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Strain by feed restriction interaction effect on carcass characteristics and meat quality of broiler chickens

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Abstract
The aim of the present investigation was to rank the performance of three exotic strains of commercial broilers as influenced by feed restriction in terms of carcass and meat quality characteristics. It is believed that breeds of animals differ in their response to whatever treatment applied. The strains of broiler birds under investigation are Arbor Acre, Hubbard and Marshall. Analyzed results showed that there was no significant (p>0.05) strain by feed restriction interaction effect on live weight and slaughter weight of broiler chickens. However, there was significant (p<0.01) strain by feed restriction interaction effect on dressed, eviscerated, back and breast weight. This implies that the expression of these traits depended on strain by treatment interaction. Furthermore, the result revealed that there was no significant (p>0.05) strain by feed restriction interaction effect on aroma, colour, tenderness, juiciness and saltiness. This implies that the expression of these traits as affected by strain and treatment is mutually exclusive and not by joint action. But, there was significant (p<0.01) strain by feed restriction interaction effect on flavor and meat texture. Arbor Acre and second week feed restriction recorded superior mean values in most cases of interaction effect, and therefore could be proposed to farmers for increased poultry meat production and profit.

Keywords: Strain, trait, meat quality, broilers, feed restriction, arbor acre

1. Introduction
The reproductive and productive efficiency of farm animals depend on genetic constitution and environment as well as interaction between the two factors. Chicken meat is unique in that its price is comparatively low, easy to partition into smaller parts and no religious restriction against its consumption (Jaturasitha, 2004) [5]. Significant genotype x environment interaction effects on egg production among four strains of commercial layers had been reported in earlier study (Gwaza and Egahi, 2009) [2]. In addition, Olawumi (2007) [10] observed significant strain by season interaction effect on egg production, fertility and hatchability of breeder hens.
The success of poultry production has been strongly related to the improvements in growth performance and carcass yield and composition. Current commercial broiler chickens strains according to Idahor *et al.* (2013) [4] are the result of successful selection programme for rapid growth and body conformation. This improvement in growth performance and carcass characteristics have resulted to physiological, immunological, biochemical and anatomical changes in broiler (Schmidt *et al*., 2009) [13]. In addition, Julian (2005) [7] reported that rapid growth rate of modern broiler chickens was associated with series of physiological disorders resulting to increase in the rate of mortality during grow-out. Earlier studies had used the concept of feed restriction in broilers to reduce the incidence of metabolic disorders and high mortality (Gonzales *et al.*, 1998; Balog *et al.*, 2000) [3, 1]. Feed restriction improved feed efficiency, reduced feed cost and mortality (Zubair and Leeson, 1996) [15].
In previous studies, breed of chickens was reported to have significant effect on live weight (Jaturasitha *et al*., 2008) [6], carcass weight (Olawumi and Fagbuaro, 2011) [11], breast and leg muscle weight (Musa *et al*., 2006) [8] and back and drumstick weight (Ojedapo *et al*., 2008) [9]. While separate effects of breed and non-genetic factors on birds' productivity were given prominence in literature, little attention has been paid to the interaction between breed and nutritional factors. This refers to the ranking order of productivity of strains of chickens as influenced by the feeding regimen imposed on them. According to Olawumi *et al.* (2012) [12],

carcass traits were significantly affected by strain x sex interaction. This implies that the traits were breed and sex dependent in their expression. In contrast, Ojedapo *et al*. (2008) [9] reported that breed x sex interaction had no significant effect on carcass traits of broiler chickens.

There is dearth of information in literature regarding interaction effects between strain and feed restriction on carcass traits and meat quality of broiler chickens. This study therefore, was undertaken to compare and rank the carcass characteristics and meat quality of three strains of commercial broilers as affected by skip-a-day feed restriction.

2. Materials and methods

The study was carried out at the poultry unit of the Teaching and Research Farm, Faculty of Agricultural Sciences, Ekiti State University, Ado-Ekiti, Nigeria. Ekiti State is situated entirely within the tropics. It is located between longitudes 40° 51' and 50° 451' East of the Greenwich meridian and latitudes 70° 151' and 80° 511' North of the Equator. The State enjoys a tropical climate with two distinct seasons. These are the rainy season (April - October) and the dry season (November - March). Temperature ranges between 21^0C and 28^0C with high humidity.

2.1 Management and feeding practices

A total number of 300 day-old broiler chicks comprising 100 chicks each of Arbor Acre, Hubbard and Marshall were purchased from reputable hatcheries. Prior to arrival of the birds, the pens were properly cleaned, washed with soap and fumigated thoroughly with 40% formaldehyde in water solution and allowed to rest for one week. The house was properly covered and pre-heated before the arrival of the birds so as to raise the temperature of the brooding environment to keep the chickens warm.

