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Effects of strain and feed restriction at starter phase on performance of broiler chickens in the humid tropics

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Abstract
The objective of the present study was to determine the effect of quantitative feed restriction on the growth performance and livability of broiler strains. It also aimed at estimating the economics of production of the different treatments applied in order to suggest the cheapest and profitable means of growing broiler chickens. A total number of 90 day-old broilers of Anak Titan and Arbor Acres were randomly allocated to three treatments: *ad libitum* (T_1), 85% *ad libitum* (T_2) and 75% *ad libitum* (T_3)from 11^{th} -18^{th} days of age. Thereafter, the birds were given full feed until the age of 49 days. Treatments were replicated three times with five birds per replicate. Data on body weights and feed consumed were recorded on weekly basis to the seventh week. It was evident from this study that feed restriction during second week post-hatch has no detrimental effects on the livability, final body weight and weight gain of the two strains of broilers. Feed cost which was a major component contributed 46% to the total cost of production. With regard to feed restriction regimen, control and 85% *ad libitum* birds were at par in body weight and weight gain, but superior to 75% *ad libitum* birds. In addition, birds fed 85% *ad libitum* had the least feed conversion ratio and recorded highest net profit per bird when compared with control and 75% *ad libitum*. Average net profit per bird for birds fed 85% *ad libitum* was $2.598, while control and 75% *ad libitum* were $2.584 and $1.906, respectively. It is suggested that for maximization of feed utilization and profitable broiler meat production in the humid tropics, Arbor Acre and 85% *ad libitum* for short-term during starter phase could be considered.

1. Introduction

Feed restriction is one of the management tools designed to limit the birds' access to feeds during a definite period of time. This might take the form of either quantitative or qualitative feed restriction regimen. The former refers to limiting the time birds have access to feeds in a day, while the latter is actual denying the birds full access to certain nutrients by diluting the formulated feeds with inert fibres such as wheat offals [1,2 3,4]. Feed restriction in broilers and pullets had been used in early studies to reduce the incidence of metabolic disorders [5,6,7,8]. It had also been reported that feed restriction help in arterial oxygenation mainly by reducing metabolic demands during the critical periods of the life span of a bird [9,10]. However, prolonged feed restriction reduced the potentials of compensatory growth in birds [7,11].

The success of any broiler production depends not only on the strain of the birds, but also on management, housing, quality and quantity of feeds given, health status and market forces. Khan et al. [12] observed that feed constituted 60% of the total cost of

production in a broiler enterprise, and whatever method to reduce this high input component should be considered for the good of the farmers and overall interest of the industry. Zubair and Leeson [13] asserted that feed restriction in broilers can help improve feed efficiency, reduce feed cost and mortality in addition to producing chicken meat at affordable price. It was further reported in literature that feed restriction reduced chances of metabolic disorders like ascities syndrome which are common with broiler production resulting in high mortality thereby making the enterprise unprofitable [14]. There are different methods of feed restriction employed in broiler production to improve efficiency of feed utilization and weight gain, and these include intermittent feeding, skip-a-day feeding [15], appetite suppression with glycolic acid [16], time of restriction [17], diet dilution [18] and quantitative feed restriction [19].

In literature, the use of quantitative feed restriction at an early age to promote efficient feed utilization, compensatory growth and reduced abdominal fat pad had been given adequate attention. Early studies had reported that feed restriction at an early age of birds for a short time elicited compensatory growth and that the birds attained similar body weight with full-fed birds at maturity [20,21]. In addition, Novele et al. [21] reported that early period 75% *ad-libitum* recorded an economic advantage over *ad-libitum* by enhancing feed utilization and that the birds attained complete compensatory live weight at 42 days of age. Some other investigators found significant strain differences in body weight gain, final body weight, feed intake and feed conversion ratio [15,18]. The researchers documented that feed restriction reduced feed intake, weight gain and body weight in all feed restricted birds. However, other previous investigators [23] observed no significant effects of feed restriction on body weights, average daily gain and average daily feed intake at week 6. In view of the conflicting reports on effect of feed restriction on broiler performance, this study was undertaken to examine the effectiveness of limiting the access of broilers to feeds at starter phase achieved through quantitative feed restriction on body weight, body weight gain, feed intake, feed conversion ratio and mortality rate at maturity.

2. Materials and Methods

The study was carried out at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti from September, 2012 to November, 2012. Ado-Ekiti is situated along latitude $7^0 31^1$ and $7^0 49^1$ North of the Equator and longitude $5^0 71^1$and $5^0 27^1$East of the Greenwich meridian.The city falls under Derived Savannah zone. The city enjoys two separate seasonal periods namely, Rainy (May-October) and Dry (November-April) seasons.

