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GROWTH PERFORMANCE AND CARCASS YIELD OF HELMETED GUINEA FOWL (*NUMIDA MELEAGRIS*) MALE KEETS RAISED IN DIFFERENT HOUSING SYSTEMS OF A TROPICAL ENVIRONMENT

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ABSTRACT
This study evaluated the growth performance and carcass yield of male helmeted guinea fowl (Numida meleagris) keets raised under three housing systems: deep litter, battery cage, and deep litter, which run in a tropical environment. The objective was to assess the influence of housing on bird productivity and carcass characteristics to inform best practices for sustainable guinea fowl production. Two hundred sixteen eight-week-old male keets were randomly distributed across the housing systems in a Completely Randomized Design, with feed and water provided ad libitum for 16 weeks. Growth performance was measured weekly, while carcass and gastrointestinal traits were evaluated post-slaughter. Data were analyzed using Analysis of Variance (ANOVA), and significant means were separated using Duncan's Multiple Range Test at a 5% significance level. Results showed significant differences ($p < 0.05$) in feed intake and some carcass parameters among housing systems. Deep litter with run birds exhibited a superior dressing percentage (74.25%) and higher ether extract content in thigh meat (5.02%). In contrast, battery cage birds showed higher drumstick meat percentage and crude protein levels. The housing system significantly influenced oesophagus length and selected gastrointestinal segments. It is concluded that deep litter with run offers a favourable environment for improved carcass traits and may enhance nutrient deposition in meat, suggesting it is a viable system in tropical settings. These findings contribute to the knowledge of guinea fowl production and recommend further investigation into the interactive effects of housing and environmental variables on performance outcomes.

Keywords: Carcass, Growth, Guinea fowl, Housing systems, Keets

INTRODUCTION
The rearing of guinea fowl (Numida meleagris) has more potential to bridge the demand-supply gap in animal protein intake. This indigenous species contributes significantly to animal protein availability in Nigeria through cheap meat and eggs, which buffers the shortage of other poultry products. Numidia meleagris is native to Africa (Adjetey et al., 2014), and guinea fowl possess valuable adaptive genetic potentials and yields small under low-input agriculture, which is typical of rural Nigeria. There is a general notion among farmers that the local birds cannot be raised under the intensive system because of their inherent feral character. However, it is known that there are large-scale commercial farms of improved guinea fowls in Europe and Africa (Vignal, 2019). Guinea birds raised for commercial purposes are reared in confinement and are managed similarly to hens (Lehr, 2024). However, limited information on performance characteristics under different housing systems for the keets, pullets, and layers is available. This information would minimise overhead costs associated with the maintenance of poultry houses and improve feed utilisation efficiency, suggesting that effective management of the guinea fowl in various housing systems might lead to profitability.
The carcass of intensively raised guinea fowl is reported to have a highly nutritive chemical composition (Śmiecińska, (2022). Investigation into its nutritional composition has shown that guinea fowl meat, like in flavour to other game birds, contains several dietary qualities that considerably enhance the diet (Śmiecińska, 2022). As a critical environmental factor, housing directly influences growth performance and carcass yield, two essential indicators of production efficiency affecting thermal comfort, welfare, health, feed utilisation, and stress levels (Attia, 2021). In West Africa, and particularly Nigeria, where guinea fowl farming plays a vital socio-economic role, studies investigating the influence of different housing systems such as deep litter, battery cage, and free-range on male keet performance are limited despite their potential for improving local food security (Soara et al., 2020). The correlation between housing types and growth measures is inadequately examined, especially in tropical regions where climatic stressors may intensify performance gaps. This study is motivated by the need to generate data on the optimal housing system for raising male keets under tropical conditions to enhance productivity, inform farmer decision-making, and support sustainable guinea fowl production.