The chicks were vaccinated against Newcastle and Infectious Bursa diseases at recommended doses, and at specified ages. During the adaptation period (1-7 days), all the chicks were fed *ad libitum*. They were thereafter allotted to four different treatments having three replicates each (8 chicks/replicate) as follows:

Treatment 1 – Control- *ad libitum*

Treatment 2 – Skip-a-day method across the three strains at 2nd week and *ad libitum* thereafter.

Treatment 3 – Skip-a-day method across the three strains at 3rd week and *ad libitum* thereafter.

Treatment 4 – Skip-a-day method across the three strains at 4th week and *ad libitum* thereafter.

The birds were fed starter mash (1-4 weeks) containing 22%CP and 3000Kcal ME Kg^{-1}, while between 4-7 weeks they were given finisher feed containing 20% CP and 3100Kcal ME Kg^{-1}.

2.2 Carcass evaluation

At 56th day of age, two birds per replicate, that is, six birds per treatment on strain basis were randomly selected after starving them overnight for carcass evaluation. The birds were numbered and weighed individually to obtain live body weight and thereafter, slaughtered, bled, scalded and plucked. After feathering, the carcasses were eviscerated and dissected manually into various parts such as breast muscle, back muscle, drumstick, thigh muscle, wings, legs and giblets (heart, liver and gizzard). The different parts were weighed using sensitive scale and were expressed in grammes.

Data collected at 56th day of age included live body weight, slaughter weight, dressing weight, eviscerated weight, carcass weight, breast weight, back muscle weight, drumstick and thigh weights, neck and head weights, wing and intestinal weight, liver, lung, heart and gizzard.

2.3 Sensory evaluation:

Samples for sensory evaluations were taken from the breast muscle and cooked to an internal temperature of 72^0C. Total of 12 trained individuals aged between 22 and 35 years males and females were employed to assess the coded meat samples. Equal bite size from each treatment was coded, replicated thrice and served for evaluation by the trainees on a 9-point hedonic scale for colour, favour, tenderness, juiciness, texture and overall acceptability.

2.4 Statistical analysis

The data collected were analyzed by the analysis of variance technique in completely randomized design, while the differences between means were separated by Duncan New Multiple Range Test as per SAS (2001)[14].

The appropriate statistical model used was:

$Y_{ijk} = \mu + (GR)_{ij} + \varepsilon_{ijk}$

Y_{ijk} = observation on k^{th} population, of i^{th} strain by j^{th} feed restriction

μ = common mean

$(GR)_{ij}$ = Fixed effect of strain x feed restriction interaction

ε_{ijk} = error term

3. Results and Discussion

Table 1 shows the effect of strain by feed restriction on live weight and carcass characteristics of broiler chickens. The result showed that there was no significant (p>0.05) strain by feed restriction interaction effect on live weight and slaughter weight of broiler chickens. The result contradicted the findings of Olawumi *et al*. (2012) [12] who reported that carcass traits were significantly affected by strain x sex interaction. For dressed weight, there was significant (p<0.01) strain by feed restriction interaction effect. This implies that the expression of this trait depended on strain by treatment interaction. Arbor Acre and Marshall birds on full feed (*ad libitum*) showed superior mean values, while Marshall birds on fourth week feed restriction interaction recorded the least mean value at 8 weeks. Also, there was significant (p<0.01) strain by feed restriction interaction effect on eviscerated weight of broiler chickens. Arbor Acre birds on full feed (*ad libitum*) showed superiority in terms of eviscerated weight, while Marshall birds on second, third and fourth week feed restriction recorded the lowest mean values.

In the same vein, there was significant (p<0.01) strain by feed restriction interaction effect on breast weight. Arbor Acre birds on fourth week feed restriction had the highest mean value, while Arbor Acre on second week feed restriction, Marshall birds on fourth week feed restriction, Hubbard birds on full feed (*ad libitum*), Hubbard birds on second week feed restriction and Hubbard birds on third week feed restriction recorded the lowest mean values of breast weight at 8 weeks. In addition, there was significant (p<0.01) strain by feed restriction interaction effect on back weight. Arbor Acre birds on fourth week feed restriction had the highest value, while Arbor Acre birds on second week feed restriction, Marshall birds on third and fourth week feed restriction, Hubbard birds on full feed (*ad libitum*), second and third week feed restriction recorded the lowest mean values. In contrast, Ojedapo *et al*. (2008) [9] reported that breed x sex interaction had no significant effect on carcass traits of broiler chickens.

