

Effects of Strain and Non-genetic Factors on the Egg Qualities and Carcass Characteristics of Indigenous Guinea Fowl (*Numida meleagris*)

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To cite this article:

Zagbede Godson Aryee, Annor Serekye Yaw, Duodu Addison, Arhin Eric. Effects of Strain and Non-genetic Factors on the Egg Qualities and Carcass Characteristics of Indigenous Guinea Fowl (*Numida meleagris*). *International Journal of Applied Agricultural Sciences*.

Vol. 5, No. 2, 2019, pp. 39-44. doi: 10.11648/j.ijaas.20190502.12

Received: January 6, 2019; Accepted: February 11, 2019; Published: May 8, 2019

Abstract: The objective of this study was to investigate the effects of strain and non-genetic factors on egg qualities and carcass characteristics of indigenous Guinea fowl. The study was carried out at the Poultry Section of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti, Ghana, from 2014 to 2016. Four strains of local Guinea fowls; namely Pearl, Lavender, White and Black were used. Three non-genetic factors were considered; season of hatch, generation and sex of bird. Data were collected on 603 local Guinea fowls for the study. Data were analysed using the General Linear Procedure (GLM) of SAS. Results obtained showed that egg weight was significantly ($p < 0.05$) affected by generation. Parental generation had higher value (37.9 ± 3.98) than the first filial generation (37.64 ± 0.93); however, strain and season had no significant ($p > 0.05$) effect on egg weight and hatch weight. Generation had significant ($p < 0.05$) effect on yolk weight. Parental and first filial generations had 13.7 ± 0.24 and 13.2 ± 0.21 yolk weights respectively. Haugh unit was significantly influenced by strain; white had highest (79.04 ± 2.49) Haugh unit, followed by lavender (77.67 ± 2.03), black (76.51 ± 2.49) and pearl (71.14 ± 1.2). Generation had significant ($p < 0.05$) influence on live and dressing weights. Sex had no significant ($p > 0.05$) effect on head, neck and shank weights. The interaction of sex and Strain had significant ($p < 0.05$) influence on live, heart and intestine weights. Generation had no significant ($p < 0.05$) effect on carcass characteristics. Strain had significantly ($p < 0.05$) influence on moisture and carbohydrate. In conclusion, the strains and non-genetics factors (sex, season and generation) influence the egg and carcass qualities of indigenous Guinea fowl, hence the effects of these factors must be considered in genetic selection of indigenous Guinea fowls.

Keywords: Strain, Non-Genetic Factors, Haugh Unit, First Filial Generation

1. Introduction

Guinea fowl production has the potential of becoming an integral part of the Ghanaian local poultry industry, especially in the three (3) northern regions of the country. This is because Guinea fowl is locally accepted as a food product and consumption of its meat and eggs are not restricted by any religious taboos [1]. Embury [2] reported that Guinea fowl production has already been proven to be profitable in many European countries like Canada, France and Italy. This is as a result of successful genetic selection for economically important traits which has brought considerable

progress in growth rate, body conformation and composition and laying performance of Guinea fowl strains in these regions. Though, there is a ready market for Guinea fowl and its products in Africa [3], studies that aim at improving Guinea fowl are very few in the region.

Moreover, little scientific research has been carried out on local Guinea fowls to estimate average values of traits and effects of genetic and environmental factors on these traits. It is therefore necessary to understand the genetic behaviour of these traits and their relationship to other production traits that are used as selection criteria in animal breeding programs [4]. Improved local poultry production is necessary

to achieve a poultry industry that is both economically viable and self-sustaining.

Large-scale commercial Guinea fowl production in Ghana has not been possible due to lack of genetically improved source of good quality day old keets to be distributed to the farmers [5]. Also it has been reported that the small body size of the local Guinea fowl as compared to the bigger body size of the European breeds is a great setback to commercialization of Guinea fowl production in Ghana [6]. To effectively utilize existing local poultry resources such as the indigenous Guinea fowl to improve poultry production, there is the need to understand the effect of strain and environmental factors on egg and carcass characteristics of these poultry birds. The present study was therefore conducted to evaluate the effect of strain and non-genetic factors on egg qualities and carcass characteristics of indigenous Guinea fowl.

