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Comparative study of feeding frequencies on growth characteristics of four strains of broiler chickens

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***Target Audience**: Broiler producers, Animal Scientists, Researchers*

Abstract

The poultry industry has evolved in recent years owing to the high demand for chicken meat. However, about 60 to 70% of broiler production cost is on feed. Thus, it becomes critical to make concerted efforts to reduce feed cost without compromising overall poultry productivity. The objective of this study was to evaluate the effect of feeding the birds twice (12 hourly) or thrice (8 hourly) on some growth characteristics of the birds. The birds were fed using commercially compounded broiler feeds [Starter (0-4 weeks) and Finisher (5-10 weeks)]. Data collected on weight was subjected to preliminary exploratory boxplot and normality analyses, and at the end of the study total of 211 of the original 304 birds were statistically evaluated. Strain, feeding frequency and sex all exerted significant ($P<0.05$) influence albeit at varying levels, on growth parameters. The model explained 36.2 percent of total variation with each of the factors respectively accounting for 33.23%, 1.37% and 1.60%. The largest source of variation was from the differences in strain, while the least was recorded on the feeding frequency. The study revealed that twice daily (12 hourly) feeding had a better impact on the parameters studied, while the male had superior performance over the female and difference due to strain was only pronounced in the Marshall which had the least values in all parameters studied. It is therefore recommended that broiler birds are fed twice daily (12 hourly), thereby reducing labour cost and frequency of disturbance to the birds.

***Keywords**: Broilers, Feeding Frequency, Growth Parameters*

Description of Problem

Broilers are specifically bred within a very short time for meat, optimal health and size to ensure quality products for the consumers [1]. Increased demand for chicken meat led to formulation of diets that satisfy the nutritional requirements of the birds such as energy, protein, amino acid, trace minerals and vitamins during their development [2].

The advances in genetics and technology have improved tremendously the development of the broiler chicken, leading to heavier weights at very short intervals of between 6 – 8 weeks. Present-day broiler chickens have undergone considerable selection pressure targeted for a rapid early growth, high meat yield, and high feed conversion efficiencies [3]. This is achievable due to the interactions between genetic improvement and optimal nutritional strategies which leads to better performing birds during the production stage [4].

Feeding has been recognized as the most important aspect in broiler production. About 60 to 70% of the cost of poultry production is attributable to feed cost alone, therefore, it has become critical to make concerted efforts to reduce feed cost without compromising the overall productivity of the birds [5, 6]. Today, the vast majority of commercial poultry are produced in large units where knowledge of science and technology have been maximized [7]. Thus, any improvement in the performance of broilers occasioned by diet would inevitably have a profound effect on profitability of broiler farming.

The success of raising broilers for maximum weight gain depends not only upon the strain of the birds and management but also on feeding regimens and quality. Feeding regimen in broilers can improve feed efficiency, reduce feed cost and mortality along with the production of quality meat at cheaper rates [5, 8, 9, 10, 11, 12, 13].

Feeding frequency has been reported to improve growth and other performance traits of broilers [14, 15, 16]. Since feeding constitutes the major cost item of producing broiler meat, considerable research efforts were concentrated in improving nutrition and efficiency of feed utilization of the broiler chicks through feeding regimens. It is therefore, important to use high quality feed that will increase the performance of the birds aimed at optimising feed efficiency and therefore performance of the broiler chicken and profit on the farm. Thus, this study aims at evaluating the effect of feeding frequencies on the growth characteristics of broilers at the starter and finisher stages, and recommending the most effective and least expensive approach to successful broiler production.

Materials and Methods

Experimental Site:

This study was carried out at the Poultry Unit of Lagos State University Ojo, Lagos, Nigeria, situated at latitude 6° 27' 59.99" N and longitude 3° 10' 60.00" E in the humid tropics of Southwest Nigeria.

Animal and Management Practices:

A total number of 304 of four strains of day-old commercial broiler birds obtained from a reputable commercial hatchery in Ibadan, Oyo State. On arrival, there were 76 chicks for each of the four strains (Arbor Acre, Cobb, Marshall and Ross strains), and all birds were all tagged with an ID and weighed on arrival. The animals were kept in four clearly delineated and demarcated plots on a deep litter system, filled with wood shavings, comprised of 19 day-old chicks from each of the fours strains, the birds were reared from day old to ten weeks on the litter. The litters were replaced bi-weekly with new ones to protect the birds from infections and microbial invasion. Management practices on the farm followed standard procedures for semi-intensive deep litter rearing, for broiler breeding and management in line with breeders' recommendations as described by [17].