MATERIALS AND METHODS
Experimental location, design, birds, and housing systems
The experimental housing units were located in the rainforest vegetation zone of South-Western Nigeria at latitude 70S 13' 49"N, longitude 30 26' 11"E, and an altitude of 76 m above sea level (Google Earth, 2024). The climate is tropical humid, with an average annual rainfall of 1037 mm, a mean temperature of 34.7ºc, and a relative humidity of 83%.
In this study, 216 eight-week-old male Pearl-helmeted guinea fowl keets were randomly allocated to three experimental housing systems: battery cage (BC), deep litter (DL), or deep litter with run (DLR). There were 72 keets per housing system, and they were divided across four replications of 18 per bird. A wire net supported with metal bars served as the housing system for the battery cage, which was equipped with linear drinkers and galvanised feeders. The cage had a floor space of 1 m^2. The deep litter housing also had a stock density of 1m^2 per bird. The deep litter housing pen floor was bedded with wood shavings, and the deep litter with free run of 2.5

m^2 per bird outdoor run area (in addition to the deep litter floor of 1 m^2 per bird) covered with grasses, whereby keets were able to supplement their diets with plants and tiny creatures that lived outdoors. The sampled grasses in the fenced run were composed of pasture (Stylosanthes hamata, Cynodon dactylon) and vegetable weeds such as Tridax procumbens, Talinum triangulae, Platostoma africanum, Gomphrena celosoides, Sida rhombifilia and Eragrostis tenella. The housing systems were equipped with feeders and drinkers and were naturally ventilated; feed and water were provided ad libitum during the 16-week study. Table 1 provides the diet's composition; the experimental treatments were arranged in a Completely Randomised Design.

Concentrate diets

The dietary nutritional guidelines for guinea fowl were considered while formulating concentrate diets (Table 1). The NRC (1984) guidelines for amino acids and energy were used as a reference for formulation. The experimental feed ingredients were purchased, milled, and processed from a reputable commercial feed mill in Abeokuta, and birds were fed ad libitum.

Table 1: Composition of Concentrate Diets (g/kg) Fed to Guinea Fowls at Ages 5-16 Weeks

Ingredients	**8-12wks**	**13-24wks**
Maize	500.00	473.00
Soybean meal	140.00	60.00
Fish meal (72% CP)	20.00	10.00
Wheat offal	150.00	300.00
Groundnut cake	125.00	65.00
Bone meal	40.00	40.00
Limestone	18.00	45.00
Salt (NaCl)	2.50	2.50
*Vit/mineral premix	2.50	2.50
Methionine	1.00	1.00
Lysine	1.00	1.00
TOTAL	1000.00	1000.00
Chemical Composition		
ME (MJ/kg)	11.54	10.97
Crude protein (g/kg)	202.3	155.9
Ether Extract (g/kg)	43.6	38.5
Fibre (g/kg)	40.3	44.7
Calcium (g/kg)	17.9	27.0
Av. Phosphorus (glkg)	8.7	7.7

*1 Kg contains: Vit A: 10,000,000 IU; Vit D3: 2,000,000 IU; Vit E: 12,000 IU; Vit K3: 2,000mg; Vit B_1: 1,500mg; Vit B_2: 5,000mg; Vit B_6: 1,500mg; Vit B_{12}: 10,000mg; Biotin: 20mg: Niacin: 15,000mg; Panthotenic Acid: 5,000mg; Folic Acid: 500mg; Manganese: 75000mg; Zinc: 50,000mg; Iron: 25,000mg; Copper: 5,000mg; Iodine: 1,000mg; Selenium: 100mg; Cobalt: 300mg; Choline: 150,000mg; Antioxidant: 125,000mg

Carcass evaluation and Gastrointestinal Tract Measurements of the Cockerel

Two cockerels from each replicate group were meticulously chosen through a random selection process. They were fasted for 24 hours, with access to water only, before their live weight was recorded prior to slaughter. The precision of the methods is further underscored by using two distinct approaches to assess carcass characteristics: physical dissection and chemical analysis of muscle (Panda, 1998; Van Marle-Koster & Webb, 2000). The parameters measured through dissection included dressing weight, cut-up parts, organ weights, and drumstick bone-to-meat ratio. Chemical analysis of muscles cut from the breast and thigh meats was assayed on a dry matter basis for crude protein, ether extract, and nitrogen-free extract, which were described according to AOAC (2005). The complete gastrointestinal tract removed from each carcass was emptied and cut into the oesophagus, crop, proventriculus, duodenum, jejunum, ileum, colon, and caeca, respectively, for each length measurement; all the weights were averaged and expressed as percentages of dressed carcass.

Data collection

The cockerel in each replicate was weighed at the start of the experiment and subsequently once a week between 8 and 16 weeks of age. A 20 kg weighing scale was used to take the weight in the morning before feeding. The difference between the body weights of two successive weights for each replicate group was used to calculate weight gain.