Ninety, one-day-old broiler (45 chicks each of Arbor Acre and Anak Titan) chicks were purchased from local hatcheries and reared in groups on strain basis for 10 days (acclimatization period). The chicks were kept under the same management conditions such as light, space, temperature, ventilation and relative humidity. They were brooded on the floor bedded with dry wood shavings, and the temperature of the house was controlled to meet their requirements using dry charcoal as heat source. On arrival, multivitamins were added to water together with prophylactic dosage of antibacterial drug. Fresh and clean water was available *ad libitum*. The chicks were vaccinated against Newcastle and infectious bursa diseases at recommended dose, and at specified ages. At 11^{th} day of age, all the chicks on strain basis were randomly distributed into nine experimental units (replicates) having five chicks each. These experimental units were allotted to three treatments per strain (three replicates/treatment), that is, T_1(*ad libitum*), T_2 (85% *ad libitum*), T_3 (75% *ad libitum*). The restricted feeding lasted 7 days, that is, 11^{th}-17^{th} day post-hatch. Thereafter, the birds were restored to full feeding till the end of the experiment (49 days).

During the adaptation period (1-10 days), all the chicks were fed *ad libitum*, but from 11^{th} to 17^{th} day, T_1 (T_1R_1, T_1R_2, T_1R_3) birds alone were given full feed, while T_2 (T_2R_1, T_2R_2, T_2R_3) and T_3 (T_3R_1, T_3R_2, T_3R_3) birds were given 85% and 75% *ad libitum*, respectively. The birds were fed starter mash (1-4 weeks) containing 22%CP and 3000Kcal/KgME, while at 4-7 weeks they were given finisher feed containing 20%CP and 3100Kcal/KgME.

Data collected include body weight at 11^{th}, 18^{th}, 25^{th}, 32^{nd}, 39^{th} and 49^{th} day of age. Also, data were collected on feed intake, body weight gain, feed conversion ratio and mortality (if any) up to 7^{th} week when the experiment was terminated. Mortality was recorded on daily basis per treatment.

$$\text{Feed conversion ratio} = \frac{\text{feedconsumed/bird(gm)}}{\text{final body weight/bird (gm)}}$$

Cost of production of the birds under each treatment on strain basis was calculated per bird in order to determine the group with highest profit margin.

2.1. Statistical Analysis

The data were analyzed by the analysis of variance technique in completely randomized design, while the differences between means were tested by Duncan New Multiple Range Test as per SAS [24].

The statistical model used was:

$$Y_{ijk} = \mu + G_i + R_j + \varepsilon_{ijk}$$

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

μ = common mean

G_i = fixed effect of strain (i=2)

R_j = fixed effect of feed restriction (j=3)

ε_{ijk} = error term

3. Results and Discussion

The least square means (Table 1) show the body weight of broiler chicken strains as affected by feed restriction regimen. There was no significant ($P>0.05$) effect of strain regardless of levels of feed restriction on the live weight of the two broiler chicken strains subjected to feed restriction at

different age divisions. Results reveal that the differences in body weight and daily gain between control and restricted group were not significant (P>0.05) at 18th, 25th, 32th, 39th and 49th day of age.

It was evident from the results of this study that feed restricted birds demonstrated what could be referred to as catch-up growth phenomenon upon refeeding. These results are in agreement with those of previous authors who obtained complete catch-up in body weight of Ross broiler chicken strains [25]. However, the effect of strain on body weight of feed restricted boiler chicken was observed by Benyi et al. [15] who reported significant strain differences in final body weight between Ross and Hybro birds. The insignificant differences observed between strains notwithstanding, all the birds within each strain increased in size from week one to the end of the study. Also, no mortality, skeletal or metabolic disorders were recorded within and between strains as a result of treatment imposed. With regards to body weight gain, no significant difference was found between the two strains. That is, the two broiler strains gained weight at equal rate during the periods of treatment and after returning them to full feeding.

In the current study (Table 2), there was significant (P<0.01) effect of feed restriction on final body weight of broiler chickens. At the expiration of one-week feed restriction period, that is, 18th day, the difference in body weight between control and 85% full feeding was not significant but they were significantly (P<0.01) superior to 75% full feeding. Also, at 49th day, control and 85% full feeding recorded significantly (P<01) higher means of body weight than 75% full feeding. In other age divisions, 75% *ad libitum* recorded the least body weight than the other two groups. As expected, body weight gain followed similar trend, that is, birds under control and 85% *ad libitum* had significantly (P<0.01) higher weight gain than 75% *ad libitum* mates. The degree or severity of feed restriction seemed to affect body weight and weight gain of broilers in this experiment. It can be inferred from this study that the birds subjected to severe feed restriction failed to make up in body weight upon refeeding when compared to other groups which were full-fed or 85% *ad libitum*. Milder feed restriction such as 85% *ad libitum* appeared beneficial, and could be practiced and is therefore, recommended to farmers in this zone since birds so treated performed better like control birds. The result of this study confirmed the findings of early researchers who reported that broiler chickens subjected to a short period of severe early feed restriction showed a complete catch-up in body weight following refeeding [25,26]. However, in contrast to this result, Khetani et al. [23] observed no significant effect of feed restriction on body weight and body weight gain in broilers.