Feeds and Feeding

The commercial broiler starter containing 22% Crude Protein [CP] and 3000Kcal/kg Metabolizable Energy [ME]) and broiler finisher feed containing 19.5% Crude Protein [CP] and 3100Kcal/kg Metabolizable Energy [ME]) with proximate composition in Table 1 was fed to the animals respectively from 0-4 weeks and 5-10 weeks. The treatments were two feeding frequencies (12 hourly and 8 hourly). Daily feed intake based on average body weight for each treatment group was weighed, and equally shared into two or three portions, and offered either twice or thrice at 12 or 8 hourly intervals respectively.

There were two replicates for each treatment groups (12-hourly and 8-hourly), and the birds were randomly selected and randomly assigned to each of the replicates within and between the treatment groups.

All birds were subjected to the same environmental conditions except the difference in feeding frequency which is being investigated. The animals were randomly assigned to each treatment to ensure that variation in initial weight within and between the treatment groups was fairly homogenous, thus eliminating any difference at the commencement of the study.

Data Collection:

Aside from the initial body weight of the birds taken at hatch, subsequent weekly body weights of the birds were taken and recorded by their identification number, using a 0.00g sensitive digital scale for 10 weeks. All birds

were sexed and individual sexes recorded along with the bird's ID. Aside from the weekly body weight measurements taken, indices such as final weight gain, weekly weight gain (WWG) and average daily gain were computed from measured variables, where Final Weight Gain (FWG) was computed as $FWG = (Wt_f - Wt_0)$, $WWG = (Wt_p - Wt_c)$ and Average Daily Weight Gain (ADWG) was derived as $ADWG = \frac{(Wt_f - Wt_0)}{Length\ (Days)}$ where Wt_f is final weight, Wt_0 is initial weight, Wt_p is previous week weight and Wt_c is current week weight.

Statistical Analyses: Although the study started with initial 76 birds for each strain totalling 304. By the tenth week, some mortalities were recorded across the four strains and some outliers were equally removed from the final analyses. Thus, a total of 211 records were eventually analysed comprising Arbor Acre (45), Cobb (49), Marshall (61) and Ross (56).

Statistical analyses were conducted using various modules of Minitab® 17 statistical software for exploratory (boxplots, descriptive, normality), general linear model analysis of variance (ANOVA) and further post-hoc tests were done with a significant ANOVA using the Tukey's Honestly Significant Difference (HSD).

The statistical model describing the final analysis of variance is given as:

$Y_{ijk} = \mu + F_i + S_j + X_k + e_{ijkl}$

Where:

Y_{ijkl} =the measure or index on each bird

μ = the overall mean

F_i = the i^{th} effect of the feeding frequency (i = 2; 12-hourly, 8-hourly)

S_j = the j^{th} effect of the strain (i = 4; Arbor Acre, Cobb, Marshall, Ross),

X_k = the k^{th} effect of the sex (i = 2; Male, Female)

e_{ijkl} = the residual error assumed to be normal, independent and random

Results

Initial Weight

The Mean ± Standard Error (S.E.) of effects of strain, feeding regimen and sex on final weight and average daily gain of broiler chicken is as shown in Table 2. The result revealed that the Initial weight of birds when assigned to the 12-hourly and 8-hourly feeding regime ranged from 28g – 43g and 27g – 46g respectively with mean values and standard error of 37.35 ± 0.37 and 36.69 ± 0.39. The overall mean initial body weight was 37.01 ± 0.27g with a coefficient of variation of 10.52%.

There was no statistical ($P>0.05$) difference in the initial weight of the four replicates, along the two treatment lines, also sex was not a significant ($P>0.05$) source of variation on the initial weight, indicating that whatever difference is observed later in the study is due to differences in the treatments

However, strain of bird though was a significant ($P<0.05$) source of variation in initial weight, but this difference averaged out when each replicate is comprised of all the four strains studied and thus did not affect the initial weight across replicates.

Total Weight Gain (TWG)

Total weight gain in the study ranged from 1417g – 4408g with a coefficient of variation of 21.03%. The overall mean total weight gain in the entire study was 2800.5 ± 40.5.