Furthermore, there was significant ($p<0.01$) strain by feed restriction interaction effect on back weight. Arbor Acre birds on fourth week feed restriction showed the highest mean value, while other interactions recorded similar ($p>0.05$) mean values. In addition, there was significant ($p<0.01$) strain by feed restriction interaction effect on thigh + drumstick. At 8 weeks, Arbor Acre birds on full feed (*ad libitum*) and fourth week feed restriction showed superior values, while Marshall birds on fourth week feed restriction and Hubbard birds on third week feed restriction recorded the least mean value. Also, there was significant ($p<0.01$) strain by feed restriction interaction effect on wing weight. Arbor Acre birds on full feed (*ad libitum*) had superior value, while Hubbard birds on second week feed restriction had the lowest value at age 8 weeks.

In addition, there was significant ($p<0.01$) strain by feed restriction interaction effect on broiler chickens' head. Marshall birds on full feed (*ad libitum*) and Hubbard birds on full feed (*ad libitum*) recorded the superior mean values, while Arbor Acre birds on second week feed restriction recorded the least mean value. Regarding heart, there was significant ($p<0.01$) strain by feed restriction interaction effect. Hubbard birds on fourth week feed restriction showed the highest value, while Arbor Acre birds on second week feed restriction, Marshall birds on third and fourth week feed restriction and Hubbard birds on full feed (*ad libitum*) showed the lowest mean values.

However, there was no significant ($p>0.05$) strain by feed restriction interaction effect on broiler chickens' liver. For proventiculus + gizzar, there was significant ($p<0.01$) strain by feed restriction interaction. Marshall birds on full feed (*ad libitum*) had the highest mean value, while Marshall birds on third week feed restriction showed the lowest mean value. In addition, there was significant ($p<0.01$) strain by feed restriction interaction effect on broiler chickens intestinal weight. Hubbard birds on second week feed restriction showed superior value, while Arbor Acre birds on full feed (*ad libitum*) had the least mean value. Also, there was significant ($p<0.01$) strain by feed restriction interaction effect on broiler chickens neck. Marshall birds on second week feed restriction recorded the highest value, while other interactions except Arbor Acre birds on third week feed restriction, Marshall birds on full feed (*ad libitum*), and Marshall birds on third week feed restriction showed the least mean values.

Table 1: Least squares means showing the effect of strain by feed restriction interaction on live weight and carcass characteristics of broiler chickens

Parameters (g)	AA×FF	AA×2nd	AA×3rd	AA×4th	MA×FF	MA×2nd	MA×3rd	MA×4th	HU×FF	HU×2nd	HU×3rd	HU×4th	SEM
Live Weight	2566.7	2433.3	2300.0	2366.7	2500.0	2283.3	2250.0	2200.00	2350.0	2358.3	2350.0	2516.7	128.76
Slaughter Weight	2466.7	2358.3	2255.0	2325.0	2433.3	2191.7	2166.7	2058.3	2233.3	2233.3	2241.7	2433.3	126.77
Dressed Weight	2400.0^{a}	2291.7^{ab}	2133.3^{ab}	2216.7^{ab}	2341.7^{a}	2108.3^{ab}	2058.3^{ab}	1916.7^{b}	2116.7^{ab}	2083.3ab	2141.7^{ab}	2283.3^{ab}	121.71
Eviscerated Weight	2015.8^{a}	1783.3^{ab}	1762.3^{ab}	1816.7^{ab}	1900.8^{ab}	1616.7^{b}	1583.3^{b}	1586.0^{b}	1708.3^{ab}	1675.0^{ab}	1700.0^{ab}	1853.7^{ab}	110.05
Breast Weight	608.3^{ab}	480.0^{b}	550.0^{ab}	780.0^{a}	558.3^{ab}	566.7^{ab}	441.7^{b}	408.3^{b}	438.3^{b}	401.7^{b}	466.7^{b}	633.3^{ab}	75.97
Back Weight	400.00^{b}	366.67^{b}	433.33^{b}	676.67^{a}	450.00^{b}	425.83^{b}	358.33^{b}	408.33^{b}	371.67^{b}	363.33^{b}	358.33^{b}	416.67^{b}	61.91
Thigh + Drumstick	566.67^{a}	525.00^{ab}	508.33^{ab}	571.67^{a}	525.00^{ab}	483.33^{ab}	491.67^{ab}	441.67^{b}	475.00^{ab}	450.00^{ab}	433.33^{b}	458.33^{ab}	37.04
Wing Weight	266.67^{a}	241.67^{ab}	233.33^{ab}	258.33^{ab}	216.67^{ab}	250.00^{ab}	225.00^{ab}	188.33^{ab}	221.67^{ab}	180.00^{b}	233.33^{ab}	200.00^{ab}	25.39
Head	70.23^{ab}	55.00^{b}	65.78^{ab}	67.55^{ab}	77.52^{a}	73.72^{ab}	64.05^{ab}	64.82^{ab}	78.77^{a}	67.78^{ab}	72.40^{ab}	71.98^{ab}	6.07
Heart	12.77^{ab}	11.68^{b}	12.00^{ab}	12.10^{ab}	14.70^{ab}	15.15^{ab}	11.17^{b}	11.20^{b}	11.12^{b}	12.75^{ab}	13.63^{ab}	15.88^{a}	1.25

