Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

# *Effect of pellet feed of different particle sizes and housing types on growth performance and blood profile of pullet chicks from weeks 4 to 12*

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Aditional keywords

Feed form.
Particle size.
Housing type.
Performance.
Blood profile.

## SUMMARY

Two hundred and forty day-old pullet chicks were randomly assigned to 4 treatment groups arranged in a 2x2 factorial experimental layout of a completely randomized design to evaluate the effects of pellet feed of different particle sizes (fine ≤ 1 mm and coarse ≤ 2 mm) on growth performance, haematology and serum biochemical parameters of pullet chicks in two housing types (battery cage and deep litter) for a 56-day period (4-12 weeks). Each treatment was replicated thrice with 20 birds per replicate. In the main effects, feed forms had no significant ($p>0.05$) influence on growth performance but housing types significantly ($p<0.05$) influenced the average feed intake and cost of feed consumed, with birds on deep litter having higher ($p<0.05$) feed intake and cost of feed consumed/kg than those in battery cage. Interaction effects of feed forms and housing types on pullet chicks significantly ($p<0.05$) influenced the average feed intake and cost of feed consumed/kg of the birds. Birds reared on deep litter had significantly ($p<0.05$) higher values. The haematological and serum biochemical parameters were affected neither ($P>0.05$) by the main effects nor by the effects of interaction between feed forms and housing types. The study concluded that the performance of the pullets (4-12 weeks) in terms of feed intake and cost of feed consumed was better in the deep litter housing type though there were no detrimental effects of either or both housing types on the birds' blood profile.

**Efecto de la alimentación con pellets de diferentes tamaños de partículas y tipos de alojamiento sobre el rendimiento de crecimiento y el perfil sanguíneo de pollitas de las semanas 4 a 12**

## RESUMEN

Doscientos cuarenta pollitos de pollitas de un día de edad fueron asignados aleatoriamente a 4 grupos de tratamiento dispuestos en un diseño experimental factorial 2x2 de un diseño completamente aleatorizado para evaluar los efectos de la alimentación con pellets de diferentes tamaños de partícula (≤ fina de 1 mm y ≤ gruesa de 2 mm) sobre el rendimiento de crecimiento, la hematología y los parámetros bioquímicos séricos de pollitos de pollitas en dos tipos de alojamiento (jaula en batería y cama profunda) durante un período de 56 días (4-12 semanas). Cada tratamiento se replicó tres veces con 20 aves por réplica. En los efectos principales, las formas de alimento no tuvieron una influencia significativa ($p>0.05$) en el rendimiento del crecimiento, pero los tipos de alojamiento influyeron significativamente ($p<0.05$) en la ingesta promedio de alimento y el costo del alimento consumido, con aves en la cama profunda que tienen una mayor ingesta de alimento ($p<0.05$) y el costo del alimento consumido / kg que aquellos en jaulas en batería. Los efectos de interacción de las formas de alimento y los tipos de alojamiento en pollitos de pollitas influyeron significativamente ($p<0.05$) en la ingesta promedio de alimento y el costo del alimento consumido / kg de las aves. Las aves criadas en cama profunda tuvieron valores significativamente ($p<0,05$) más altos. Los parámetros hematológicos y bioquímicos séricos no se vieron afectados ni ($P>0,05$) por los efectos principales ni por los efectos de la interacción entre las formas de alimentación y los tipos de alojamiento. El estudio concluyó que el rendimiento de las pollitas (4-12 semanas) en términos de ingesta de alimento y costo del alimento consumido fue mejor en el tipo de alojamiento de cama profunda, aunque no hubo efectos perjudiciales de uno o ambos tipos de alojamiento en el perfil sanguíneo de las aves.

Palabras clave

Formulario de alimentación.
Tamaño de partícula.
Tipo de vivienda.
Rendimiento.
Perfil sanguíneo.