The largest source of variation on total weight gain is attributable to the effect of strain, accounting for 33.53% of the variation in total weight gain, and this effect was highly significant ($P<0.0001$) on total weight gain. Although, the values were not statistically different in three of the strains but the Marshall strain clearly had the lowest value which was statistically significant ($P<0.05$) from the values obtained on the other three strains (Table 2).

Twice daily (12-hourly) feeding recorded 2859.6g in total weight gain, while the thrice daily (8-hourly) had 2743.1g (Table 2).

Feeding frequency was significant (P<0.05) on total weight gain of broilers in this study (Table 3) accounting for 1.38% of the total variation observed in total weight gain. The twice daily feeding regimen outperformed the thrice daily regimen (Table 2) with 4.25 percent over and above the latter mean values.

Male birds had mean total weight gain of 2812.1g, while female birds recorded mean total weight gain of 2792.6g (Table 2). Influence of sex on total weight gain was significant (P<0.05). The male birds marginally recorded 0.7% superiority over the female birds and sex accounted for 1.59% of the variation in total weight gain (Table 3).

Table 1: Proximate composition of the feed used as treatment[+]

Constituents	Hybrid Super Starter	Hybrid Broiler Finisher
Crude Protein	22%	19.5%
Fat	5.1%	5.5%
Crude Fibre	4.3%	3%
Calcium	1.2%	1.2%
Available Phosphorus	0.45%	0.44%
Methionine	0.56%	0.5%
Lysine	1.3%	1.2%
Metabolizable Energy	3000Kcal/kg	3100Kcal/kg

[+]Source: Hybrid Feeds Limited

Weekly Weight Gain (WWG)

Weekly weight gain in the ten-week period of the study ranged from 141.70g to 440.80g with an overall mean of 280.05 ± 4.05g and a coefficient of variation of 21.03% (Table 2). Weekly weight gain progressively increased up to the fourth week before a decline at the fifth and sixth week and it peaked again at the seventh week. The twice daily feeding frequency was superior at weekly intervals except at the sixth and eighth week (Figure 1) where it dropped below the thrice daily feeding frequency.

Strain exerted the largest influence on weekly weight gain (Table 3) accounting for 33.22% of the total variation. This observation followed the same trend as observed in the total weight gain. There was remarkable similarity in the mean weekly weight gain recorded in the Arbor Acre, Cobb and Ross strains which were not statistically different (P>0.05) but the values obtained for Marshall was highly significantly (P<0.0001) lower than values obtained in the other three strains (Table 2).

Feeding frequency was significant (P<0.05) on weekly weight gain of broilers in this study (Table 3) accounting for 1.37% of the total variation observed in weekly weight gain. Twice daily (12-hourly) feeding recorded 285.96g in weekly weight gain, while the thrice daily (8-hourly) had 274.31g (Table 2). There was a 4.25 percent superiority in weekly weight gain of the twice daily feeding frequency over the thrice daily feeding frequency (Table 2).

Influence of sex on weekly weight gain was significant (P<0.05) on mean weekly weight gain (Table 3), the male birds marginally recorded 0.7% superiority over the female birds and sex alone accounted for only 1.60% of the total variation in mean weekly weight gain (Table 3). Male birds had mean total weight gain of 281.21g, while female birds recorded mean weekly weight gain of 279.26g (Table 2).

Average Daily Gain

The minimum and maximum average daily gain recorded in the study was 20.24g and 62.97g respectively, with a mean value of 40.01g and coefficient of variation of 21.03% (Table 2).

Variability in average daily gain as expressed in the respective coefficient of variation across the four strains indicated that the Marshall strain had the least CV and as such was more homogenous in average daily gain than the other three strains. Average daily gain was largely influenced by strain accounting for 33.22% of the total variation (Table 3). The similarity in the effect of strain on total weight gain, weekly weight gain and average daily gain can be adduced to similarity in the computation of three indices.