A known quantity of feed was fed to each group at the beginning of each day, and the leftover at the end of each week was subtracted from the amount fed to obtain the weekly feed consumed.

Feed intake (g/bird) = $\frac{\text{Feed supplied} - \text{leftover}}{\text{no of birds}}$

The efficiency of feed utilization of feed consumed by the guinea fowl was determined by the feed conversion ratio calculated as shown in the formula below

Feed conversion ratio = $\frac{\text{Feed consumed g/bird}}{\text{weight gain g/bird}}$

Data from carcass evaluation and GIT tract measurements were collated for statistical analysis

Statistical Analysis

All the experimental data collected were laid out accordingly and were subjected to Analysis of Variance in a Completely Randomized Design (SAS, 2002). Statistical Analysis System (SAS, 2002) and Duncan's Multiple Range Test were used to differentiate significantly ($p<0.05$) different means and ranges accordingly among variables.

The model was:

$Y_{ij} = \mu + \beta_i + \varepsilon_{ij}$

Where:

Y_{ij} = Individual Observatio

μ = Population means
β_i = Effect of housing systems
ε_{ijk} = Residual error

RESULTS AND DISCUSSION

The effects of different housing systems on the performance of guinea fowl male keets between 8-16 weeks of age are displayed in Table 2. Initial and final body weights, weight gain per keet per day, feed intake per keet per day, and feed conversion ratio were measured. In the housing systems, there were significant differences in the feed intake ($P < 0.05$). Results showed that birds in the battery cage system and deep litter had a significantly higher feed intake (16.34 g and 16.33 g, respectively) than keets raised in deep litter with run housing with a feed intake of 16.27 g/bird. The differences in the other parameters measured were not significant enough to demonstrate a direct impact of the housing systems on the performance of the guinea fowl keets. This observation is consistent with the findings of Nsoso et al. (2006), who observed that keets raised in totally confined poultry houses consumed more feed than those in semi confined-poultry houses as in DLR. The authors retorted that eating more feed led to higher weight gain.
However, in this research, the keets raised in the fenced open natural area (DLR) consumed less concentrate feed but gained more weight; this can be attributed to the consumption of insects and other natural feed resources in the housing type, apart from the concentrate. In contrast, Yamak et al. (2016, 2018) reported that guinea fowl and partridges raised indoors had considerably greater body weight than those reared under free-range or outdoor systems between 6 and 16 weeks, indicating that indoor rearing atimes promotes better weight gain across different bird species.
Furthermore, Haruna et al. (2018) also showed that conventionally raised broilers had higher growth rates than broilers raised in outdoor systems. Neil (2022) expatiated on free-run raised guinea fowl feed consumption; he noted that they fed on grass, seeds, leaves, bulbs, other vegetable matter, insects, and worms together with small stones, which means that the semi-confined poultry house with fenced open natural area (run) housing types, compared to conventional poultry houses, provided extra feeds in addition to concentrate mash, which was provided in all the confined housing types. Guinea fowl raised in confined poultry house types (deep litter or battery cages) depends entirely on the feed provided. The floor was cemented and covered with wood shaving, which did not allow the birds free access to insects and vegetation matter.
This experiment revealed that the housing type did not significantly affect the feed-to-meat capacity of guinea fowl, as the feed conversion ratio values were similar across the treatments. These values were consistent with those reported by Oke et al. (2020), who found that keeping guinea fowls at different stocking densities increased the feed conversion ratios. In contrast, Mesa et al. (2017) observed a significant increase in feed conversion ratio in a concrete floor house compared to a semi-confined poultry house with a fenced open natural grazing area.

Table 2: Effect of Housing System on the Post-Hatch Performance of Guinea Fowl Keets (8– 16 Weeks of Age)

Parameters	Housing System			SEM	P value
	Deep Litter	Battery Cage	Deeplitter with Run		
Initial body (g/keet)	559.64	578.88	566.17	3.80	0.090
Finalbodywt(g/keet)	1086.17	1109.00	1093.67	108.54	0.451
Wtgain(g/keet/day)	6.27	6.31	6.28	0.04	0.919
Feed intake (g/keet/day)	16.34^a	16.33^a	16.27^b	0.46	0.03
Feed Conversion Ratio	3.50	3.49	3.41	0.06	0.862

$^{a, b, c}$ Means in the same row not sharing common superscripts are significantly different ($p<0.05$)