2. Materials and Methods

2.1. Location and Time of Study

The study was carried out at the Poultry Section of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana, from 2014 to 2016. Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana. The climatic, vegetation and demographic characteristics of Mampong-Ashanti have been described [7]. Essentially, Mampong-Ashanti lies between latitude 07° 04' north and longitude 01° 24' west with an altitude of 457m above sea level. Maximum and minimum annual temperatures recorded during the study period were 30.6°C and 21.2°C, respectively [8]. Rainfall in the district is bimodal, occurring from April to July (major rainy season) and again August to November (minor rainy season), with about 1224mm per annum. The dry season occurs from December to March. The vegetation is transitional savanna woodland, which guarantee proper poultry keeping.

2.2. Sources of Feed Ingredients and Experimental Birds

The feed ingredients used in the experiment that is maize, tuna fish, soya bean, wheat bran, premix and salt were bought from commercial feed supplier, Agricare Ghana Limited, Kumasi and formulated in the feed unit of the animal science farm for optimum growth and performance in Guinea fowl breeders.

The experimental birds (Guinea keets) at day-old were obtained from Akate Farms at Kumasi.

2.3. Experimental Birds and Design

Data were collected on 603 local Guinea fowls to estimate average values of traits. Four strains of local Guinea fowls: namely Pearl, Lavender, White and Black were used. Three non-genetic factors were considered: season of hatch (Major rainy season and Minor rainy season), generation of bird

(parental generation and First filial generation) and sex (Male and Female) of bird. Completely Randomized Design was used in the study.

Table 1. Composition of feed used in the experiment.

Ingredients	Stage of Bird		
	Starter (kg)	Grower(kg)	Breeder(kg)
Maize	57.5	58	53
Wheat bran	11	21	20
Soya bean meal	8.5	5	8
Tuna	11	6	7
Russia fish	9	7	3
Oyster shells	1.5	1.5	7.5
Calcium	0.5	0.5	0.5
Vitamin Premix	0.5	0.5	0.5
Salt	0.5	0.5	0.5
TOTAL	100	100	100

Source: [6].

2.4. Management of Experimental Birds

2.4.1. Egg Collection and Incubation

A total of 1176 eggs were obtained from Mampong College of Agriculture Guinea Fowl Unit. Eggs were collected, as recommended [9], in the morning in containers which were cushioned to avoid breaking or shaking. Cracked and dirty eggs were discarded during egg collection. Each egg was identified individually with a marker before incubation and thereafter weighed using an electronic weighing scale. Eggs were incubated at 37.5-37.8 C and 60% relative humidity for 28 days [10]. Candling was done at 14 days after egg set to determine fertile and unfertile eggs.

2.4.2. Housing of Experimental Birds

Birds were brooded for 6 weeks [11] before transferred to a deep litter floored house each of size of 49.9m x 8.17m x 2.48m. Each room had thirty cages each of size 3.15m x 0.99m x 2.12m. They were individually caged at the ages of three and four months respectively of size 0.68m x 0.595m x 0.44m.

2.4.3. Feeding and Watering

Birds were then maintained at ambient temperatures between 21°C and 30°C until the end of the experiment. Feed and water were supplied *ad libitum*. Day old keets were fed ground maize in flat feeders followed by a starter ration from day 2 until 6 weeks of age. This was followed by a grower ration from 6 weeks of age until 21 weeks of age, and then a finisher feed until the end of the experiment. The starter ration contained 22% crude protein and 2,950 Kcal ME/kg diet. The grower ration contained 14% crude protein and 2,800 Kcal ME/kg diet, and the finisher ration contained 17.5% crude protein and 2,800 Kcal ME/kg diet [6].

2.5. Data Collection

The parameters that were measured comprised of egg qualities and carcass characteristics.