Table 2: Mean ± Standard Error (S.E.) of effects of strain, feeding regimen and sex on final weight and average daily gain of broiler chickens

Variables		N	Initial Weight (g)	TWG (g)	WWG (g)	ADG (g)
Strain						
	Arbor Acre	45	37.69 ± 0.47^{b}	3074.8 ± 87.5^{a}	307.48 ± 8.95^{a}	43.93 ± 1.25^{a}
	Cobb	49	38.27 ± 0.42^{ab}	3026.7 ± 77.4^{a}	302.67 ± 7.74^{a}	43.24 ± 1.11^{a}
	Marshall	61	33.33 ± 0.36^{c}	2292.4 ± 44.9^{b}	229.24 ± 4.49^{b}	32.75 ± 0.64^{b}
	Ross 308	56	39.39 ± 0.44^{a}	2935.8 ± 66.4^{a}	293.58 ± 6.64^{a}	41.94 ± 0.95^{a}
Feeding Frequency						
	Twice Daily	104	37.35 ± 0.37	2859.6 ± 62.3^{a}	285.96 ± 6.23^{a}	40.85 ± 0.89^{a}
	Thrice Daily	107	36.69 ± 0.39	2743.1 ± 51.9^{b}	274.31 ± 5.19^{b}	39.19 ± 0.74^{b}
Sex						
	Female	125	37.31 ± 0.35	2792.6 ± 52.4^{b}	279.26 ± 5.24^{b}	39.89 ± 0.75^{b}
	Male	86	36.58 ± 0.42	2812.1 ± 64.4^{a}	281.21 ± 6.44^{a}	40.17 ± 0.92^{a}
Overall		211	37.01 ± 0.27	2800.5 ± 40.5	280.05 ± 4.05	40.01 ± 0.58

^{abc}Means with different superscript within the same column are statistically different (P<0.05)
N = Sample Size, TWG (g) = Total Weight Gain, WWG = Weekly Weight Gain, ADG = Average Daily Gain

Table 3: Least Squares Analysis of Variance of factors affecting growth parameters

Sources	df	Mean Squares Initial Weight	Mean Squares Final Weight	Mean Squares TWG	Mean Squares ADWG
Feed Frequency	1	35.60^{ns}	1011066*	999102*	203.90*
Strain	3	408.99***	8174630***	8068910***	1646.72***
Sex	1	0.40^{ns}	1165987*	1164617*	237.68*
Error	195	9.286	233625	233788	47.71
Eta Squared (%)		40.19	34.53	34.22	34.22

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

Values obtained for Arbor Acre, Cobb and Ross strains were not statistically different (P>0.05), while value obtained for Marshall strain was highly significantly (P<0.0001) lower than values obtained in the other three strains (Table 2).

Twice daily (12-hourly) feeding recorded 40.85g in weekly weight gain, while the thrice daily (8-hourly) had 39.19g (Table 2). There was a 4.24 percent improvement in average daily gain of the twice daily feeding frequency over the thrice daily feeding frequency (Table 2). Feeding frequency was significant (P<0.05) on weekly weight gain of broilers in this study accounting for 1.37% of the total variation (Table 3).

Male birds marginally had an average daily gain of 0.7% over the female birds (Table 2). Sex accounted for only 1.60% of the total variation in average daily gain (Table 3), albeit it was a significant ($P<0.05$) source of variation in average daily gain.