Information

Cronología del artículo.
Recibido/Received: 11.04.2019
Aceptado/Accepted: 10.10.2022
On-line: 15.10.2022
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## INTRODUCTION

The poultry industry in Nigeria plays a significant role in developing the Nigerian economy and is a major source of egg and meat which have high value nutritionally in protein supply (Okonkwo & Ahaotu 2019, pp. 22-6). Layers are poultry predominantly reared for the purpose of egg production. However, several internal and external factors including genotype, housing system and age influence egg quality traits (Hanusova *et al.*

2015, pp. 22-3; Kraus *et al*. 2019, pp. 1247-50; Soko1owicz *et al*. 2019, pp. 11-9). Biochemical blood indicators have an effect on health status of hens (Pavlík *et al*. 2007, pp. 341-6). Galli *et al*. (2018, pp. 103-5) reported that ensuring good health status of hens positively affects final quality of eggs. The role blood plays in the transportation of nutrients, metabolic waste products and gases around the body is important and represents a means of assessing animal's clinical and health status. Various body functions are made possible by either singular or collective actions of the blood constituents - haematological or biochemical (Atansuyi *et al.* 2019, pp. 10-4). Diet formulation and nutrition also have an important influence on the health and production capacity of layers.

In addition to nutrient composition, reports have shown that feed structure is a major factor affecting digestibility, animal health, and poultry performance (Schreiter *et al.* 2021, p. 773). Given the importance of structured feeds to animal health and productivity, most laying hens are fed a complete diet, formulated commercially to provide the required nutrients for optimal health, egg production and welfare (Bryden *et al.* 2021, pp. 894-7). A tremendous increase in attention to feed particle size has arisen and the poultry industry searches for ways of enhancing feed utilization and production efficiency. Herrera *et al*. (2017, p. 444-6) observed that medium and coarse grindings were preferable for maize in layers and there was no advantage in reducing particle size below 800 µm. In young brown hens, particle size had no significant effect on the productive performance or egg quality whereas feed intake was greater in hens fed coarsely ground cereals compared to hens on medium and finely ground cereals as reported by Safaa *et al*. (2009, pp. 609-11). A study conducted by Ruhnke *et al.* (2015, pp. 695-7) on white layer strains showed that at the beginning of peak production there was no significant response of birds to alterations in particle size, milling method and feed form (mash vs pellet) in terms of performance parameters. This was corroborated by the findings of Koçer *et al.* (2016, p. 80) that there was no explicit information as regards effects of particle size and feed form on laying hen performance. However, Sonkamble *et al.* (2020, pp. 265-6) observed that feed and housing are two principal factors for success in poultry farming business. A good layer poultry housing system keeps the bird safe, productive and protects the birds from adverse weather conditions, injury and predators.

The majority of commercial laying hens in the world are housed in cage systems in contrast to non-cage systems such as aviaries, barns or free range (Dikeir Kogoor *et al.* 2021, pp. 119-20). Housing types for hens range from small, pasture-based flocks to large, commercial-scale operations that intensively confine tens of thousands of hens indoors (Shields & Duncan 2009, p. 1). According to animal welfare activists, the conventional cages cause many welfare problems and the impetus to investigate alternative systems for egg production has arisen because of the public perception that cages are deleterious to poultry welfare (Gerzilov *et al.* 2012, pp. 954-55). The authors then posited that laying cages are still the most economical way to produce eggs and the best system for disease prevention.

Various studies (Amerah *et al.* 2008, pp. 2324-6; Ahammed & Ohh 2013, pp. 1198-9; Herrera *et al.* 2017, pp.444-6; Bozkurt *et al*. 2019, 4018-20) have been conducted on the influence of production systems and feed components or types in poultry production but there is an increasing need to evaluate the interplay between feed particle sizes and production systems in egg type chickens in order to facilitate their use in the overall assessment and appraisal of the poultry industry with emphasis on the growing egg type chickens. This study therefore evaluated the effects of pellet feed of different particle sizes on growth performance and blood profile of pullet chicks from weeks 4 to 12 on two housing types.