2.5.1. Egg Qualities

Egg characteristics measured were egg weight, shell weight, shell thickness, yolk weight, albumin weight, yolk height, albumin height and Haugh Unit. The weight of the eggs were determined with the aid of an electronic sensitive scale adjusted to the nearest 0.01 g. The internal traits measured were yolk weight, yolk height, yolk diameter, albumen weight, albumen height, albumen diameter. The above mentioned internal qualities were determined by cracking and breaking gently each into a clean petri dish and measurements were taken with the aid of a vernier calliper sensitive to 0.01 mm. Shell weight was calculated as the difference between the egg weight and the weights of yolk and the albumin.

Micrometer screw gauge was used to determine the shell thickness from the broad end, narrow end and the middle of the shell and the average of the three measurements was taken as shell thickness in millimetre.

The Haugh Unit values were calculated for individual egg using the Haugh equation [12]:

$$HU = 100 \log (H - 1.7w^{0.37} + 7.6)$$

where:

$$Y_{ijklm} = \mu + B_i + G_j + H_k + S_l + (GS)_{jl} + (BG)_{ij} + (BH)_{ik} + (BS)_{il} + (SH)_{kj} + (BH)_{ik} + e_{ijklm}$$

Where:

Y_{ijklm} = Observation of m th animal in the i th strain in j th generation of i th sex, hatched

lnk th season

μ = Overall mean

B_i = fixed effect of i th strain (1, 2, 3, 4)

G_j = random effect of j th generation (1, 2)

H_k = random effect of k th season of hatch (1, 2)

S_l = random effect of l th sex (1, 2)

$(GS)_{jl}$ = random effect of the interaction between j th generation and l th sex

$(BG)_{ij}$ = random effect of the interaction between i th strain and j th generation

$(BH)_{ik}$ = random effect of the interaction between i th strain and k th season of hatch

$(BS)_{il}$ = random effect of the interaction between i th strain and l th sex

$(SH)_{kj}$ = random effect of the interaction between l th sex and j th season of hatch

e_{ijklm} = random error

3. Results and Discussion

3.1. Effects of Strain on Egg Qualities

Strain had significant ($p < 0.05$) influence on albumen height. However, albumen weight was not significantly ($p > 0.05$) influenced by strain. Pearl had the highest albumen height compared to white, black and lavender (Table 2). Yolk weight, egg diameter and shell weight were not significantly ($p > 0.05$) influenced by strain of birds. Shell thickness and Haugh Unit were significantly ($p < 0.05$) affected by strain of birds. The highest shell thickness was recorded by lavender

HU – Haugh Unit

H – observed height of albumen in mm

w – weight of egg in g

2.5.2. Carcass Characteristics

The birds per strain were sampled for the carcass analysis. Before slaughtering, the birds were starved overnight but had free access to water. After slaughtering, carcasses were gutted and weighed.

The following carcass parameters were studied: Live weight, dressing percentage, weight of heart, weight of lungs, weight of liver, weight of kidneys, intestine with content, intestine without content.

Biochemical analysis of carcass was done at Biochemistry laboratory of Kwame Nkrumah University of Science and Technology on the following parameters: Moisture %, Protein %, Fat%, Ash%,

Carbohydrate%, pH and Energy KJ content of the meat.

2.6. Statistical Analysis

Data were analyzed with the General Linear Procedure (GLM) of SAS. According to the model:

followed by white, black and pearl. However, pearl had the highest Haugh Unit than white, black and lavender (Table 2). The significant effects of strain of birds on egg qualities such as yolk height, albumen height, shell thickness and Haugh unit may be attributed to the size of the egg, as egg size directly influences egg characteristics. Generally, the bigger the egg, the more the contents (albumen and yolk height) in size. Moreover, different strains have variant genetic makeup, hence differences in the egg qualities. Also, the higher calcium content of the feed of birds used in the study could be a contributing factor as calcium is used to form the egg shells. Higher calcium inclusion levels in diets leads to thicker egg shells. Furthermore, it could also be due to the genetics of the birds studied. Egg quality of birds are known to be influenced by factors such as strain of birds [13]. This is a general trend in poultry birds, where genotype of birds influence egg quality as noted [14-15].