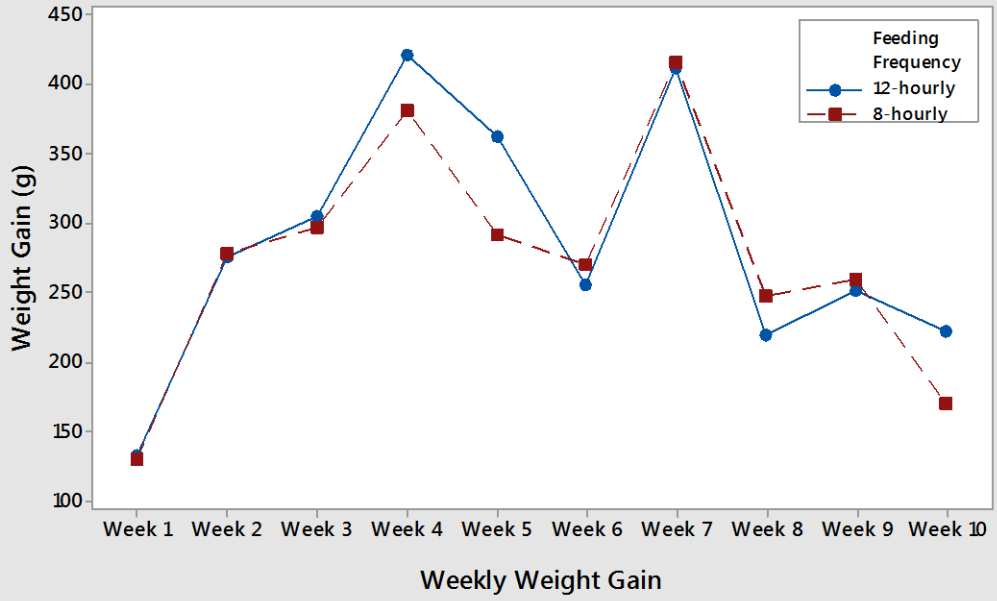

Figure 1: Mean Weekly Weight Gain of Broilers

Discussion

The only significant difference due to strain observed in term of initial body weight in Marshall strain against the other three strains (Arbor Acre, Cobb and Ross) can be explained by the fact that, while the other three strains were of temperate origin, the Marshall strain evolved in the tropical region and was developed more for fitness trait than for productivity trait.

Also, differences in the genetic make-up of the different strains of broilers is expected to influence the performances of the birds even when reared under similar environmental conditions [30, 31, 32].

Modern day broilers originated from great grandparent stock which were sourced from same origin and developed through intense selection and breeding by the different commercial broiler breeders. This explain the similarity in the total weight gain recorded in Arbor Acre, Cobb and Ross strains. However, the Marshall strain was developed to perform better in the stressful environment of the tropics and has not evolved to the stage of the other strains in terms of performance [18]. This observation confirms earlier reports [19, 20, 21, 22] on the effects of strain or breed on broiler growth parameters.

The reason that can be adduced to the superiority of the twice daily feeding frequency may be due to the fact that the larger portion allotted to the animals on each of the twice feeding was more to allow them feed to satiation and allow enough time to digest the feed before the next feeding [14,15,16]. This 12-hourly feeding has the advantage of well-defined and clearly delineated period of feeding, digestion and resting of the birds, resulting in improved physiological processes

and ultimately improved growth. This observation corroborates previous research on feeding frequencies [23, 24, 25] who all reported that birds fed twice daily out performed those fed thrice daily.

Differences in the physiological status of animals due to sex and their respective needs for growth and development explain the differences in the values obtained in this study due to sex. Several researchers have reported effect of sex on different growth parameters of broiler birds [26,27,28]. These researchers have established the superiority in growth characteristics of male birds over their female counterparts.

The same reason earlier advanced to explain differences in total weight gain can equally be adduced to the differences in weekly weight gain since the latter was derived from the former. Thus, genetic differences in the strains studied was responsible for the different values obtained for weekly weight gain across the four strains. This assertion is in alignment with reports of previous researchers [22, 29, 30].

Derivation of the weekly weight was predicated on the total weight gain and as such factors affecting the former will also affect the latter. There was progressive superiority of the twice daily (12-hourly) feeding method over the thrice daily (8-hourly) method throughout the weekly weight recordings, except for week 6 and week 8 where the later marginally recorded higher values. This is an indication that the twice daily method was superior at almost every stage of development of the birds. This corroborates previous research on feeding frequencies [23, 24, 25] who all reported that birds fed twice daily out performed those fed thrice daily on weekly gain.

Several researchers have reported effect of sex on different growth parameters of broiler birds [31, 32, 33, 34, 35] and just as it was reported in their reports, the influence of sex on weekly weight gain followed the same pattern as that observed in total weight gain, with the male birds exhibiting superiority over the female birds in weekly weight gain.

The same reasons that were advanced for the previous two growth parameters viz: total weight gain and weekly weight gain also applies to the average daily gain. Influence of strain, feeding frequency and sex all followed the trend as was earlier discussed [33, 34, 35, 36, 37].

Conclusion and Application

The following can be concluded from this study;

1. Differences in genotype of the four strains studied was a significant source of variation in total weight gain, weekly weight gain and average daily gain. It is only the Marshall strain that exhibited significantly different values in all parameters studied.
2. Twice daily (12-hourly) feeding regime is superior to the thrice daily (8-hourly) feeding regime in all parameters studied.
3. Male birds outperformed female birds in total weight gain, weekly weight gain and average daily gain.
4. The twice daily feeding regimen should be encouraged in broiler production for improved growth parameters on one hand for reducing labour cost occasioned by the additional feeding on the other hand.