## MATERIALS AND METHODS

### Location of Study

The study was carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The area is situated in the South-Western part of Nigeria and is a derived savanna zone with a mean annual air temperature of 30$^0$C and a relative humidity of 82%. It is located in the region 70m above sea level at latitude 7$^0$5' to 7$^0$8'N and longitude 3$^0$11.2'E (Federal University of Agriculture, Abeokuta, Meteorological Station).

### Experimental diets mix

The macro feed ingredients (maize, soybean, wheat offal and palm kernel cake) were divided equally into two portions. The first portion was milled using a 1mm sized grinding mill and the particles were considered as feed particle size ≤ 1 mm (finely-ground particle size). The second portion was milled using a 2 mm sized grinding mill to get ≤ 2mm particle size feed (coarsely-ground particle size). The micro feed ingredients (ground bone meal, fish meal, oyster shell, vitamin, and mineral premix, salt, lysine and methionine) were divided equally into each of the two portions of 1 mm (fine particle) and 2 mm particle (coarse particle) sizes and mixed thoroughly with the already milled macro feed ingredients. The feed was then pelleted at 2 mm width. Pelleting was done using a pellet mill, where the feed was conditioned and thermally treated in the fitted conditioners of a pellet mill.

### Experimental birds and management

Two hundred and forty (240) day-old pullet chicks were purchased from a reputable commercial hatchery and brooded for four weeks. Afterwards, they were randomly divided into four treatment groups with 3 replicates of 20 birds each. The experiment was laid out in a 2x2 factorial arrangement based on two housing types (battery cage and deep litter/litter-covered floor) and two types of pelleted feed either fine particle size (0 ≤ 1mm) or coarse particle size (1 ≤ 2mm). Required bio-security measures and vaccinations were carried out, and birds were dewormed and given vitamins at regular intervals. The chicks were fed dietary mix

(**Table I**) in mash form until they were 28 days old (4 weeks) before the commencement of the study when the pelleted form of either fine or coarse feed particles were introduced to the birds. Both feed and fresh water were given to the chicks *ad libitum*. The composition (%) of the diet is presented in **Table I**.

## DATA COLLECTION

### Growth performance characteristics

Feed intake was determined by weighing a quantity of feed offered to the birds and subtracting the left over the following morning. This was used to determine daily feed intake and consequently weekly feed intake. At the commencement of the trial, body weight was determined and subsequently on a weekly basis, to determine weight gain. Feed conversion ratio was calculated as the ratio of feed intake to body weight gain. Cost of feed consumed per bird was also determined at the end of the study period using the prevailing market prices of each feed ingredient.

### Blood Parameters

At the end of the feeding trial of 8 weeks, blood samples were collected from wing vein of three birds per replicate using 5ml sterilized syringe. Blood was collected into sterilized bottles containing Ethylene Diamine Tetra-Acetate (EDTA), an anti-coagulant, for haematology analysis. The plain bottles without anticoagulant were used to collect blood samples serum biochemical analysis. For haematology, the following parameters were determined: Packed Cell Volume (PCV), Haemoglobin concentration (Hb), Red Blood Cell count (RBC), White Blood Cell count (WBC), Heterophils, Lymphocytes, Eosinophils, Basophils and Monocytes. For biochemistry analysis, parameters measured were: Total protein, Albumin, Globulin, Creatinine, Aspartate transaminase (AST), Alanine transaminase, (ALT), Uric acid and Blood cholesterol. All data generated were subjected to two way analysis of variance (ANOVA) using the PRO GLM of SAS (2010) at 5% level of significance. Significantly (<0.05) different means were separated using the Duncan's Multiple Range Test of the same software package.