3.2. Effects of Non-genetic Factors on Egg Qualities

3.2.1. Effects of Season on Egg Qualities

Albumen height, albumen weight, yolk height were not significantly ($p > 0.05$) influenced by season of hatch. Also, shell thickness, egg diameter, shell weight and Haugh unit were not significantly ($p > 0.05$) influenced by season of hatch (Table 2). The non-significant effect of season on egg characteristics (Table 2) could be due to the fact that season did not influence body weight of birds as body weight influences egg weight. The current study differs from Yakubuet *al.* [16] who reported that, birds performed significantly better in the wet than hot-dry season on egg weight. The non-significant influence of season in the current study could be due to differences in species and the study environments.

3.2.2. Effects of Generation on Egg Qualities

Albumen height, shell thickness and Haugh unit were not significantly ($p>0.05$) influenced by generation of birds. However, yolk weight and height as well as albumen weight were significantly ($p<0.05$) affected by generation of birds. Parental generation had a better yolk weight and albumen weight than first filial generation. Yolk weight and height were higher in parental generation than in first filial generation. Likewise egg diameter was higher in parental generation than in first filial generation. Shell weight was also higher in parental generation than in first filial

generation (Table 2). The significant influence of generation on egg characteristics may be due to positive response of body weight to selection and higher body weight directly influences egg characteristics. First filial generation birds were better than parental generation birds and body weight influences egg characteristics. The result of the current study is comparable to earlier studies [15], that there were significant ($p<0.01$) influence of generation for external and internal egg quality traits and percentage albumen, yolk and shell thickness.

Table 2. Effects of strain and non-genetic factors on egg qualities factors.

Generation	Albumen Height(mm)	Albumen Weight(g)	Yolk Weight(g)	Yolk Height(mm)	Shell Thickness(mm)	Egg Diam(mm)	Shell Weight(g)	Haugh Unit
Parental	22.59±0.733	13.70±0.24	13.70±0.24	19.91±0.59	0.095±0.004	36.81±0.44	9.11±0.44	75.76±1.7
First filial	21.57±0.62	13.21±0.21	13.21±0.21	18.41±0.51	0.098±0.003	35.35±0.38	5.87±0.37	76.40±1.4
P-values	0.1597	0.0064	0.0424	0.0117	0.5327	0.0010	<0.0001	0.7064
Strain								
Black	22.181±1.063	16.95±0.48	13.47±0.35	19.144±0.867	0.088±0.006	36.06±0.64	7.42±0.63	76.51±2.49
Lavender	20.24±0.512	17.06±0.23	13.49±0.17	17.94±0.41	0.110±0.003	35.90±0.30	8.07±0.30	71.14±1.20
Pearl	23.12±1.064	16.53±0.48	12.91±0.35	19.66±0.86	0.084±0.0063	36.33±0.64	7.42±0.64	79.00±2.49
White	22.78±0.86	16.74±0.394	13.93±0.29	19.88±0.70	0.10±0.005	36.04±0.52	7.06±0.52	77.67±2.03
P-value	0.0019	0.625	0.1019	0.0138	<0.0001	0.9130	0.1879	0.0003
Season								
Major Rain	22.195±0.43	16.80±0.198	13.55±0.146	19.389±0.35	0.1003±0.0026	35.86±0.26	7.55±0.26	76.52±1.26
Minor Rain	21.97±1.04	16.84±0.472	13.36±0.349	18.93±0.84	0.093±0.006	36.30±0.62	7.43±0.62	75.64±2.44
p-value	0.8404	0.9277	0.6082	0.6096	0.2932	0.5034	0.859	0.7344

Table 3. Effects of strain and non-genetic factors on Carcass Characteristics.