The result in Table 3 revealed that the deep litter with run housing system had the highest ($P < 0.05$) dressing percentage (74.25%), followed by the deep litter system (72.15%), and the battery cage system had the lowest dressing percentage (70.57%), observed in guinea fowl cockerels raised in a battery cage, suggesting that birds in cages exhibited a lower level of physical activity; which clearly showed that housing significantly influenced by carcass quality. However, Li et al. (2017) reported that growing birds in free-range or free-run systems increased their physical activity and growth performance, affecting the carcass yield. This observation was inconsistent with the observations of Ying et al. (2017), who reported that the eviscerated carcass percentage of chickens in the total indoor floor group was significantly greater than that of birds grown in the cage group, as noticed in this study. Tong et al. (2015) further stated that the eviscerated carcass percentage significantly increased when birds had outdoor access because of increased motor activity. The carcass yield (72.15 %) obtained in the deep litter and 74.25% in the deep litter with run-reared guinea fowls were within the range reported by Tjetjoo et al. (2022) at the same age. Nobo et al. (2012) observed lower dressing weight in birds kept in the deep litter with a run compared to those in deep litter and battery cages. The carcass yields found in the present study were lower than the 75.0% reported by Ebegbulem and Asuquo (2018).
In addition, some retail-cut parts, like the wings and back, revealed notable variations across the housing systems; the battery cage system had a 10.63% percentage of wing cuts, which was significantly lower than the values in the deep litter with run (11.65%) and deep litter value (11.35%). The back part percentage is significantly higher in ($p<0.05$) battery cage system (17.56%) compared to deep litter with the run system (16.69%) and 16.91% in deep litter. The battery cage system had a significantly higher total drumstick bone (24.45%), followed by that of deep litter (23.42%) and deep litter with run (22.21%). The total drumstick weight meat varied across the housing systems; the battery cage system had the highest percentage (92.64%), followed by the deep litter system (89.42%), and the deep litter with the run system had the lowest percentage (84.67%). These findings are in tandem with the previous studies of (Ajibola and Sonaiya, 2017), who stated that the battery cage system generally produced higher percentages of specific retail cuts, such as drumstick bone and meat weights, suggesting more uniform muscle development likely due to restricted movement and controlled feeding Also, the studies of Abo Ghanima et al., (2020) indicate improved carcass yield in caged birds. However, the lower percentage of wing cuts in the battery cage system compared to the deep litter systems contrasts with findings from studies of Wang et al. (2025) that reported no significant differences or even higher yields in free-movement systems for specific

parts due to enhanced muscle activity. Additionally, the higher percentage of back parts in the battery cage system aligns with literature suggesting increased fat and back development due to reduced activity levels (Wang et al., 2017)

Table 3: Effect of Housing System on Carcass Trait of Guinea Fowl Cockerel (16 weeks)

Parameters	Housing system			SEM	Pvalue
	Deep litter	Battery Cage	Deep litter with a run		
Live weight (g/bird)	1086.17	1109.00	1093.67	5.450	0.238
Bled weight (g/bird)	1019.50^{b}	1098.67^{a}	1018.67^{b}	14.497	0.004
Dressing percentage (%)	72.15^{b}	70.57^{c}	74.25^{a}	0.533	0.000
Retail cut parts (%)					
Drumsticks	13.13	13.14	13.12	0.186	0.930
Thighs	17.20	17.21	17.25	0.235	0.716
Wings	11.35^{a}	10.63^{b}	11.65^{a}	0.164	0.004
Breast	37.06	37.05	37.10	0.160	0.464
Back	16.91^{b}	17.56^{a}	16.69^{b}	0.148	0.110
Organs (%)					
Liver	1.57	1.66	1.59	0.019	0.145
Gizzard(empty)	2.24^{a}	2.21^{a}	2.03^{b}	0.370	0.010
Heart	0.54	0.54	0.57	0.01	0.455
Bone-meat proportion					
Total drumstick bone (g)	23.42^{ab}	24.45^{a}	22.21^{b}	0.352	0.004
% Drumstick bone	20.75	20.87	20.79	0.535	0.708
Total drumstick meat 2(g)	89.42^{b}	92.64^{a}	84.67^{c}	0.228	0.001
% Drumstick meat	79.25	79.13	79.21	0.053	0.078

$^{a, b, c}$ Means in the same row not sharing common superscripts are significantly different (p<0.05)