**Table I: Composition (%) of experimental diets** (Composición (%) de las dietas experimentales).

| Ingredients | Chick Mash |
|---|---|
| Maize | 48.00 |
| Wheat offal | 10.00 |
| Palm kernel cake | 19.00 |
| Soybean cake | 17.00 |
| Fish meal (72% CP) | 2.00 |
| Bone meal | 1.00 |
| Oyster shell | 2.00 |
| Lysine | 0.20 |
| Methionine | 0.20 |
| Salt (NaCl) | 0.30 |
| *Vitamin/mineral premix | 0.30 |
| Total | 100.00 |
| Determined analysis (%) | |
| Crude Protein | 18.50 |
| Metabolizable Energy (KCal/Kg) | 2928.40 |

* Premix will contain: (Univit. 15 Roche) 1500I.U., Vit. A; 1500I.U., Vit. D; 3000I.U., Vit. E; 3.0g, Vit. K; 2.5g, Vit. B2; 0.3g, Vit. B6; 8.0mg, Vit. B12; 8.0g, Nicotinic acid; 3.0g, Ca-Pantothenate; 5.0mg, Fe; 10.0g, Al; 0.2g, Cu; 3.5mg, Zn; 0.15mg, I; 0.02g, Co; 0.01g Se.

## RESULTS AND DISCUSSION

The main effects of pelleted feed forms and housing types on growth performance of growing pullet is presented in **Table II**. Feed form had no significant (p>0.05) influence on all the growth performance parameters. Guzman *et al.* (2015, pp. 253-7) and Ege *et al*. (2019, pp. 3790-6) reported that diet form and particle size had no significant effect on weight gain and feed intake. Amerah *et al*. (2008, pp. 2324-6) reported no significant difference in body weight gain because of fine and coarse particle sizes. The findings of this current study also agrees with Frikha *et al*. (2011, pp. 109-13) who indicated a lack of any effect of the screen size used to determine feed particle size on body weight gain, feed intake and the feed conversion ratio of brown laying pullets from 1 to 120 d of age. However, this negates the common opinion that finely ground feed enables digestive secretions have better access to substrates, thus improving digestion and absorption, and then growth efficiency (Abdollahi *et al*. pp. 10-7). The lack of significant improvement in feed conversion ratio of birds on pelleted feed with coarse particles in this study could probably be attributed to a lack of increased digestibility of ether extract and nitrogen, and the activity of pancreatic amylase. From another point of view, it could probably be due to lack of increased function of the gizzard (Bozkurt *et al.* 2019, pp. 4018-20). Feed forms had no effect on the cost of feed consumed in this study and this disagrees with Okedere *et al.* (2020, p. 74) who indicated there was no economic difference between the use of either mash or pellet feed in poultry.

Housing type significantly (p<0.05) influenced the average feed intake and cost of feed consumed by the birds. Pullets on deep litter had significantly (p<0.05) higher values for feed intake (87.64 g/bird) and cost of feed consumed/kg (₦13.71) compared to those in battery cage. Similar results of increased feed intake for birds on deep litter were reported by Ahammed & Ohh (2013, pp. 68-70) and Ahammed *et al.* (2014, pp. 1198-9), that birds reared on barn system spent more time for frequent locomotion and consumed more feed compared to birds on cage rearing system. Study by Rouf *et al.* (2015, pp. 153-4) showed that higher stocking densities in cages have been associated with less movement of hens and minimum loss of heat increment, resulting in lower feed consumption. Olaniyi *et al.* (2012, pp. 513-9) observed that feed consumption was significantly affected by housing type, with birds on deep litter consuming more than those reared on free range. This however differed from previous observations made showing that the effect of housing type on feed consumption was considered of importance

**Table II:** Main effect of feed form and housing type on growth performance of pullet chicks (Efecto principal de la forma de alimento y el tipo de alojamiento en el rendimiento de crecimiento de pollitas pollitas).

