows:

The first 1st treatment, 2 birds were stocked per cell across the tiers;

The second 2nd treatment, 3 birds were stocked per cell forming "V" shape arrangement;

The 3rd treatment, 4 birds were stocked per cell in an equilateral triangle arrangement.

Management of birds

The birds were fed with 115g/bird/day of growers mash at the start of the experiment and changed to layers mash when 10% egg lay was recorded. 150g of layers feed was given to each bird daily while water was supplied *ad libitum*. Other recommended management practices, vaccination and medication were strictly followed.

Data Collection

Data were collected daily on cage ambient temperature and relative humidity using digital thermometer (LCD Digital Thermo-Hygrometer with indoor/outdoor

Temperature and Relative Humidity Display). Rectal temperature of the experimental birds were taken daily with aid of digital basal thermometer (MT-301) and heat balance (Q_s) was calculated with the equation proposed by the CIGR Report (CIGR, 2002).

$$Q_s = 0.67[1000 + 20(20 - t_i)] - 9.8 \cdot 10^{-8} t_i^6 K_s$$

Where:

Q_s = heat from a laying hen at temperature t (W)

t_i = average indoor temperature ($^{\circ}\text{C}$)

$k = 0.9$ (Correction factor as an additional adjustment)

Blood Sample Collection

Blood sample was obtained via the wing vein puncture (Fransson, 1986) using needle and syringe. Each blood sample was emptied into 2 sets of well labeled sample bottles; one containing ethylene diamine tetra-acetate (EDTA) as anti-coagulant while the other one contained no anti-coagulant. The sample containing anti-coagulant was used to analyze for the haematological traits while the other sample that did not contain anti-coagulant was used to analyze the serum bio-chemical traits of the birds per treatment.

The samples were collected twice, first as the birds were stocked while the second sample was collected at the end of the experiment (70d). Samples were analyzed for haematological traits (Packed Cell Volume (PCV), Haemoglobin (Hb), Red Blood Cell (RBC) and White Blood Cell (WBC)) and biochemical traits (blood glucose, serum albumin, total serum protein and serum globulin, blood urea nitrogen, and white blood cell differential).

Statistical Analysis

Data generated were subjected to ANOVA in a randomized complete block design using SAS (1999). Significant means at 5%

level of probability were separated using Duncan's Multiple Range Test as contained in SAS (1999).

Results and Discussion

Figure 1 shows record of ambient temperature of the cage as influenced by stocking density in locally fabricated battery cage. Ambient temperature ranged between 33.25 and 33.75 $^{\circ}\text{C}$. Cage stocked with 2birds/cell had the least (33.25 $^{\circ}\text{C}$) ambient temperature while cage stocked 4birds/cell recorded the highest (33.75 $^{\circ}\text{C}$). However, ambient temperature was not significantly ($P>0.05$) different with cage stocking density. It could be that the environment was well ventilated and heat was easily dispersed. Garcimartin *et al.* (2007) reported that too high stocking density for the size and design of house and ventilation equipment resulted in rise in temperature as there would be more metabolic heat being added to the house air than was planned for because more radiant transfer from bird to bird would be greater and stagnant hot air would be trapped between the birds. Also good air quality and current had been reported to aid heat lost by convection (Garcimartin *et al.*, 2007) therefore, the cage could be assumed to aid air movement fast enough to break down the boundary layer of still air which surrounds the body.

Figure 2, shows the record of rectal temperature of laying birds under varying stocking densities in the cage type. Rectal temperature was significantly ($P<0.05$) different across treatment. Birds stocked 2, 3 and 4/cell recorded 41.15 $^{\circ}\text{C}$, 41.14 $^{\circ}\text{C}$ and 41.27 $^{\circ}\text{C}$ respectively. No reason could be advanced for now as heat production had been reported to be affected by body weight, species and breed, level of production, level of feed intake, feed quality, to a lesser extent, by the amount of

Heat balance blood chemistry of layers reared in locally fabricated metal-type cage system

