Nig. J. Anim. Prod. 2021, 48(6):391 -
Nigerian Journal of Animal Production

Influence of breed, sex and their interaction on liveweight, dressed weight and dressing percentage of broiler chicken

[2]Kareem-Ibrahim, K. O., [1,2]Abanikannda, O. T. F., [1]Nwadialo, S. and [1]Ayinde, H. T.
[1]*Department of Zoology and Environmental Biology, Lagos State University, Ojo*
[2]*Department of Animal Science, School of Agriculture, Lagos State University, Epe*
Corresponding author: otfabanikannda@hotmail.com; +234 802 312 8376

Abstract

Broiler birds bred specifically for meat production due to their fast growth rate and carcass conformation. Some factors comprising genetic and non-genetic components have been identified to influence their growth rate and ultimately final weight at slaughter. This study was carried out to investigate the effect of breed, sex and their interaction on liveweight at slaughter, dressed weight and dressing percentage in four different breeds of broilers. The experimental birds were randomly selected from an initial population of 304 birds comprised 76 birds each of Arbor Acre, Cobb, Marshall and Ross, raised from day old to ten weeks. In all, a total of 105 birds were selected, weighed, slaughtered and eviscerated. Measurements of their liveweight and warm dressed weight were taken and recorded, while dressing percentage was computed for each bird. Breed, sex and interaction of breed x sex were significant (P<0.05) for all parameters studied except for sex effect on dressing percentage which was not significant (P>0.05). The Cobb breed outperformed other breeds in liveweight and dressed weight, while Arbor Acre had highest values for dressing percentage, and Marshall had the least values across all parameters studied. Correlation amongst variables studied varied between low, moderate and high, with the relationship between liveweight and dressing weight consistently highest and was statistically highly significant (P<0.001) between and within breeds. The coefficient of determination of the model were all very high and the regressions were highly significant throughout the entire study. The study revealed disparate performances in the breeds of temperate and tropical origins, and also provided predictive potentials for the dressed weight of birds using their liveweight.

Keywords: Broiler, breed, sex, liveweight, dressed weight, dressing percentage

Influence de la race, du sexe et de leur interaction sur le poids vivant, le poids dressage et le pourcentage de parties utilisables de poulet

Résumé

Les oiseaux de poulets à griller ont considérablement augmenté pour la production de viande en raison de leur taux de croissance rapide et de leur coefficient de carcasse. Certains facteurs comprenant des composantes génétiques et non génétiques ont été identifiés de manière à ce que leur taux de croissance soit définitivement définitif lors de l'abattage. Cette étude a été réalisée sur l'effet de la race, du sexe et de leur interaction sur le poids vivant à l'abattage, du poids dressage et du pourcentage de parties utilisables dans quatre races différentes de poulet à griller. Les oiseaux expérimentaux ont été sélectionnés au hasard à partir d'une initiale de 304 oiseaux comprenant 76 oiseaux chacun de l'Acre d'Arbor, Cobb, Marshall et Ross, élevés de jour à dix semaines. Au total, un total de 105 oiseaux ont été sélectionnés, pesés, abattus et éviscétaires. Les mesures de leur poids vivant et de leur poids chaud ont été prises et enregistrées, tandis que le pourcentage de dressage était calculé pour chaque oiseau. La race, le sexe et l'interaction de la race x sexe étaient significatives (p <0,05) pour tous les paramètres étudiés à l'exception de l'effet sexuel sur le pourcentage de dressage qui n'était pas significatif (p> 0,05). La race Cobb a surperformé d'autres races de *poids vivant et de poids dressage, tandis que l'Acre Arbor avait des valeurs les plus élevées pour le pourcentage de dossier et Marshall avait les moins valables sur tous les paramètres étudiés. La corrélation entre variables étudiées variées entre bas, modérée et élevée, avec la relation entre poids lourd et poids de pansement de manière toujours la plus élevée et statistiquement très significative (p <0,001) entre et dans les races. Le coefficient de détermination du modèle était très élevé et les régressions étaient très importantes dans toute l'étude. L'étude a révélé des performances disparates dans les races d'origines tempérées et tropicales, ainsi que des potentiels prédictifs pour le poids dressage des oiseaux utilisant leur poids vivant.*