Note: a, b, c means with different superscripts along rows are significantly different ($p<0.01$)
AA: Arbor Acre MA: Marshall Hu: Hubbard
FF: Full feed; 2nd: Second week; 3rd: Third week; 4th: Fourth week

Table 2 represents strain by feed restriction interaction effect on meat qualities at 8 weeks. The result revealed that there was no significant ($p>0.05$) strain by feed restriction interaction effect on aroma, colour, tenderness, juiciness and saltiness. This implies that the expression of the traits as affected by strain and treatment is mutually exclusive and not by joint action. However, there was significant ($p<0.01$) strain by feed restriction interaction effect on flavour. Marshall birds on third week feed restriction recorded highest mean value, while Marshall birds on fourth week feed restriction showed the lowest mean value.

In the same vein, there was significant ($p<0.01$) strain by feed restriction interaction effect on texture. Arbor Acre birds on full feed (*ad libitum*) showed superiority to other interactions, while Marshall birds on second week feed restriction showed the lowest mean value. Also, there was significant ($p<0.01$) strain by feed restriction interaction effect on the overall acceptability at 8 weeks. Marshall birds on second week feed restriction had the highest mean value, while Hubbard birds on fourth week feed restriction showed the least mean value. The findings in this study showed that expression of meat texture and overall acceptability are strain and treatment dependent.

Table 2: Least squares means showing strain by feed restriction interaction on sensory values of broiler chickens at eight week

SENSORY VALUES	AA_FF	AA_SF	AA_TF	AA_FFR	MA_FF	MA_SF	MA_TF	MA_FFR	HU_FF	HU_SF	HU_TF	HU_FFR	SEM
Aroma	55.83	53.50	50.17	54.33	45.17	51.83	51.83	51.17	46.83	46.83	46.17	45.33	3.51
Colour	60.17	62.00	61.00	61.33	60.17	59.50	62.33	58.67	56.67	62.33	56.00	58.83	2.22
Flavour	60.00^{ab}	55.00^{abc}	58.17^{abc}	57.17^{abc}	61.00^{ab}	56.00^{abc}	62.83^{a}	51.83^{c}	55.17^{abc}	61.50^{ab}	57.67^{abc}	53.67^{bc}	2.42
Tenderness	61.00	62.83	61.00	59.50	56.17	58.83	61.83	56.67	58.50	61.17	59.00	58.83	2.23
Juiciness	59.50	63.83	61.50	61.50	60.33	59.50	57.83	59.17	59.17	62.50	58.50	56.67	2.06
Texture	62.50	58.50^{abc}	61.33^{ab}	60.67^{abc}	55.33^{bc}	54.00^{c}	54.67^{bc}	56.67^{abc}	55.00^{bc}	60.33^{abc}	59.17^{abc}	57.17^{bc}	2.10
Saltiness	54.67	53.83	59.17	52.67	54.33	60.00	54.83	54.67	55.00	60.50	57.50	57.83	2.66
Overall Acceptance	63.17^{ab}	63.83^{ab}	63.00^{ab}	60.67^{ab}	57.50^{ab}	65.00^{a}	57.33^{ab}	59.50^{ab}	61.33^{ab}	61.33^{ab}	64.00^{ab}	57.00^{b}	2.30

Note: a, b, c means with different superscripts along rows are significantly different ($p<0.01$)
AA – Arbor Acre, MA- Marshal, HU- Hubbard,
SF- Second week feed restriction, TF- Third week feed restriction, FFR- Fourth week feed restriction

4. Conclusion

The findings of this study revealed significant strain by feed restriction interaction effect on most carcass traits of broiler chickens. This in effect indicates that the expression of the traits are strain and treatment dependent.

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