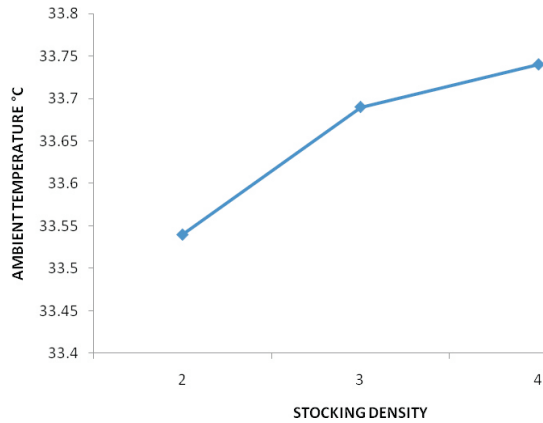


Figure 1: Effect of stocking density on ambient temperature of laying birds in metal-type battery cage

activity and exercise (Garcimartin *et al.*, 2007). Though, in a related study feed intake varied significantly ($P < 0.05$) with stocking density in the battery cage system. Birds stocked at 2/cell had the highest feed intake (114.00g/birds/day) while birds

stocked at 3 per cell recorded the least (103.89g/bird/day). This probably could be responsible for the variation in the body temperature of the birds as more heat of production was probably generated. Bolton *et al.* (1972) gave credence to this opinion.

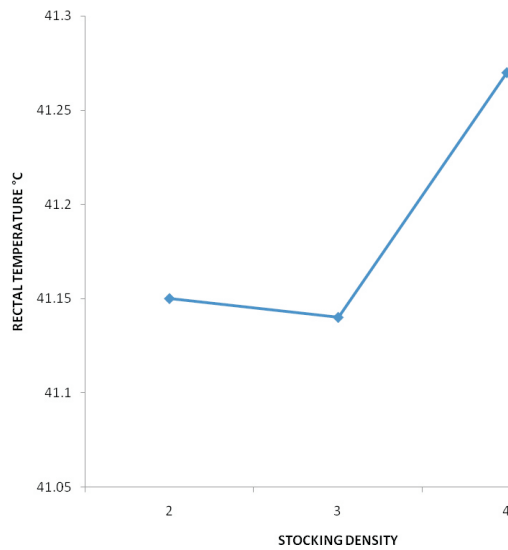


Figure 2: Effect of stocking density on rectal temperature of laying birds in metal-type battery cage

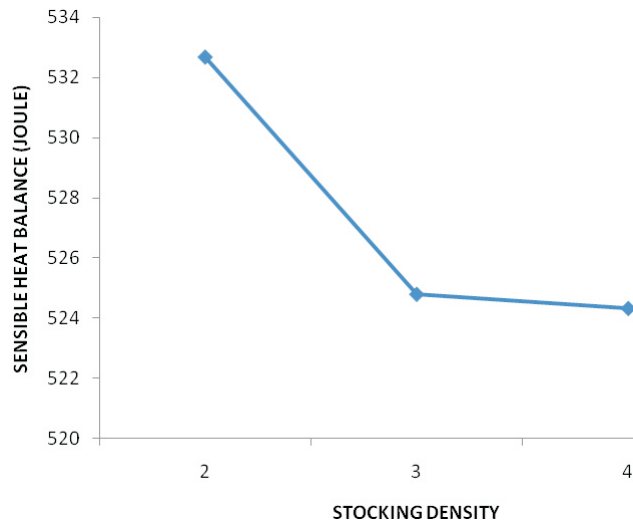


Figure 3: Effect of stocking density on sensible heat balance of laying birds in metal-type battery cage

Figure 3, shows the sensible heat balance of laying birds under varying stocking density. Sensible heat balance was not significantly ($P>0.05$) different among birds stocked under varying density. Cage with

2birds/cell had the highest sensible heat balance followed by cage stocked 3birds/cell and 4birds per cell. Despite the variation, the values were similar ($P>0.05$). Relative humidity increased with increasing stocking density from 55.79% to 56.35% among layers stocked 2 to 4/cell

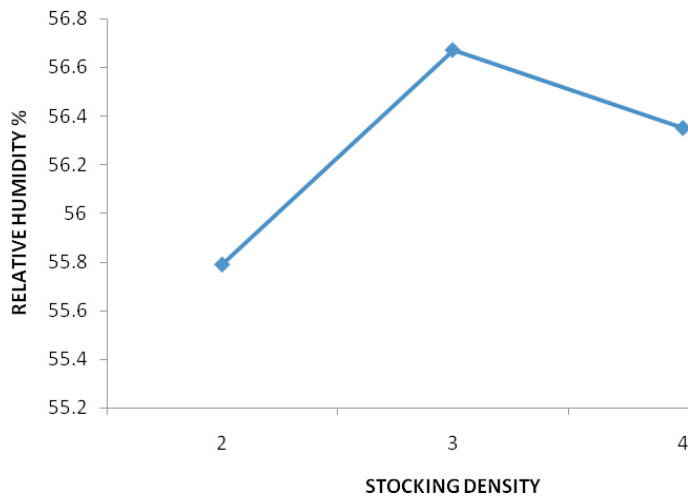


Figure 4: Effect of stocking density on relative humidity of laying birds in metal-type battery cage