| Parameter | Feed form | | | | Housing type | | | |
|---|---|---|---|---|---|---|---|---|
| | Fine | Coarse | SEM | P-value | Battery cage | Deep litter | SEM | P value |
| Initial weight (g) | 496.67 | 538.33 | 19.72 | 0.160 | 495.00 | 540.00 | 19.72 | 0.110 |
| Final weight (g) | 1216.70 | 1173.30 | 36.30 | 0.423 | 1173.30 | 1216.70 | 36.3 | 0.423 |
| Average weight gain (g/bird) | 10.29 | 9.07 | 0.473 | 0.107 | 9.69 | 9.67 | 0.47 | 0.972 |
| Average feed intake (g/bird) | 5.39 | 85.76 | 0.535 | 0.645 | 83.71$^{b}$ | 87.44$^{a}$ | 0.54 | 0.001 |
| Cost of feed consumed/kg (₦) | 13.39 | 13.45 | 0.084 | 0.645 | 13.13$^{b}$ | 13.71$^{a}$ | 0.084 | 0.001 |
| FCR | 8.39 | 9.50 | 0.378 | 0.071 | 8.79 | 9.11 | 0.38 | 0.559 |

$^{ab}$ Means on the same row having different superscripts are significantly (p<0.05) different.
FCR = Feed Conversion ratio $1 = ₦414.00

as more feed was consumed by birds in wooden cage compared to deep litter for exotic breed of birds while consumption was high on deep litter for the locally-adapted breed of birds (Sogunle *et al*. 2013, pp. 406-10). In addition, it was observed in another study (Okedere *et al.* 2020, p.74) that birds kept in battery cage recorded the highest values for daily feed intake compared to birds on deep litter and free range. Li *et al.* (2017, pp. 901-5) posited that different housing systems and enzyme supplementation had no significant effect on daily weight gain. However, daily feed intake of the birds on litter-covered floor was significantly increased compared to that of caged birds in the study. The cost of feed consumed was highest for birds on deep litter and was similar to the value for birds on fine particle pelleted feed in this experiment. Results of a study by Okedere *et al*. (2020, p. 74) for cost benefit analysis showed significant influence of management systems on some parameters including total cost of feed consumed. Birds kept in battery cage recorded the highest values daily for feed intake, total feed intake, and total cost of feed consumed.

In the interaction effects between pelleted feed forms and housing types on growth performance of pullet chicks shown in **Table III**, significant (p<0.05) differences were observed in the average feed intake and cost of feed consumed/kg. The values of both parameters in birds reared on deep litter or litter-covered floor were significantly (p<0.05) higher and similar for birds on both coarse particle (87.84 g, ₦13.77) and fine particle (87.04 g, ₦13.65) pelleted feeds. Not much research is available on the potential interactions between feed particle size and feed form on pullet performance but a study by Bozkurt *et al.* (2019, pp. 4018-20) reported that manipulating ingredient particle sizes (fine or coarse) or forms of the final feed mixture (mash or crumble) had no significant effects on the weight gain, uniformity of body weight, feed intake and feed conversion ratio of pullets at the end of 112 days rearing period. Corzo *et al.* (2011 p. 70) reported no differences in any of the performance parameters considered when broilers were fed pelleted feeds of different qualities. They concluded that pelleting evened out the differences in particle size distribution. Naderinejad *et al*. (2016, pp. 93-7 ) did not observe any significant interaction between feed form and particle size for body weight of birds at ages 21d and 42d, respectively. The results of the current study showed that the birds in battery cage housing system were less varied in their performances probably on account of a more uniform and benign micro environment in the battery cage system. Birds reared on deep litter are exposed to a myriad of unequal and stressful environmental effects and influences from pen mates such as cannibalism and competition for feed, water and space (Gerzilov *et al.* 2012, pp. 954-55; Golden *et al.* 2012, pp. 96-9). These factors brought about variations in performance of individual birds and in turn influenced the overall performance of a flock (Golden *et al.* 2012, pp. 96-9). The cost of feed consumed for birds on deep litter was

**Table III:** Interactive effect between feed form and housing type on growth performance of pullet chicks (Efecto interactivo entre la forma de alimento y el tipo de alojamiento en el rendimiento de crecimiento de pollitas pollitas).