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References

1. Petracci, M., S. Mudalal, A. Bonfiglio, and C. Cavani. (2013). Occurrence of white striping under commercial conditions and its impact on breast meat quality in broiler chickens. *Poultry Science*. 92:1670–1675
2. Hillar, M. and Swick, R. A. (2019). Nutritional implications of feeding

reduced-protein diets to meat chickens. *Animal Production Science.* 59 (11): 2069-2081

3. Thiruvenkadan, A. K., Prabakaran, R., and Panneerselvam, S., (2011). Broiler breeding strategies over the decades: an overview. *Worlds Poultry Science Journal* 67: 309–336
4. Jawasreh, T. Chamberlin, V.D. MCcartney, M.G and Toughburn S. P. (2019). Effect of feeding system on growth and feed conversion of several crosses and strain of turkeys. *Poultry Science* 41: 910-916.
5. Wilson, K. J. and Beyer, R. S. (2000). Poultry nutrition information for the small flock. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. http://www.oznet.ksu.edu.
6. Austic, B. (2015). Effect of reduced feeding time using mash or crumble pellet dietary regimes on chicken broiler performance. *Poultry Science* 16: 740-746.
7. Crouch, A. N, Lerner, S. P, and Karunakaran, D. (2010). Influence of feed quality in the brooding period of commercial turkey and its subsequent effect on market performance. *Poultry Science* 79 (sup.1): 67-68.
8. Calini, F. and Sirri, F., (2017). Breeder nutrition and offspring performance. *Brazilian Journal of Poultry Science* 9: 77–83.
9. Yahav S. (2015) Domestic fowl-strategies to confront environmental conditions. *Avian and Poultry Biology Review* 11:81-95.
10. Koppenol, A., Delezie, E., Aerts, J., Willems, E., Wang, Y., Franssens, L., Everaert, N., and Buyse, J. (2014). Effect of the ratio of dietary n-3 fatty acids eicosapentaenoic acid and docosahexaenoic acid on broiler breeder performance, egg quality, and yolk fatty acid composition at different breeder ages. *Poultry Science* 93: 564–573.
11. Soltanmoradi, M.G., Seidavi, A., Dadashbeiki, M., Laudadio, V., Centoducati, G., Tufarelli, V., (2014). Influence of feeding frequency and timetable on egg parameters and reproductive performance in broiler breeder hens. *Avian Biology Research* 7: 153–159
12. Lilbum, M. S. (2017). Feeding the male broiler. In "Recent development in poultry nutrition 2, Eds. PC Garnsworthy and T. Wiseman, Nottingham University Press
13. Agah, M.J. and Norollahi, H. (2008). Effect of Feed Form and Duration Time in Growing Period on Broilers Performance. *International Journal of Poultry Science*, 7: 1074-1077.
14. Cave, N. A., (2011). Effect of diurnal programs of nutrient intake on performance of broiler breeder hens. *Poultry Science* 60, 1287–1292.
15. Farmer, M., Roland, D. A., and Brake, J., (2013). Calcium metabolism in broiler breeder hens. *Poult. Sci.* 62, 465–471
16. Spradley, M. H., Brown, H. B. and McCartney, M. G. (2018). Effect of dietary energy and protein and feeding time on broiler performance. *Poultry Science* 61: 304-310.
17. Kareem-Ibrahim, K. O., Abanikannda, O.T.F. and Nwadialo, S.O. (2021). Breed differences in growth parameters of broiler chickens. *Nigerian Journal of Animal Science* 23 (1): 18-29.
18. Nargish, P., Tapas, K. M., Vijaylaxmi, S., Sabyasachi, S. and Ashok, K. S. (2010). Effect of increasing protein percentage feed on the performance carcass characteristics of the broiler chicks. *Asian Journal of Poultry Science* 4 (2): 53 – 59.
19. Udeh, I., Ezebor, P.N. and Akporahuarbo, P.O. (2015). Growth performance and carcass yield of three commercial strains of broiler chickens raised in a tropical environment. *Journal of Biology and Agricultural Health*, 2: 62–67.
20. Thutwa, K., Nsoso, H.J., Kgwatalala, P.M. and Moreki, J.C. (2012). Comparative live weight, growth performance, feed intake carcass traits and meat quality in two strains of Tswana chickens raised under intensive system. *International Journal of Applied Poultry Research*, 11: 121–126.