Mots-clés: griller, race, sexe, poids vivant, poids habillé, pourcentage de parties utilisables

Introduction

Chicken meat and eggs are the major protein source for consumers in most countries around the world, and its consumption has been on the increase in last few years due to rise in health awareness of consumers.Broiler chickenhas distinguished itself as an important source of animal-based protein in many countriesdue to its unique performance trait, yielding high production of meat over a short period of time (Elahi *et al.,* 2020; Chia *et al*., 2019; Saadu *et al*., 2018; Riber *et al*., 2018; Sleman *et al*., 2015). Broilers are bred and raised specifically for meat production and along with weight gain broilers have a significant carcass conformation, particularly breast muscle development. Different authors have reported that chicken growth performance is mainly determined by sex, genotype and weight at slaughter (López*et al.,*2011). The demand for poultry meat and products has increased appreciably in recent times due to health concerns arising from red meat consumption, also there are no known religious taboos against its production and consumption, and the success of poultry production, especially broiler chickens has been attributed to the improvements in growth performance and carcass yields and composition (Farrell, 2013). Genetic selection in broiler production have led to rapid growth rates and increased meat yield in broilers and thus, dramatically decreasing slaughter age and the amount of feed and energy required to raise these birds to market weight (Tallentire *et al*., 2016). This improvement impactedincreased growth rates by over 400% between 1957 and 2005, with about 85–90% of this increase being attributed to genetic selection while the remainder was attributed to diet and nutrition (Zuidhof *et al*., 2014). Since broilers are kept primarily for their meat, and the emerging global impact of the disruptions in economic and agricultural activities due to the scourge of COVID-19 pandemic cannot be overemphasized (Lusk and Chandra, 2021), there is urgent need to investigate those factors that can result in better meat-for-weight in broiler production by examining the influence of breed or strain, sex and their interactions on the live weight, dressed weight and dressing percentage of broilers, which this study aims to achieve. Consequently, the objective of this study is to evaluate these various parameters and also assess the relationships between liveweight, dressed weight and dressing percentage of four strains of broilers.

Materials and methods

Study site

The experiment was conducted at the Broiler rearing unit of the poultry farm at the Lagos State University, Ojo-Lagos located located at latitude 6° 27' 59.99" N and longitude 3° 10' 60.00" E within the humid tropics, with prevailing weather conditions typical of warm wet climates.

Experimental units

Four strains of day-old chick broiler birds comprising Arbor Acre, Cobb, Marshall and Ross were obtained from a reputable commercial hatchery located in Ibadan, Oyo State, and transported to the farm same day. Each of the strain is composed of 76 birds all totaling 304. All birds were properly labelled with an ID and each label is composed of alphanumeric identification indicating strain of bird and its serial number within the strain. The birds were reared for a ten-week period and a random sample of 105 birds consisting of Arbor Acre (19), Cobb (14), Marshall (46) and Ross (26) were weighed and slaughtered. The birds were tagged and weighed at the commencement of the experiment and their final weight (liveweight) was recorded at the tenth week of rearing. The warm weight of the dressed chicken was taken after slaughter / evisceration and the dressing percentage, which is the quotient of the dressed weight relative to the liveweight of the birds was computed and recorded against their identification tag.

Management practices

The birds were reared under stringent management practices including provision of feed and water *ad lib* and maintenance of recommended medication and vaccination schedule. The birds were reared on deep litter from brooding to slaughter.The litter are consistently changed at two weeks interval to prevent microbial build-up, thus reducing the risk of infections. All medications and vaccination were duly adhered to and sick birds were isolated from the flock.

Experimental design

The birds were all reared in a four-replicate plot, each comprising 19 birds for each strain and totaling 76 across each of the four replicates. The experiment was a simple completely randomized design where the only factors of interest were just the breed/strain and sex of the birds on the three parameters (Liveweight, Dressed Weight and Dressing Percentage) studied. The birds were kept under similar rearing conditions in the four replicates and maintained under strict similar conditions throughout the period of study.

