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Effect of Stocking Density on the Performance, Carcass Yield and Meat Composition of Broiler Chickens

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Authors' contributions

This work was carried out in collaboration between all authors. Author GOA designed the study and wrote the protocol. Author OOF managed the analyses of the study, performed the statistical analysis and wrote the first draft of the manuscript. Author TIA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Broiler chickens require adequate feed intake and uninterrupted emission of heat for intensive growth. An eight-week feeding trial was conducted to investigate the effects of stocking density on performance, carcass yield and meat composition of broilers. A total of 240 one-day old Arbor acre broiler chicks were randomly allocated to three stocking densities: Lower stocking density (LSD) of 10 birds/m^2; Recommended stocking density (RSD) of 12 birds/m^2; and Higher stocking density (HSD) of 14 birds/m^2 respectively, with 4 replicates each having 20 birds per replicate. Feed and water were supplied *ad libitum*. Final live weight(FLW); Feed intake(FI); Feed conversion ratio(FCR); Mortality(%); Dressed weight(%); Prima cuts(%); Abdominal fat(%) and meat composition were assessed. Data were subjected to descriptive statistics and ANOVA ∞=0.05. Birds on HSD had numerically higher FLW (2262.80 g), better FCR (2.08) that was similar to that of LSD (2.07) and significantly lower mortality (0.00%). The values of the prime cuts (thigh, drumstick and breast), abdominal fat and meat protein were similar between birds on LSD and HSD. Up to stocking density 14birds/m^2 broiler chickens' performance and carcass characteristics were not negatively affected.

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Keywords: Broilers; stocking density; performance; carcass yield; meat composition.

1. INTRODUCTION

Poultry are kept in most areas of the world and they serve as a good source of an animal protein to most people throughout the world. Poultry is the second most widely eaten meat in the world, accounting for about 30% of meat production worldwide, after pork at 38% [1]. The poultry industry has played a significant role in man's civilization in many ways and has gone through phase of rapid development and commercialization. Eggs and meat of birds have been consumed since pre-historical times. Poultry comprises of chickens, turkeys, ducks, quails, pheasants, peafowl etc. whether dressed or alive which are reared for their economic benefit [2]. Broiler chickens are juvenile animals that may exhibit very high growth rates and feed efficiency [3]. The time required to reach 1.5 kg live weight was reduced from 120 days in1925 to 30days in 2005 [4]. The modern broiler house enables producers to have great control over the house environment. Birds can be placed at higher densities as long as the correct environment (temperature, ventilation, humidity) is provided. Factors to consider when determining stocking density include but are not limited to bird size, feeder space, drinker space, house dimensions, bird welfare, nutrition, breed, performance and economic return. Stocking density is currently expressed as a mass per unit of space rather than numbers of birds being reared in a given area [5]. Stocking density has critical implications for the broiler industry because higher returns can be obtained as the number of birds per unit space increases, but economic profit may come at the cost of reduced bird performance, health, and welfare if densities are excessive. In the broiler industry, the major concern is the effect of high stocking densities on the welfare of birds, especially during the final weeks of the growing period when body weight per unit area is high [6]. Higher mortality, lower meat production, greater incidence of leg disorders, and cannibalism occur at higher stocking densities in broilers. This expression of stocking density is calculated based on body mass (in kg or lb) per unit of housing space (in m^2 or ft^2). However, income per bird often decreases primarily due to reduction in growth rate, increased proportion of downgraded carcasses, and greater risk of health-related problems [7]. The objective of this study was to investigate the effect of stocking density on the performance, carcass yield and meat composition of broiler chickens raised in humid tropical environment.

2. MATERIALS AND METHODS

This experiment was conducted at Poultry Unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. Located in the humid forest zone of South West Nigeria. The mean temperature and relative humidity during this experiment were 27.77℃ and 74.34% respectively.