Factors	Live weight (g)	Dressed weight (g)	Wing weight (g)	Head weight (g)	Neck(g)
Parental	1429.1±34.72	58.95±3.25	4.33±0.12	2.58±0.07	3.92±0.10
First filial	1291.2±60.14	91.32±5.14	5.36±0.21	2.67±0.13	4.35±0.18
P-value	0.057	<.0001	0.0003	0.566	0.0543
Sex					
Female	1370.2±45.93	74.24±4.31	4.67±0.16	2.25±0.10	3.90±0.14
Male	1350.2±45.93	76.03±4.31	5.02±0.16	3.00±0.10	4.37±0.14
P-value	0.74	0.753	0.1165	<.0001	0.020
Strain					
Black	1369.27±62.6	77.67±5.87	4.75±0.22	2.58±0.13	4.19±0.19
Lavender	1342.39±62.6	70.20±5.87	4.82±0.22	2.66±0.13	3.79±0.19
Pearl	1389.27±62.6	70.87±5.87	4.82±0.22	2.58±0.13	4.04±0.19
White	1339.89±62.6	81.81±5.87	4.98±0.22	2.68±0.13	4.51±0.19
P-value	0.927	0.418	0.880	0.926	0.079

Table 3. Continued.

Factors	Thigh(g)	Heart(g)	Gizzard(g)	Intestine(g)	Whole Crop(g)
Parental	5.39±0.21	0.57±0.02	1.40±0.07	1.684±0.06	1.95±0.164
First filial	10.19±0.3	0.56±0.04	1.97±0.13	1.726±0.11	0.52±0.28
P-value	<.0001	0.294	0.0011	0.7407	0.0002
Sex					
Female	7.65±0.28	0.42±0.03	1.775±0.1	1.83±0.08	1.68±0.217
Male	7.92±0.28	0.65±0.03	1.603±0.1	1.574±0.08	0.79±0.217
P-value	0.483	<.0001	0.2105	0.00227	0.0042
Strain					
Black	7.60±0.3	0.57±0.04	1.58±0.13	1.795±0.11	1.517±0.296
Lavender	8.062±0.3	0.513±0.04	1.79±0.13	1.561±0.11	1.548±0.296
Pearl	7.90±0.3	0.497±0.04	1.74±0.13	1.926±0.11	1.187±0.296
White	7.58±0.3	0.573±0.04	1.63±0.13	1.537±0.11	0.712±0.296
P-value	0.767	0.428	0.6675	0.0473	0.1606

Table 4. Effects of strain and non-genetic factors on biochemical composition of Guinea fowl carcass.

Factors	Moisture %	Protein %	Fat%	Ash%	Carbohydrate%	pH	Energy KJ	Cholesterol%
Parental	74.76±0.08	13.16±0.08	2.995±0.03	1.54±0.04	7.53±0.046	4.29±0.02	459.20±2.56	2.28±0.30
First filial	74.76±0.08	13.16±0.08	2.995±0.03	1.54±0.04	7.53±0.046	4.29±0.02	459.20±2.56	2.28±0.30
P-values	1.00	1.00	1.00	1.00	1.00	0.919	0.139	1.00
Sex								
Female	74.96±0.08	12.90±0.08	2.87±0.037	1.68±0.04	7.557±0.042	4.26±0.20	447.36±2.56	2.37±0.030
Male	74.55±0.08	13.43±0.08	3.11±0.037	1.41±0.04	7.48±0.042	4.33±0.20	465.58±2.56	2.20±0.030
P-values	0.0009	<0.0001	<0.0001	0.0002	0.138	0.0229	<0.0001	0.0004
Strain								
Black	74.82±0.11	13.23±0.11	2.97±0.052	1.50±0.06	7.47±0.06	4.29±0.02	457.99±3.62	2.25±0.043
Lavender	74.49±0.11	13.30±0.11	3.069±0.05	1.49±0.06	7.63±0.06	4.37±0.02	462.70±3.62	2.72±0.043
Pearl	74.99±0.11	13.04±0.11	2.87±0.052	1.72±0.06	7.36±0.06	4.21±0.02	451.24±3.62	2.39±0.043
White	74.72±0.11	13.09±0.11	3.065±0.05	1.47±0.06	7.64±0.06	4.32±0.02	453.93±3.62	2.23±0.043
P-value	0.029	0.372	0.038	0.034	0.0041	0.0030	0.1439	0.0431
Generation*Sex	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	<0.0001	<0.0001	<0.0001
Generation*Strain	0.0004	<0.0010	<0.0001	<0.0001	0.0216	<0.0001	0.0005	<0.0001
Sex*Strain	<0.0001	0.0004	0.055	<0.0001	0.0493	<0.0001	0.1452	<0.0001