Data collection and handling

All weights (Liveweight and Dressed Weight) were taken using a professional digital scale sensitive to 0.00g and recorded against the bird's ID. The liveweight was the weight of the bird at the tenth week just before slaughter and the dressed weight was taken immediately after defeathering and evisceration of the birds, when it was still warm. The dressing percentagewas computed using the formula

$$DP\,(\%) = \frac{W_D}{W_L} x\ 100$$

where DP is Dressing Percentage, W_L is liveweight and W_D is warm dressed weight.

Statistical analyses

Basic descriptive statistical analysis was done to look at the consistency of the data by using an exploratory statistical technique in order to identify values that may be considered as outliers, and such values were eliminated from the final analyses in this study. Consequently, a total of 105 broiler birds across the four strains were finally included in the statistical analysis.

All statistical procedures including descriptive, correlation, regression and general linear model of analysis of variance were done using Minitab® 17StatisticalSoftware. A further post-hoc test for multiple comparison of means was done using the Tukey's procedure.

The statistical model describing the parameters (liveweight, dressed weight and dressing percentage) for all variables (breed, sex and their interaction) studied is given as;

$$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}.$$

Where Y_{ijk} is the

observed value of parameter on a particular fish
μ = the overall mean
a_i = the i^{th} effect of breed (i = 4, Arbor Acre, Cobb, Marshall, Ross)
b_j is the j^{th} effect of sex (j = 2, Male, Female)
$(ab)_{ij}$ is the interaction effect of breed x sex, and
e_{ijk} is residual random error
Regressions were also estimated for dressing percentage using the regression equation for between and within breed as; $Y = a + b_0L + b_1D$, where Y is the predicted dressing percentage, a is the intercept, b_0 and b_1 are the respective coefficients for liveweight (L) and dressed weight (D).

Results and discussion

Liveweight

The overall mean liveweight of the broiler birds was 2139.10g with a minimum value of 1287.0g and maximum recorded value of 3209.0g. The Cobb breed had the highest mean value of 2312g, while the Marshall breed had the least liveweight of 1969.70g (Table 1). Breed exerted highly significant (P<0.001) influence on liveweight (Table 2), and the statistical model explained almost 40% of the total variation observed in liveweight. The breed difference in liveweight was only pronounced in the Marshall breed, which had highly significant (P<0.001) liveweight value compared to the other three breeds (Arbor Acre, Cobb and Ross) that were not significantly (P>0.05) different from one

Table 1: Mean ± standard error of liveweight, dressed weight and dressing percentage by breed and sex within breed

Breed	N	Liveweight (g) Mean ± S.E.	Dressed weight (g) Mean ± S.E.	Dressing Percentage (%) Mean ± S.E.
Arbor Acre	19	2235.10 ± 87.2	1798.50 ± 83.4	80.15 ± 1.22
Female	17	2290.90 ± 83.1	1846.80 ± 81.8	80.35 ± 1.35
Male	2	1761.00 ± 331.0	1389.00 ± 301.0	78.41 ± 2.33
Cobb	14	2312.00 ± 126.0	1853.00 ± 106.0	80.12 ± 1.57
Female	9	2547.00 ± 119.0	2068.70 ± 93.1	81.50 ± 2.27
Male	5	1890.00 ± 154.0	1464.0 ± 109.0	77.63 ± 1.17
Marshall	46	1969.70 ± 41.3	1445.80 ± 32.6	73.39 ± 0.61
Female	22	1837.60 ± 45.2	1315.90 ± 35.0	71.59 ± 0.63
Male	24	2090.70 ± 58.0	1565.00 ± 40.9	75.04 ± 0.91
Ross	26	2275.40 ± 46.4	1744.70 ± 45.4	76.52 ± 0.72
Female	20	2245.40 ± 52.8	1719.50 ± 53.0	76.36 ± 0.75
Male	6	2375.20 ± 92.8	1828.80 ± 85.1	77.03 ± 1.98
Overall	105	2139.10 ± 34.3	1637.9 ± 31.9	76.28 ± 0.52