Two hundred and forty, one-day old Arbor acre chicks were individually weighed and randomly allocated into three stocking densities: Lower stocking density (LSD) of 10 birds/m^2; Recommended stocking density (RSD) of 12 birds/m^2; and Higher stocking density (HSD) of 14 birds/m^2 respectively, with four replicates each, having twenty birds per replicate.

2.1 Housing and Management of Birds

Birds were housed in an open sided house with 32 cm high dwarf wall, with the inside partitioned according to the stocking density with 0.05 m^2/bird provided for feeder and drinker in each partition. Two hanging feeders and two eight-litre water bowl of 30 cm diameter were provided for each partition from week three. The floor was covered with wood shaving litters, which was changed at week four and six. Vaccination and medications were administered as recommended by the hatchery operator. Starter diet with 3083 ME (kcal/kg) and 23.06% crude protein was supplied with water *ad libitum* for four weeks while finisher diet with 3217ME (kcal/kg) and crude protein was offered from week five to week eight. Records of feed intake and birds' weight were taken weekly, while mortality record was taken daily. Feed conversion ratio (FCR) was calculated by dividing the feed intake by weight gain.

2.2 Carcass Characteristics

At the end of week eight twenty four birds were randomly selected at the rate of two birds per replicate for carcass analysis. The selected birds were starved overnight and their live weight taken before sacrificing them. The birds were sacrificed by severing the jugular vein. Each of the carcasses was thoroughly bled, scalded,

defeathered, eviscerated and portioned according to the procedure of Jones [8].

2.3 Carcass Traits

The relative weight of dressed carcass, prima cuts, internal organs and abdominal fat expressed as percentages of live weight.

2.4 Meat Composition

Breast and thigh cuts were de-boned and de-skinned. Samples were weighed, oven dried at 70℃ for 72 hours, milled and stored for protein and fat analysis AOAC [9].

Feed offered were analysed for proximate composition according to the method described by AOAC, [9].

2.5 Statistical Analysis

Data generated were subjected to analysis of variance using general Linear Model [10]. Significantly different means were separated using Duncan Multiple Range test. All values were expressed as statistical means ±standard error of the mean (SEM).

3. RESULTS

3.1 Proximate Composition of the Diets

Proximate composition of the Starter and Finisher diets are presented in Table 2. The values obtained in the Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), Ash and Ether Extract (EE) for starter diet was higher than the values obtained for the finisher diet except Nitrogen Free Extract (NFE).

3.2 Performance Characteristics

The effect of stocking density on the performance of broiler chickens is shown in Table 3. Stocking density had no significant effect ($p<0.05$) on all the parameters observed but birds on HSD had the highest average daily weight gain (39.71 g) followed by LSD (39.67 g) and RSD (39.18 g) respectively. Similar trend was observed in the values for live weight (g).

Feed Conversion Ratio (FCR) observed in this study was not significantly influenced by the stocking density. Birds on LSD had the best FCR (2.07) while birds on RSD had the worst (2.14). No mortality was observed in stocking density 14 birds/m^2 but stocking density 10 birds/m^2 and 12 birds/m^2 have same value of 3.13%.

Table 1. Gross composition of starter and finisher diets fed to three different stocking densities

	Experimental diets	
	Starter (%)	Finisher (%)
Maize	49.00	58.50
Wheat offal	5.00	2.00
FFSB	8.65	15.40
GNC	25.00	15.00
Fish meal	4.00	0.00
Palm oil	3.00	3.81
Bone meal	3.00	3.00
Oyster shell	1.50	1.50
Salt	0.25	0.25
Broiler premix	0.25	0.25
DL-Methionine	0.10	0.11
L- Lysine	0.25	0.18
Total	100.00	100.00
Calculated analysis		
CP (%)	23.06	19.92
ME (kcal/kg)	3083.00	3217.00
L- Lysine (%)	1.20	1.04
DL- Methionine (%)	0.45	0.40

FFSB- Full fat soyabean, GNC-Groundnut cake, CP- Crude protein, ME- Metabolisable energy

Table 2. Proximate composition of starter and finisher diets fed to three different stocking densities