| Feed form | Fine | | Coarse | | SEM | P-value |
|---|---|---|---|---|---|---|
| Housing type | Battery cage | Deep litter | Battery cage | Deep litter | | |
| Parameters | | | | | | |
| Initial weight (g) | 473.30 | 520.00 | 516.70 | 560.00 | 23.70 | 0.906 |
| Final weight (g) | 1200.00 | 1233.30 | 1146.70 | 1200.00 | 51.40 | 0.851 |
| Average weight gain (g/bird) | 10.38 | 10.19 | 9.00 | 9.14 | 0.67 | 0.809 |
| Average feed intake (g/bird) | 83.75$^{b}$ | 87.04$^{ab}$ | 83.68$^{b}$ | 87.84$^{a}$ | 0.76 | 0.580 |
| Cost of feed consumed/kg (₦) | 13.13$^{b}$ | 13.65$^{ab}$ | 13.12$^{b}$ | 13.77$^{a}$ | 0.12 | 0.580 |
| FCR | 8.19 | 8.59 | 9.38 | 9.63 | 0.53 | 0.897 |

$^{ab}$ Means on the same row having different superscripts are significantly (p<0.05) different.
FCR = Feed Conversion ratio $1 = ₦414.00

higher than for birds in other treatments in this study. Thus it may not be economically advantageous to administer pelleted feed forms of either fine or coarse particles to pullet chicks in deep litter. The high cost of feeding coarse particle feeds to birds on deep litter may result in narrow profit margin which could lead to what Sogunle *et al*. (2013, pp. 406-10) described as a collapse of the once prosperous poultry industry with high cost of production occasioned by higher feed intake. The authors further opined that high feed cost is a major challenge the poultry farmer faces in the Nigerian poultry industry. Prevalent and sometimes unwarranted increase in feed ingredient prices have contributed substantially to the difficulties experienced by these farmers.

There were no significant (p>0.05) differences observed in the main effects of pelleted feed form and housing type on the haematological parameters of pullet chicks (**Table IV**). This same trend (p>0.05) was recorded in the effects of interaction between pelleted feed form and housing type on haematological parameters of pullet chicks (**Table V**) across the treatment groups. However, the values obtained in this study were within the normal range for healthy birds. **Table VI** shows the main effects of pelleted feed form and housing type on serum biochemical parameters of pullet chicks. There were no significant (p>0.05) differences in all parameters examined. Also, in **Table VII**, no significant (p>0.05) differences were recorded in the effects of interaction between pelleted feed form and housing type on serum biochemical parameters of the pullet chicks across the treatment groups. These results corroborated the findings of Pavlik *et al*. (2007, pp. 341-6) that showed no significant changes in total protein concentrations of blood serum in different housing systems for Isa Brown layers. In addition, from the observations made in a study by Kraus *et al.* (2021, pp. 1143-50), housing system reflected no significant effect of factors such as the housing type, age and breed on albumin concentration of blood serum of laying hens. Similarly, in a 56-day study to evaluate the effect of two different feed forms on haematology and serum biochemistry of broilers, findings (Ilo *et al.* 2019, pp. 177-80) showed no significant influence of feed forms on any of the parameters except uric acid.

**Table IV**: **Main effects of feed form and housing type on haematological parameters of pullet chicks** (Principales efectos de la forma de alimento y el tipo de alojamiento en los parámetros hematológicos de pollitos pollitas).