Table 2: General linear model analysis of variance of factors affecting liveweight (g), dressed weight (g) and dressing percentage (%)

Source	df	Liveweight Mean Squares	Dressed weight Mean Squares	Dressing Percentage Mean Squares
Breed	3	620609^{***}	682303^{***}	188.72^{***}
Sex	1	549921^{**}	422514^{**}	2.41^{ns}
Breed x Sex	3	896644^{***}	766917^{***}	53.11^{*}
Error	47	79503	58099	19.33
Eta Squared				

^{ns} = P>0.05 * = P<0.05 ** = P<0.01 *** = P<0.001

The major reason that can be adduced to this was because the other three breeds from the temperate regions evolved from the same highly developed foundation stock with similar genetic base, whereas the Marshall breed, was developed in India specifically for the tropical region. The growth performance of the Marshall breed is not as superior as other breeds. Influence of breed on weight gain of broiler birds has severally been reported in literature and this study corroborate the reports of most of these earlier researchers (Al-Marzooqi *et al*., 2019; Benyi *et al*., 2015; López *et al.,* 2011; Abdullah *et al*., 2010 and Ojedapo *et al.,* 2008). Sex effect was significant (P<0.01) source of variation on liveweight (Table 2), with the female birds reporting marginally higher albeit statistically significant values compared to male (Table 1). This unusual observation may be due to the disproportionate sample size as a result that male birds accounted for only 35% of the total bird population. This disproportionate subclass size with its attendant higher standard errors for male birds may confound the computation of sex effect on liveweight and as such, lead to this unusual observation. Although, this observation of significant sex effect on liveweight was largely reported in literature (Ikusika *et al*., 2020; Uhlíová *et al*., 2018; Fernandes *et al*., 2013 and Rondelli *et al*., 2003) but it is noteworthy that most previous researches indicated superiority of male birds over the female, which is contrary to what was observed in this current study. The female birds in the entire study were 9.90% heavier than male across all breeds but were 30.04% and 34.76% heavier than male birds in the Arbor Acre and Cobb breeds respectively, while the male birds were 13.77% and 5.78% heavier than female birds in the Marshall and Ross breeds. Breed x Sex interaction was highly significant (P<0.0001) on liveweight of broiler birds (Table 2), and in fact exhibited greater influence on liveweight than the fixed factors studied. The intra breed differences in liveweight as presented in Table 1, where female birds within the Cobb breed were significantly (P<0.05) heavier than their male counterparts. This observation is in consonance with earlier reports (Uhlíová *et al*., 2018 and Olawumi *et al.*, 2012).

Dressed weight

Overall mean dressed weight across the four breeds was 1637.9g representing 76.57% of the overall mean liveweight recorded on all the breeds (Table 1). Effect of breed on dressed weight followed similar trend as was reported on liveweight, whereby it was highly significant (P<0.001). Aside from the Marshall breed that had the least dressed weight, other breeds were not significantly different from one another. The statistical model used in this analysis was more fitted than for other analyses, where it explained 49.15% of the total variation observed in dressed weight (Table 2). The Cobb breed had the highest values, while the Marshall breed recorded the lowest values (Table 1). This observation is in agreement with reports of some previous researchers (Akporhuarho and Unukevwere, 2015; Fernandes *et al*., 2013 and Olawumi and Fagbuaro, 2011) who all reported influence of breed on dressed weight of broilers. Sex of birds was a significant (P<0.01) source of variation on dressed weight of broiler birds (Table 2). The female birds had significantly (P<0.05) higher dressed weight than male birds, with the female weighing 11.27% than the male. Despite this overall superiority of female birds over the male birds, it is noteworthy that intra-breed differences occur within the breeds. This was displayed in the significantly superior dressed weight of the female Cobb breed over its male counterpart, with 41.28% superiority. However, the male Marshall breed had significantly heavier dressed weight that its female counterpart, accounting for 18.93% superiority over the female birds. Although this study also confirmed earlier reports of significant difference in dressed and weight of broilers due to sex (Uhlíová *et al*., 2018; Fernandes *et al*., 2013 and Olawumi *et al*., 2012), but the skewed sex ratio of 37:68 in male to female in this study may mask the true direction of superiority, accounting for the unusual direction of female birds superiority over male in dressed weight. Breed x Sex interaction accounted for the largest source of variation in dressed weight and the model explained 49.15% of total variation observed in dressed weight (Table 2). This intra breed sex difference was significantly manifested in both the Cobb and Marshall breeds but not significantly exhibited in the Arbor Acre and Ross. This observation is in consonance with earlier research investigating the interaction of genotype by sex (Uhlíová *et al*., 2018 and Olawumi *et al*, 2012).