3.2.3. Effect of Strain on Carcass Characteristics

Strain had no significant ($p>0.05$) effect on live weight and dress weight (Table 3). However, intestine weight was significantly ($p<0.05$) influenced by strain of birds. Pearl had the highest intestine weight, followed by black, lavender and white (Table 3). Strain had significant ($p<0.05$) influence on moisture, fat and carbohydrate. The carcass of pearl had the highest moisture content than black, white and lavender. Lavender recorded the highest fat, followed by white, black and pearl. White had the highest carbohydrate content followed by lavender, black and pearl (Table 4). Also, strain significantly influences the ash%, pH and cholesterol% content of the carcass. Pearl strain had the highest ash% and White strain had the least Ash% content. The highest pH and cholesterol% were obtained in the lavender strain of birds (Table 4). The significant influence of strain on chemical composition of meat (Table 3) may be due to genetic variations of the birds. Strains are genetically distinct; they are results of different selection goals; as strains overlap in a definite management system, the strain differences are mostly genetic, hence their influence on chemical composition meat also differ. Chemical compositions of meats are influenced by hormones whose secretions are affected by genes. The result of the current study is comparable to the findings [17] which reported that genotype of Guinea fowl had significant influence on meat composition.

3.3. Effect of Non-genetic Factors on Carcass Characteristics

3.3.1. Effects of Sex on Carcass Characteristics

Live weight and dressing percentage were not significantly ($p>0.05$) influenced by sex of birds. However, head and heart weights were significant ($p<0.05$) (Table 3). Male birds had a higher head weight than female birds. Heart weight was higher in male than in female. Sex had significant ($p<0.05$) influence on moisture, fat and energy, Protein, Ash and Cholesterol content of carcass. Female birds had higher moisture content than male birds. Male birds had a higher

fats and protein content than female birds, the energy content was higher in male birds than in female birds. However, ash and cholesterol content were higher in female birds than in male birds (Table 4). The significant higher protein, fat and energy content of the carcass recorded in the male birds than female birds (Table 4) could be due to the fact male birds use more energy as well as protein and fats for flight activities and protection of the female birds. Furthermore, this could be due to the fact that male birds were aggressive than female birds during feeding in the same pen, hence male birds took in more feed resulting into higher protein, fat and energy content than female birds. Baezaet *al.* [18] also reported similar findings in Guinea fowl.

Live weight and dressing weight were not significantly ($p>0.05$) influenced by sex of birds (Table 3). This is because at maturity, the weights of male and female Guinea fowls are similar. Moreover, dressing weight is a function of live weight and as live weight is not significantly influenced, so was the dressed weight. Similar result was reported [19] in indigenous Guinea fowl in Nigeria. The current finding contradicts the result [18], that sex had significant effect on live weight and dressing weight of Guinea fowl. This difference could be due to the management of birds and environment of the study.

3.3.2. Effects of Generation on Carcass Characteristics

Generation had significantly ($p<0.05$) affected live weight, dress weight and wing weight. The interaction of sex x strain was significant on live weight. Parental generation had a better live weight than first filial generation. Dress weight was higher in first filial generation than parental generation (Table 3). The significant influence of generation on dressing percentage (Table 3) may be due to better body weights recorded in birds in first filial generation compared to parental generation; thus better response of body weight to selection. The body weights might have influenced the carcass characteristics. This result is comparable to the findings [20] which observed that generation had significant effect on live weight and dressing percentage in Japanese quail.

4. Conclusion

In conclusion, strain of birds (Pearl, Lavender, White and Black) and environmental factors such as sex, season of hatch and generation of birds had influence egg qualities and carcass characteristics of indigenous Guinea fowl (*Numidameleagris*).

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