Parameters	Experimental diets	
	Starter (%)	Finisher (%)
DM (%)	92.14	91.07
CP (%)	25.03	21.88
CF (%)	4.00	1.00
ASH (%)	9.30	6.75
EE (%)	13.82	13.41
NFE (%)	49.82	59.12

DM- Dry matter, CP- Crude protein, CF- Crude fibre, EE- Ether extract, NFE- Nitrogen free extract

3.3 Carcass Yield

The effect of stocking density on the carcass parameters and relative internal organs of broiler chickens are presented in Table 4. The parameters observed were not significantly ($p>0.05$) influenced by stocking density except the Back, Drum stick, head and Abdominal fat. Birds on LSD and HSD had similar values in Back, Drum stick, and head. The abdominal fat was significantly ($p<0.05$) lower for birds on stocking density 14 birds/m^2 (HSD) (3.14%), while birds on LSD and RSD had similar values. Internal organs observed in this study were not significantly ($p>0.05$) influence by the stocking density.

3.4 Meat Composition

The effect of stocking density on meat composition is shown on Table 5: In all the meat composition parameters observed in this study, only meat crude protein (CP), was significantly influenced by stocking density. Birds on HSD had higher meat protein (22.34%) that was similar to that of LSD (20.86%).

4. DISCUSSION

Stocking density did not seem to influence significantly the performance of broiler chickens in this study. The insignificancy of total feed intake (TFI) among the stocking densities agrees with the observations of [11,12] and must have been due to the sumptuous feeding space provided for each bird in all the stocking densities. Insufficient feeding space had

Table 3. Effect of stocking density on performance, Feed Conversion Ratio (FCR) and mortality of broiler chickens

Parameters	Treatments			SEM
	10 birds/m^2	12 birds/m^2	14 birds/m^2	
Initial weight (g)	39.00	38.75	38.75	0.11
Final weight (g)	2260.70	2232.80	2262.80	40.97
Total weight gain (g)	2221.70	2221.70	2224.00	40.99
ADWG (g/day)	39.67	39.18	39.71	0.73
Total feed intake (g)	4581.30	4681.60	4616.30	66.73
ADFI (g/day)	81.81	83.60	82.43	1.19
FCR	2.07	2.14	2.08	0.04
Mortality	3.13	3.13	0.00	1.40

SEM means standard error of mean. ADWG (Average daily weight gain); ADFI (Average daily feed intake), FCR (Feed conversion ratio)

Table 4. Effect of stocking density on carcass yield and relative internal organs

Parameters	Treatments			SEM
	10 birds/m^2	12 birds/m^2	14 birds/m^2	
Carcass yield				
Live weight (g)	2125.00	2025.00	2200.00	64.94
Dressed (%)	73.68	71.13	78.53	2.15
Neck (%)	5.14	4.98	4.85	0.16
Breast (%)	19.98	20.38	21.47	0.78
Thigh (%)	11.23	11.06	12.29	0.35
Wing (%)	7.71	9.36	8.67	0.33
Back (%)	17.09^a	7.71^b	17.29^a	4.97
Drum stick (%)	10.03^a	2.11^b	11.10^a	1.25
Head (%)	2.37^a	1.90^b	2.27^a	0.08
Shank (%)	3.89	3.60	3.64	0.14
Abdominal fat	2.58^b	14.75^a	3.14^b	1.74
Internal organ				
Heart (%)	0.57	0.38	0.59	0.05
Gizzard (%)	1.69	1.69	1.54	0.15
Liver (%)	1.66	1.53	1.84	0.13

^{a,b} means in the same row having different superscript are significantly different ($p<0.05$)
SEM means standard error of mean

Table 5. Effects of stocking density on meat composition (Moisture content, crude protein and fat)

Parameters	Treatments			SEM
	10 birds/m^2	12 birds/m^2	14 birds/m^2	
Meat composition (%)				
Moisture	74.54	75.16	74.21	0.27
Crude protein	20.86^{ab}	18.32^b	22.34^a	0.75
Fat	4.48	3.69	5.12	0.40