Dressing percentage

The overall mean dressing percentage across all breeds was 76.28% (Table 1).

Breed of birds highly significantly (P<0.001) impacted dressing percentage (Table 2), where the Arbor Acre had the highest values, while Marshall breed had the least dressing percentage. The reason that can be adduced to this observation may be due to the differences in genotype of the broiler birds studied, which can broadly be stratified into two groups comprising the temperate and tropical breeds (Table 1). This explains the similarities in the higher values obtained amongst the temperate breeds, whereas the Marshall that is a tropical breed recorded the least dressing percentage.This observation is in consonance with earlier reports on the effect of breed or strain on carcass yield and dressing percentage of different breeds of broiler birds (Ikusika *et al*., 2020; Udeh *et al*., 2015; Thutwa *et al*., 2012 and Nargish *et al*., 2010). Sex of birds was not a significant (P>0.05) source of variation on dressing percentage (Table 2). This observation may arise as a consequence of the imbalance in sex ratio across the study, which hiked the within group difference that ultimately absorbed the between group differences. Most earlier workers reported significant effect of sex on carcass traits and dressing percentage (Uhlíová *et al*., 2018; Shim *et al*., 2012; Olawumi *et al.*, 2012 and Abdullah *et al*., 2010). Breed x Sex interaction was significant (P<0.05) on dressing percentage (Table 2). This implies that despite the non-significance of sex on dressing percentage, the within breed sex differences was significant (P<0.05). This observation confirms previous researches (Ikusika *et al*., 2020;Uhlíová *et al*., 2018; Fernandes *et al*., 2013; Shim *et al*., 2012; Olawumi *et al*., 2012 and Rondelli *et al*., 2003).

Relationship between liveweight, dressed weight and dressing percentage

Relationship amongst the three pairs studied is presented in the scatterplot matrix in Figure 1. Between breed and within breed correlation coefficient amongst the three variables and four breeds studied are presented in Table 3. The interbreed correlation coefficient for the three pairs were all highly significant (P<0.01). The highest coefficient was recorded in the pair of liveweight vs dressed weight, while the lowest was recorded between liveweight and dressing percentage, and the relationship between dressed weight and dressing percentage was moderate.

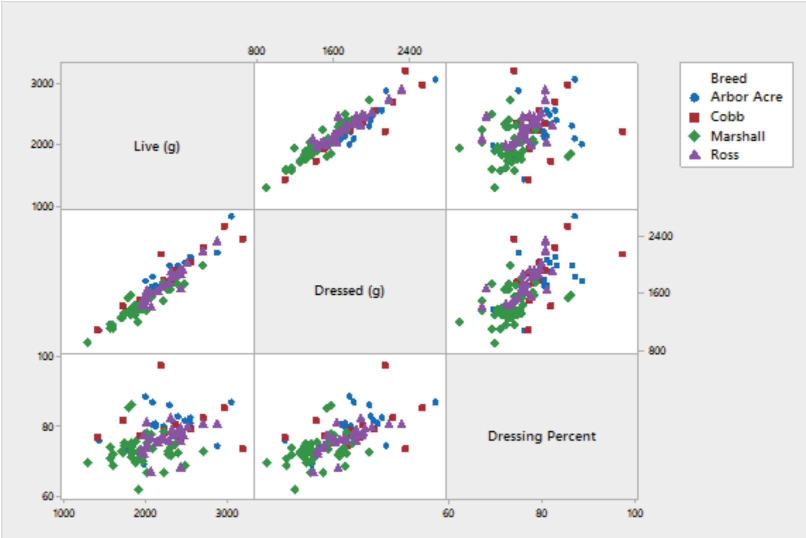

Figure 1: Matrix plot of liveweight, dressed weight and dressing percentage by breed