| Parameter | Feed form | | | | Housing type | | | |
|---|---|---|---|---|---|---|---|---|
| | Fine | Coarse | SEM | P value | Battery cage | Deep litter | SEM | P value |
| Packed cell volume (%) | 27.750 | 28.250 | 0.559 | 0.561 | 27.000 | 29.000 | 0.559 | 0.065 |
| Haemoglobin concentration (g/dl) | 9.075 | 9.175 | 0.230 | 0.774 | 8.925 | 9.325 | 0.230 | 0.287 |
| Red blood cell counts ($x10^{12/L}$) | 2.200 | 2.375 | 0.108 | 0.314 | 2.250 | 2.325 | 0.108 | 0.648 |
| White blood cell counts ($x10^{9/L}$) | 9.85 | 12.30 | 1.66 | 0.355 | 9.62 | 12.53 | 1.66 | 0.284 |
| Heterophil (%) | 31.50 | 32.50 | 4.92 | 0.893 | 28.25 | 35.75 | 4.92 | 0.342 |
| Lymphocytes (%) | 63.75 | 61.00 | 3.89 | 0.643 | 66.75 | 58.00 | 3.89 | 0.186 |
| Eosinophil (% ) | 1.250 | 1.750 | 0.559 | 0.561 | 2.000 | 1.000 | 0.559 | 0.275 |
| Basophil (%) | 2.000 | 1.250 | 0.685 | 0.482 | 1.250 | 2.000 | 0.685 | 0.482 |
| Monocytes (%) | 1.500 | 1.000 | 0.559 | 0.561 | 1.750 | 0.750 | 0.559 | 0.275 |

Of pullet chicks.

**Table V**: **Interactive effect between feed form and housing on haematological parameters of pullet chicks** (Efecto interactivo entre la forma de alimentación y el alojamiento sobre los parámetros hematológicos de pollitas pollitas).

| Feed form | Fine | | Coarse | | | |
|---|---|---|---|---|---|---|
| Housing type | Battery cage | Deep litter | Battery cage | Deep litter | SEM | P value |
| Parameters | | | | | | |
| Packed cell volume (%) | 28.00 | 27.50 | 26.00 | 30.50 | 0.79 | 0.034 |
| Haemoglobin concentration (g/dl) | 9.30 | 8.85 | 8.55 | 9.80 | 0.33 | 0.060 |
| Red blood cell counts ($x10^{12/L}$) | 2.30 | 2.10 | 2.20 | 2.55 | 0.15 | 0.145 |
| White blood cell counts ($x10^{9/L}$) | 8.35 | 11.35 | 10.90 | 13.70 | 2.34 | 0.968 |
| Heterophil (%) | 28.00 | 35.00 | 28.50 | 36.50 | 6.96 | 0.946 |
| Lymphocytes (%) | 67.00 | 60.50 | 66.50 | 55.50 | 5.49 | 0.703 |
| Eosinophil (% ) | 1.50 | 1.00 | 2.50 | 1.00 | 0.79 | 0.561 |
| Basophil (%) | 1.50 | 2.50 | 1.00 | 1.50 | 0.97 | 0.809 |
| Monocytes (%) | 2.00 | 1.00 | 1.50 | 0.50 | 0.79 | 1.000 |

Of pullet chicks.

**Table VI: Main effect of feed form and housing type on serum biochemical parameters of pullet chicks** (Efecto principal de la forma de alimento y el tipo de alojamiento en los parámetros bioquímicos séricos de pollitos pollitas).

| Parameters | Feed form | | | | Housing | | | |
|---|---|---|---|---|---|---|---|---|
| | Fine | Coarse | SEM | P value | Battery cage | Deep litter | SEM | P value |
| Total protein (g/dl) | 7.38 | 7.55 | 0.375 | 0.758 | 6.93 | 8.000 | 0.375 | 0.113 |
| Albumin (g/dl) | 3.67 | 11.60 | 5.61 | 0.374 | 11.32 | 3.95 | 5.61 | 0.405 |
| Globulin (g/dl) | 3.70 | 3.83 | 0.24 | 0.732 | 3.48 | 4.05 | 0.240 | 0.166 |
| Creatinine (mg/dl) | 1.00 | 1.20 | 0.34 | 0.701 | 1.10 | 1.10 | 0.343 | 1.000 |
| AST (U/L) | 65.25 | 64.25 | 4.87 | 0.892 | 69.25 | 60.25 | 4.87 | 0.261 |
| ALT(U/L) | 33.00 | 27.50 | 3.54 | 0.334 | 29.75 | 30.75 | 3.54 | 0.852 |
| Uric acid (mg/dl) | 3.225 | 3.13 | 0.11 | 0.552 | 3.025 | 3.325 | 0.109 | 0.123 |
| Triglyceride (mg/dl) | 114.75 | 106.50 | 12.80 | 0.671 | 98.75 | 122.50 | 12.80 | 0.258 |
| HDL (mg/dl) | 47.80 | 44.42 | 8.95 | 0.803 | 48.08 | 44.15 | 8.95 | 0.772 |
| LDL (mg/dl) | 26.25 | 20.52 | 5.41 | 0.496 | 24.43 | 22.35 | 5.41 | 0.800 |
| VLDL (mg/dl) | 22.95 | 21.30 | 2.55 | 0.671 | 19.75 | 24.50 | 2.55 | 0.258 |
| TC (mg/dl) | 97.00 | 86.24 | 12.60 | 0.580 | 92.26 | 91.00 | 12.60 | 0.948 |