^{a,b} means in the same row having different superscript are significantly different ($p<0.05$)
SEM means standard error of mean

been attributed to be the cause of reduced feed intake at high stocking density [7,13]. The observed non-significant difference in final live weight (FLW) and weight gain (Wg) among the three stocking densities must be a consequence of the insignificant feed intake. The result was in agreement with the result of [14], who observed no differences in the FLW of birds as stocking density increased from 11 to 15 birds/m^2 and those of [6,14] who observed no significant difference in the final weight and daily gain of broiler chickens raised on 16, 20 and 24 birds/m^2 and on 12.75-16.84 birds/m^2 respectively. However, our findings are not in line with some previous evaluations involving stocking density ranges of 10 to 20 birds/m^2 that showed a trend of linear decrease in individual body weight and feed intake with increasing population density [15-18]. Feed conversion ratio (FCR) is a function of feed intake and weight gain and since both parameters were not significantly different, hence the non-significantly difference of the dependent variable (FCR) among the stocking densities. However, the result agrees with the conclusion of [19], that stocking density did not affect feed conversion ratio. However, [6] reported that increasing stocking density of broiler adversely affected FCR. Mortality is considered as the end point of welfare, therefore the final indicator of stress [20]. High stocking density has been reported to increase incidence of diseases and death [21,16]. The observed lower mortality at the HSD in this study is a consequence of good husbandry and health management. In a similar manner, several studies have observed that the effect of stocking density on mortality was not significant [22,23].

Rearing of broiler chickens in lower stocking density tends to provide more intensive growth and higher absolute yield of processed carcass, better body development and higher shares of carcass parts which contain more meat especially breast [24]. The independence of carcass yield, and breast muscle might not be unconnected with the observed insignificancy of final live weight and feed intake among the stocking densities.

Additionally, birds on the LSD must have spent much of the energy on excessive exercise while the restricted movement in HSD would enable them to utilise the derived nutrient to lay down muscle. The similar percentage dressed weight and abdominal fat agreed with the observation of [15,17] that there was no significant influence of stocking density on carcass and abdominal fat yield relative to body weight of Ross x Cobb broilers raised for 50 days on stocking densities 9,10,12 and 14 birds/m^2 and that of male Ross broilers raised at 10, 14 and 18 birds/m^2 respectively. The insignificant of breast muscle yield among the stocking densities agrees with the conclusion of [18,25,26], who concluded that stocking density had no effect on breast meat yield but in contrary other researchers like [27] stated that increasing stocking density decreased breast fillet yield.

The non-significant effect of stocking density on hind limbs (thighs and drum sticks) agreed with the submission of [21,18] that better development of hind limbs expressed through value of thigh girth doesn't follow adequately the increase of body mass, so the share of thighs and drumsticks did not increase significantly.

Differences were not observed among the relative internal organ weight of broiler chickens which is in agreement with [28,20] who reported that there were no differences in the relative organ weights of the broilers. However, [29,30] reported that giblets weights were influenced by housing density.

There were no differences in meat composition parameters observed except the crude protein, which was also similar between LSD and HSD which confirm the claim of [4], that the most important factor influencing carcass composition is the potential genetics of the animal.

5. CONCLUSION

The results of this study indicated that, providing adequate ventilation, feeding and watering spaces broiler chickens could be raised at stocking density of 14birds/m^2 at an average ambient temperature and relative humidity of 27.79° and 70.82% without negative effect on growth performance and carcass characteristics. This indicates that, up to stocking density 14 birds/m2, stocking density did not pose physiological and welfare challenges as indexed by the non-significant difference in blood serum glucose and cholesterol in addition to insignificant effect of stocking density 10, 12 and 14 birds/m^2 on Heterophil: Lymphocyte (H:L) ratio and gait score observed by [22] while studying the effect of stocking density on the welfare, haematology and serum biochemical indices of broiler chickens on this same experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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