21. Hossain, M.A., Suvo, K.B. and Islam, M.M. (2011). Performance and economic suitability of three fast- growing broiler strains raised under Farming condition in Bangladesh. *International Journal of Agricultural Research Innovation and Technology*, 1(1&2): 37-43
22. Abdullah, A.Y., Al-Beitawi, N.A., Rjoup, M.M.S., Qudsieh, R.I. and Ishmais, M.A.A. (2010). Growth performance, carcass and meat quality characteristics of different commercial crosses of broiler strains of chicken. *Journal of Poultry Science*, 47: 13-21.
23. Skinner, D. O., Noble, Berry J.G. and Teeter R.G. (2011). Use of a single diet feeding programme for female broilers. *Animal Science Research Report*. 43-46.
24. Vandegrift, K. (2012). An analysis of the nonlinear dynamics of daily broiler growth and feed intake. M.S. Thesis. Penn State University, PA.
25. Vandegrift, K., Cravener, T.L., Hulet, R.M. and Roush, W. B. (2013). Analysis of the nonlinear dynamics of daily broiler growth and feed intake. *Poultry Science*, 82:1091-1099.
26. Ikusika, O.O., Falowo, A.B., Mpendulo, C.T., Zindove, T.J. and Okoh, A.I. (2020). Effect of strain, sex and slaughter weight on growth performance, carcass yield and quality of broiler meat. *Open Agriculture*, 5: 607–616.
27. Uhlíová, L., Tmová, E., Chodová, D., Vlková, J., Ketta, M. and Volek, Z. (2018). The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of Geese. *Asian-Australasian Journal of Animal Science*, 31: 421–428.
28. Fernandes, J.I.M., Bortoluzzi, C., Triques, G.E., Neto, A.F.G. and Peiter, D.C. (2013). Effect of strain, sex and age on carcass parameters of broiler. *Acta Scientiarum Animal Sciences Maringá*, 35(1): 99-105.
29. Hoffmann, I. (2005). Research and investment in poultry genetic resources. *World's Poultry Science Journal*, 61(1): 57-70.
30. Sarker, M.S.K., Islam, M.A., Ahmed, S.U. and Alam, J. (2002). Profitability and meat yield traits of different fast growing broiler strains in Winter. *Online Journal of Biological Science*, 2(6): 361-363.
31. Shim, M.Y., Tahir, M., Karnuah, A.B., Miller, M., Pringle, T.D. and Aggrey, S.E. (2012). Strain and sex effects on growth performance and carcass traits of contemporary commercial broiler crosses. *Poultry Science*. 91: 2942–2948.
32. Olawumi, S. O., Fajemilehin, S. O. and Fagbuaro, S. S. (2012). Genotype X Sex Interaction Effects on Carcass Traits of Three Strains of Commercial Broiler Chickens. *Journal of World's Poultry Researchers.* 2(1), 21–24.
33. Rondelli, S., Martinez, O. and Garcia, P.T. (2003). Sex effect on productive parameters, carcass and body fat composition of two commercial broilers lines. *Brazilian Journal of Poultry Science*, 5: 169-173.
34. Nargish, P., Tapas, K. M., Vijaylaxmi, S., Sabyasachi, S. and Ashok, K. S. (2010). Effect of increasing protein percentage feed on the performance carcass characteristics of the broiler chicks. *Asian Journal of Poultry Science*, 4 (2): 53 – 59.
35. Al-Marzooqi, W., Al-Maskari, Z.A.S. Johnson, E.H., Al-Kharousi, K., Mahgoub, O., Al-Saqri, N.M. and El Tahir, Y. (2019). Comparative evaluation of growth performance, meat quality and intestinal development of indigenous and commercial chicken strains. *International Journal of Poultry Science*, 18: 174-180.
36. Tavárez, M. A. and Solis de los Santos, F. (2016). Impact of genetics and breeding on broiler production performance: a look into the past, present, and future of the industry. *Frontiers*, 6(4): 37-41.
37. Puchała, M., Krawczyk, J., Sokołowicz, Z. and Utnik-Banaš, K. (2015). Effect of breed and production system on physicochemical characteristics of meat from multi-purpose hens. *Annals of Animal Science*, 15: 247–261.