(Figure 4). However, there was no significant ($P>0.05$) variation in the values. It could be that that the cage type still enable good ventilation such that cage ambient temperature and relative humidity were still within tolerant limit. This result was in line with the finding of Lin *et al.* (2005b) who reported that high humidity above 60% impaired heat transmission from body core to peripheral at 35°C. Low relative humidity range between (55.79 and 56.35%) and temperature (33.25 and 33.75°C) in this study could be responsible for the result obtained as they were not up to the range opined by Lin *et al.* (2005b). However, Yahav *et al.* (2000) reported that the effect of relative humidity in the laying birds is minor.

Haematological parameters of layers under varying stocking density

The results of the haematological parameters of laying birds under different stocking density in locally fabricated metal-type battery cage are presented in Table 1. Packed cell volume (PCV) showed non significant ($P>0.05$) difference between the initial and final values PCV of the experimental birds. Birds stocked 2/cell before and at the end of the study recorded 26.67% and 25.33% PCV, respectively. Birds stocked 3/cell before and after the study recorded 25.67% and 24.67%, respectively while birds placed 4/cell had 26.75% and 25.33%, respectively. However, the low arithmetic values of the final PCV obtained was not significant

Table 1: Effect of cage on the Haematological Parameters of Egg-typed Chicken

Measurements	Initial				Final			
	Stocking Density (birds/cell)				Stocking Density (birds/cell)			
	2	3	4	SEM	2	3	4	SEM
PCV (%)	26.67	25.67	26.67	1.77	25.33	24.87	35.33	1.76
Hb (g/dl)	8.83	8.56	8.84	0.63	8.44	8.22	8.44	0.59
WBC ($\times 10^6/\text{mm}^3$)	29467	25650	30254	2777	26883	30533	30975	2415
RBC ($\times 10^6/\text{mm}^3$)	2.15	2.12	2.21	0.14	2.25	2.16	2.29	0.21
Neutrophil (%)	29.00	28.00	26.17	5.13	28.67	37.67	40.33	8.25
Lymphocytes (%)	67.67	70.17	72.42	5.68	68.83	59.00	55.50	8.28
Monocytes (%)	2.33	0.83	0.67	1.61	1.17	1.83	1.83	1.53
Eosinophils (%)	0.17	0.83	0.17	0.87	1.17	0.67	1.83	1.29
Basophils (%)	0.67	0.17	0.50	0.85	0.17	0.83	0.50	0.69
Heterophils (%)	29.17	28.83	26.33	4.87	29.83	38.33	42.17	8.23
H/L	0.44	0.41	0.36	0.11	0.44	0.65	0.81	0.24

Means with different superscript on the same row are significantly different ($P<0.05$); PCV- packed cell volume, Hb- haemoglobin, WBC – white blood count, RBC – red blood cell, H/L – Heterophils/Lymphocytes ratio. SEM – standard error mean

($P > 0.05$). These values fall within the range of 23-55% PCV recommended for healthy birds (Maxwell *et al.*, 1990). The results of Bello *et al.* (2011) who reported 24.33 – 30.67% PCV in laying birds and Alabi *et al.* (2011) who also reported 25.00 – 29.00% PCV in finisher broiler chicken gave credence to this finding.

Table 1 also revealed that stocking density in the cage type had non significant ($P > 0.05$) difference on the initial and the final Hb concentration of the experimental birds. The Hb concentration of birds stocked 2, 3 and 4/cell before and the end of the study recorded were 8.83 and 8.44g/dl, 8.56 and 8.22g/dl and 8.84 and 8.44g/dl, respectively. The values still fall within the recommended Hb concentration (7-18.6g/dl) for healthy birds (Pellet and Young 1980). Also the findings of Alabi *et al.*, (2011) who reported 7.50 – 9.2g/dl with laying birds gave credibility to this result.