AST = Aspartate transaminase; ALT = Alanine transaminase; HDL = High density lipoprotein; LDL = Low density lipoprotein; VLDL = Very low density lipoprotein; TC = Total cholesterol.

**Table VII: Interactive effect between feed form and housing type on serum biochemical parameters of pullet chicks** (Efecto interactivo entre la forma de alimento y el tipo de alojamiento en los parámetros bioquímicos séricos de pollitas).

| Feed form | Fine | | Coarse | | SEM | P value |
|---|---|---|---|---|---|---|
| Housing | Battery cage | Deep litter | Battery cage | Deep litter | | |
| Parameters | | | | | | |
| Total protein (%) | 7.10 | 7.65 | 6.75 | 8.35 | 0.53 | 0.379 |
| Albumin (g/dl) | 3.50 | 3.85 | 19.15 | 4.05 | 7.93 | 0.385 |
| Globulin (g/dl) | 3.60 | 3.80 | 3.35 | 4.30 | 0.34 | 0.332 |
| Creatinine (mg/dl) | 0.80 | 1.20 | 1.40 | 1.00 | 0.49 | 0.456 |
| AST (U/L) | 68.50 | 62.00 | 70.00 | 58.50 | 6.88 | 0.735 |
| ALT (U/L) | 32.00 | 34.00 | 27.50 | 27.50 | 5.01 | 0.852 |
| Uric acid (mg/dl) | 3.30 | 3.15 | 2.750 | 3.500 | 0.15 | 0.043 |
| Triglyceride(mg/dl) | 99.50 | 130.00 | 98.00 | 115.00 | 18.00 | 0.727 |
| HDL (mg/dl) | 53.50 | 42.00 | 42.60 | 46.20 | 12.70 | 0.582 |
| LDL (mg/dl) | 27.05 | 25.45 | 21.80 | 19.25 | 7.65 | 0.953 |
| VLDL(mg/dl) | 19.90 | 26.00 | 19.60 | 23.00 | 3.61 | 0.727 |
| TC (mg/dl) | 100.50 | 93.50 | 84.00 | 88.50 | 17.90 | 0.764 |

AST = Aspartate transaminase; ALT = Alanine transaminase; HDL = High density lipoprotein; LDL = Low density lipoprotein; VLDL = Very low density lipoprotein; TC = Total cholesterol.

## CONCLUSION

The study showed that in the growing phase, feed intake and cost of feed consumed were higher in birds raised on deep litter housing type than those raised on battery cage housing type. Neither feed form nor housing type had detrimental effects on the haematological or serum biochemical parameters of the pullets at growing phase. Therefore, it could be recommended that pullets could be reared in the battery cage system during the growing stage to reduce cost of feed consumed.

## CONFLICT OF INTEREST STATEMENT

The authors hereby declare that there is absolutely no conflict of interest with any individual or organisation regarding the materials discussed in the manuscript.

## ETHICAL APPROVAL

The study protocol was approved by Animal Care and Use Review (AC & UR) Committee of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (FUNAAB, 2013 pp. 6-10).

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