Table 3: Correlation matrix of liveweight, dressed weight and dressing percentage by breed

	Liveweight (g)	Dressed Weight (g)
Overall		
Dressed Weight (g)	0.942^{***}	
Dressing Percentage (%)	0.334^{***}	0.627^{**}
Arbor Acre		
Dressed Weight (g)	0.954^{***}	
Dressing Percentage (%)	0.376^{ns}	0.631^{**}
Cobb		
Dressed Weight (g)	0.937^{***}	
Dressing Percentage (%)	0.010^{ns}	0.355^{ns}
Marshall		
Dressed Weight (g)	0.931^{***}	
Dressing Percentage (%)	0.031^{ns}	0.392^{ns}
Ross		
Dressed Weight (g)	0.948^{***}	
Dressing Percentage (%)	0.439^{*}	0.701^{***}

^{ns} = P>0.05 * = P<0.05 ** = P<0.01 *** = P<0.001

Aside for Ross breed that had all three pairs statistically significant (P<0.05), within breed correlation coefficient was different in the other three breeds (Table 3). The pair of liveweight vs dressing percentage was not significant (P>0.05) for Arbor Acre, Cobb and Marshall, while the pair of dressing weight and dressing percentage was also not significant (P>0.05) in the Cobb breed.

Regression coefficients along with coefficient of determination are presented in Table 4. The model of best fit (99.07%) was recorded in the Ross breed while Arbor Acre had the least (97.12%). This implies that regression of dressing percentage on liveweight and dressed weight almost accounted for all the variation in regression values. It is equally noteworthy that the regression analysis of variance for all four breeds were all highly significant (P<0.001).

Table 4: Regression coefficients of dressing percentage on liveweight and dressed weight by breed

Breed	Intercept (a)	Liveweight coefficient (b_0)	Dressed weight coefficient (b_1)	Coefficient of determination (r^2)
Overall	76.12	- 0.035	0.045	97.64
Arbor Acre	79.15	- 0.035	0.045	97.12
Cobb	78.51	- 0.033	0.042	97.92
Marshall	72.53	- 0.037	0.051	98.96
Ross	77.34	- 0.034	0.044	99.07

Conclusions and recommendations

Breed was a significant source of variation on liveweight, dressed weight and dressing percentage. The Arbor Acre, Cobb and Ross breeds consistently outperformed the Marshall breed on all three parameters studied. Sex was significant on liveweight and dressed weight but did not significantly affect dressing percentage. On the average, female birds in the study recorded significantly higher values for both liveweight and dressed weight. However, the male in the Marshall and Ross breeds outperformed the females. Interaction of breed and sex was significant on all parameters studied albeit at varying levels of significance. Correlation coefficients for liveweight and dressed weight was highest all through the breeds and the correlation was significant for all parameters in the entire study and within the Ross breed. Correlation of liveweight and dressing percentage was not significant in the Arbor Acre, Cobb and Marshall breeds. Regressions of dressing percentage on liveweight and dressed weight were all statistically significant and the coefficient of determination was very high across all breeds. Consequently, the following recommendations are made based on the outcome of this study; The rearing of Arbor Acre and Cobb breeds should be encouraged in commercial broiler production due to their relatively higher dressing percentage, resulting in more meat and less offal thereby culminating in higher profit. The very high relationship between liveweight and dressed weight is a good indicator of the potential of the bird for higher dressing percentage and thus can be used as predictors for future performance of the birds.

Acknowledgment

The authors gratefully appreciate Mr. and Mrs. Ayinde for funding this research, and research assistants involved with the feeding and slaughter of the birds.

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Received: 1st September, 2021
Accepted: 10th January, 2021