Stocking density of the cage had no significant ($P > 0.05$) effect on the initial and the final white blood cell of the birds (Table 1). Layers stocked 2/cell recorded 29467 $\times 10^6/\text{mm}^3$ and 26883 $\times 10^6/\text{mm}^3$ as initial and final WBC, respectively. Those stocked 3/cell recorded 25650 and 30533 $\times 10^6/\text{mm}^3$ WBC, respectively while layers stocked 4/cell had 30254 and 30975 $\times 10^6/\text{mm}^3$ WBC, respectively. Although, there was arithmetic increase in WBC of the birds with stocking density increasing from 26883 $\times 10^6/\text{mm}^3$ to 30975 $\times 10^6/\text{mm}^3$, it could be that high stocking density compromised welfare of the birds and this aid disease transmission. Birds stocked 4/cell had more challenged health-wise and probably suffered more infection and disease transmission. This could be responsible for higher WBC (30975 $\times 10^6/\text{mm}^3$) recorded in this study. Also, values recorded were higher than those reported by Bello *et al.*, 2011 who recorded

22292 - 25737 $\times 10^6/\text{mm}^3$ for laying birds. This could be due to variation in treatment, age of the bird and season.

The result of the Red blood cell obtained showed non significant ($P < 0.05$) difference between the initial and the final values recorded across the treatment (Table 1). Birds stocked at 2/cell had 2.15 and 2.25 $\times 10^6/\text{mm}^3$ RBC, respectively and those stocked 3 and 4/cell recorded 2.12 and 2.16 $\times 10^6/\text{mm}^3$ and 2.21 and 2.29 $\times 10^6/\text{mm}^3$, respectively. These values were still within the normal range of 2.0 - 4.5 $\times 10^6/\text{mm}^3$ recommended for healthy chicken (Maxwell *et al.*, 1990) and within the range of 2-3 $\times 10^6/\text{mm}^3$ reported by Swenson (2004) and Sjaastad *et al.* (2005). The birds could be adjudged to be rich in oxygen carrying capacity for normal metabolic activities.

Table 1 also shows the WBC differential of laying birds under different stocking density in the cage type. WBC differential were similar ($P > 0.05$) across the treatment. Lymphocytes values fall within the normal range of 55-70% recommended for healthy chicken as reported by Mistruka and Rawnsley (1977). It could imply, the birds were of good immune status.

Heterophils/Lymphocytes ratio reveals the level of stress in caged birds. Birds stocked 2/cell recorded 0.44 before and after the experiment. Birds stocked 3/cell before and after the experiment had 0.41 and 0.65, respectively, while those stocked 4/cell recorded 0.36 and 0.81, respectively. Though there was non significant ($P > 0.05$) difference between the initial and final values, the result indicated birds stocked 4/birds were under stress (H/L=0.8) according to Maxwell *et al.* (1990) who opined heterophils and lymphocytes ratio of greater than 0.5 as a stress free indicator in caged birds.

Table 2 shows percentage change in the

Table 2: Percentage Change in the Haematological Parameters of Egg-typed Chicken under Varying Stocking Density

Measurements (%)	Stocking Density (birds/cell)		
	2	3	4
Packed Cell Volume	5.30*NS	4.10*NS	5.60*NS
Haemoglobin	4.70** NS	4.20** NS	4.80** NS
Red Blood Cell	4.50** NS	1.90** NS	3.50** NS
White Blood Cell	9.7* NS	16.00** NS	2.4** NS
Neutrophil	1.15* NS	25.70** NS	35.20** NS
Lymphocytes	1.7** NS	19.00* NS	30.5* NS
Monocytes	99.15*S	54.70**S	63.40**S
Eosinophils	85.47**S	23.88*S	90.71**S
Basophils	294.12*S	79.52**S	0.00**S
Heterophils	2.21**NS	24.78**NS	37.56**NS
Heterophil-Lymphocyte Ratio	0.00**NS	36.92**NS	55.56**NS

* = Decrease; ** = Increase; S= Significant ($P < 0.05$); NS = Non Significant ($P > 0.05$)

haematology of layers under varying density in locally fabricated battery cage. Birds stocked 3/cell recorded least reduction change in PCV (4.10%), lymphocytes (19%) and eosinophils (23.9%). However, the birds had the least increase in Hb (4.2%), RBC (1.9%), neutrophils (25.7%) and monocytes (54.7%) compared with other stocking values. Increased eosinophils had been reported to be associated with allergic/hypersensitivity reactions, parasitism, tissue injury etc (Cynthia, 2005) therefore layers stocked 3/cell in locally fabricated battery cage did not suffer tissue injury while those stocked 2/cell and 4/cell suffered tissue injury as a result of under and over stocking, respectively in the cage type. However, the result did not follow a particular trend. There was increased basophil change in layers stocked 3/cell compared with birds stocked 2/cell and basophil had been reported to have direct relation with eosinophil (Cynthia, 2005). Both eosinophil and basophil recorded significant change in this study.