The gastrointestinal tract length result in Table 4 showed that the housing system significantly influenced the length of the oesophagus, duodenum, and caeca (p <0.05). Birds in the deep litter and deep litter with run systems had significantly longer oesophagus (15.33cm,15.00cm) than those in the battery cage system (12.33cm). The duodenum was longer in deep litter (14.17cm) and battery cage systems (14.67cm) than in deep litter with run (12.00 cm). Caeca were significantly longer in battery cage systems and deep litter with run systems than in deep litter. Differences in the crop, proventriculus, jejunum, ileum, and colon were not statistically significant, although the colon approached significance. The findings suggest that housing systems affect certain parts of the GI tract in guinea fowl cockerels, and this is in line with the study of Gillies & Siddiqi-Davies (2025), who reported that the longer oesophagus and caeca in birds from less restrictive or enriched systems could reflect differences in feeding behaviour and microbial activity. A longer duodenum in deep litter and battery cage may be attributed to differences in intestinal motility or nutrient processing. These differences highlight the importance of housing design in promoting optimal digestive development in guinea fowl.

Table 4: Effect of Housing System on the Gastrointestinal Tract Length (cm) of Guinea Fowl Cockerels (16 Weeks of Age)

Parameters (cm)	Housing Systems			SEM	P value
	Deep Litter	Battery Cage	Deep Litter with run		
Oesophagus	15.33^{a}	12.33^{b}	15.00^{a}	0.511	0.002
Crop	7.33	7.33	7.67	0.110	0.403
Proventriculus	7.00	9.00	9.33	0.468	0.620
Duodenum	14.17^{a}	14.67^{a}	12.00^{b}	0.457	0.008
Jejunum	30.67	32.00	31.67	1.748	0.961
Ileum	37.33	34.00	29.00	1.628	0.089
Colon	15.67	8.50	9.00	1.485	0.061
Caeca	8.00^{b}	13.33^{a}	13.00^{a}	1.003	0.018

^{a,b} Means in the same row not sharing common superscripts are significantly different (p<0.05)

The housing systems for raising cockerel guinea fowl in this study significantly influenced the chemical composition of the thigh meat. The highest dry matter (29.07%) content was found in birds raised in battery cages (BC); the reduced dry matter content of birds raised in deep litter systems (DL) and deep litter with run (DLR) may result from greater moisture levels. BC birds have better feed management and less physical activity in small quarters, and their crude protein (33.87%) content was higher in contrast with DLR birds, which had the lowest crude protein content, probably due to increased physical activity; DLR birds have (5.02%) a higher ether extract-representative fat content. The findings of this study align with previous research by Wegner et al. (2024), indicating that housing systems significantly influence the chemical composition of poultry meat. Specifically, the higher dry matter and crude protein content observed in guinea fowls raised in battery cages (BC) corroborate earlier studies which reported that restricted movement and controlled feeding conditions in cage systems contribute to increased protein deposition and reduced moisture levels in poultry meat (Englmaierová et al., 2021). Conversely, the lower crude protein and higher ether extract (fat) content in guinea fowls raised in deep litter with run (DLR) systems are consistent with findings by Fonseca et al. (2018), who noted that increased physical activity in more spacious and open systems may lead to more significant fat accumulation and reduced muscle protein due to higher energy expenditure.

Table 5: Effect of Housing System on the Chemical Composition of Cockerel Guinea Fowl Thigh Meat (%)

Parameters	Housing Systems			SEM	P value
	Deep litter	Battery cage	Deeplitter with run		
Dry matter (%)	28.87^{a}	29.07^{a}	26.27^{b}	0.453	0.000
Ash(%)	5.20^{b}	5.17^{b}	5.83^{a}	0.122	0.03
Crude protein (%)	32.63^{ab}	33.87^{a}	31.33^{b}	0.417	0.02
Ether extract (%)	3.75^{b}	3.75^{b}	5.02^{a}	0.220	0.000

^{a,b,c} Means in the same row not sharing common superscripts are significantly different ($p<0.05$)

CONCLUSION

Results obtained in this study established that deep litter with a run housing system promoted optimum performance characteristics and better carcass yield. These results also imply that additional factors like physical activity have influenced the post-hatch performance of guinea fowl keets and that the housing system may not be the only determinant of this performance. Further research is suggested to examine likely additional factors impacting how well guinea fowl keets perform in various housing systems.

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