Heterophil-Lymphocyte ration (H/L) had been reported as stress indicators in cage birds. Layers stocked 4/cell had highest H/L increase of 55.56% followed by layers stocked 3/cell (36.92%) while layers stocked 2/cell 0% H/L. Since H/L had been reported as stress indicators in cage birds, stocking density of 2birds/cell could be considered as stress free density for layer production in locally fabricated metal-type battery cage. However, since there was non significant effect on the values, 3birds/cell could be ideal stocking rate to commercial farms where welfare and economic consideration are paramount.

Serum chemistry of layer under varying stocking density

Table 3 shows the results of the serum chemistry of layer under varying stocking density in locally fabricated metal-type cage. Blood glucose showed non significant ($P > 0.05$) difference between the initial and final values recorded across the treatments. Layers stocked 2/cell recorded 210.20mg/dl initial blood glucose and 201.17mg/dl for final (70d) blood glucose.

Birds stocked 3/cell also recorded 207.69 and 208.62mg/dl at beginning and end of the experiment, respectively while those stocked 4/cell recorded 224.05 and 203.03mg/dl, respectively. These values were within the normal range of 200-400mg/dl recommended for healthy chicken (Altman, 1979). In addition, Maxwell *et al.* (1990) reported blood glucose range of 200-450mg/dl for laying birds and these reports gave credence to this finding.

Total protein showed non significant ($P>0.05$) difference between the initial and the final values recorded with birds stocked 2/cell which recorded 4.60 and 4.50g/dl, respectively and layers stocked 3/cell which recorded 4.33 and 4.37g/dl, respectively but with significant ($P<0.05$) variation among birds stocked 4/cell (4.39 and 5.22g/dl). Nevertheless, the values were within the normal range (3-9gm/dl) recommended by Altman, 1979 and Maxwell *et al.* (1990) for healthy chicken. Blood glucose recorded 0.5% increase in birds stocked 3/cell while it decreased by 4.5% and 10.4% in birds stocked 2 and 4/cell, respectively. Also, total protein increased with stocking density. Layers stocked 3birds/cell recorded 0.92%

increase while those stocked 4birds/cell recorded 15.9%. Total protein still fall within the normal range (2.5-5.5 g/dl) recommended for the healthy chicken.

While, albumin decreased by 2.4% among layers stocked 2birds/cell and 1.2% among layers stocked 3birds/cell, it increased to 2.6% among layers stocked 4birds/cell. The same trend was recorded with blood urea of the experimental birds which recorded 37.80, 36.15 and 52.70% increase with initial value when stocked 2, 3 and 4birds/cell. Studies of birds prey indicated that the blood urea nitrogen level will become elevated only after major kidney damage (Bauck and Haigh, 1984) and since the basophil and eosinophil had significant change with under and over stocking, stocking rate of 3birds/cell could also be assumed to be the optimum stocking density to prevent tissue injury thus the least increase (36.15%) in blood urea.

Conclusion

The study concluded that locally fabricated metal-type battery cage could be used to rear layers and stocking density of 3birds/cell was ideal without deleterious on the welfare of layers. A comparative study should be carried out with imported 3-tier

Table 3: Effect of Cage Density on Bio-Chemical Parameters of Egg-typed Chickens

Measurements	Initial				Final			
	Stocking Density (birds/cell)				Stocking Density (birds/cell)			
	2	3	4	SEM	2	3	4	SEM
Glucose (mg/dl)	210.20	207.67	224.05	10.05	201.17	208.62	203.03	6.70
Total Protein (g/dl)	4.60 ^a	4.33 ^a	4.39 ^a	0.46	4.50 ^a	4.37 ^a	5.22 ^b	0.33
Albumin (g/dl)	2.66	2.61	2.68	0.09	2.60	2.58	2.75	0.11
Urea (mg/dl)	5.05	5.30	5.67	0.57	8.12	8.30	11.97	2.26

^{ab} - means with different superscript on the same row are significantly different ($P<0.05$)

SEM – standard error mean

ble 4: Percentage Change in Serum Bio-Chemistry Parameters of Egg-typed Chicken under Varying Stocking Density

Measurement (%)	Stocking Density (birds/cell)			SEM
	2	3	4	
Glucose	4.50*NS	0.50**NS	10.40*NS	50.00
Total Protein	2.22*NS	0.92**NS	15.90**NS	39.39
Albumin	2.30*NS	1.20*NS	2.60**NS	18.18
Urea	37.80**S	36.15**S	52.70**S	74.78

* = Decrease; ** = Increase

battery cage type. Also study should be repeated using other layer strains.

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