Table 1. *Least squares means (±SE) showing the effect of strain on body weight and body weight gain*

Traits	Age (days)	Breeds	
		Arbor Acre	Anak Titan
Body weight (g)	11	141.02±3.68	142.93±5.13
	18	266.76±9.03	255.91±12.55
	25	503.47±9.46	491.20±12.28
	32	865.34±13.29	820.89±29.43
	39	1244.44±21.70	1204.89±32.51
	49	1829.79±27.59	1799.11±43.67
Body weight gain (g)	11-17	125.73±6.60	112.98±9.79
	18-24	236.71±6.97	235.29±10.05
	25-31	361.88±13.26	329.69±23.90
	32-38	379.10±13.62	384.00±21.26
	39-49	585.33±24.09	594.22±14.91
	11-49	1688.76±27.28	1656.18±40.93

Table 2. *Least squares means (±SE) showing the effect of feed restriction on body weight and body weight gain*

Traits	Age (days)	Feed Restriction		
		100%	85%	75%
Body weight (g)	11	149.47^{a}±3.47	146.37^{a}±4.29	130.10^{b}±4.66
	18	284.13^{a}±5.77	272.30^{a}±7.82	227.57^{b}±11.88
	25	509.60±10.80	509.20±12.48	473.20±12.34
	32	857.12^{ab}±11.32	875.50^{a}±11.44	796.73^{b}±43.13
	39	1262.90^{a}±25.39	1215.10^{a}±10.44	1160^{b}±43.35
	49	1862.43^{a}±24.05	1860.90^{a}±36.66	1720^{b}±44.12
Body weight gain (g)	11-17	134.67^{a}±6.56	125.93^{a}±5.81	97.47^{b}±11.44
	18-24	225.47±7.80	236.90±11.18	245.63±11.52
	25-31	347.52±10.38	366.30±7.75	323.53±39.95
	32-38	405.78±21.40	375.60±17.04	363.27±24.37
	39-49	599.53±20.30	609.80±30.32	560±18.19
	11-49	1712.97^{a}±24.30	1714.53^{a}±37.86	1589.90^{b}±43.56

ab means along rows with different superscripts are significantly different (P<0.01)

The least squares analysis in Table 3 represents feed consumption and feed conversion ratio (FCR) of the birds during the experimental period for control (*ad libitum*), 85% *ad libitum* and 75% *ad libitum.* The values for feed intake were 3985g, 3936g and 3908g, respectively. It was evident that the birds fed 75% *ad libitum* consumed significantly (P<0.01) less feed than those of the other two groups. The control birds had the highest mean values in term of feed intake, while 85% *ad libitum* recorded intermediate mean values. Previous study by Mahmood et al. [27] found that feed restriction resulted to depressed feed consumption. With regard to feed conversion ratio, the values obtained for control, 85% *ad libitum* and 75% *ad libitum* were 2.33, 2.30 and 2.47, respectively. Feed conversion ratio was calculated based on the quantity of feed consumed to produce a unit live weight gain in birds under evaluation. The results of the study reveal that birds fed 85% *ad libitum* had the least FCR when compared with the control and 75% *ad libitum.* This implies that the former utilized their feed given efficiently than those fed *ad libitum* and 75% *ad libitum.* The results of the present study corroborates the findings of Lee and Leeson [19] and Mahmood et al. [27] who observed better feed efficiency in feed restricted broilers than those fed *ad libitum.* Probable explanation for the efficient feed utilization of the birds fed 85% *ad libitum* may be due to reduced heat stress arisen from lesser energy expended during food digestion as compared to birds fed *ad libitum.* It was obvious from the results of this study that severe feed restriction such as 75% *ad libitum* has detrimental effects on birds' feed efficiency judging from high FCR obtained in the present study.

Table 3. *The average initial and final body weight, feed intake, weight gain and feed conversion ratio of broilers from 11-49 days*

Description	Feed Restriction			
	100%	85%	75%	SE
Initial body weight (g)	149.47[a]	146.37[a]	130.10[b]	2.12
Feed intake (g)	3985[a]	3936[b]	3908[c]	5.20
Final body weight (g)	1862.43[a]	1860.90[a]	1720[b]	2.30
Weight gain (g)	1712.97[a]	1714.53[a]	1585.90[b]	0.80
Feed conversion ratio (FCR)	2.33[ab]	2.30[b]	2.47[a]	6.65

abc means along rows with different superscripts are significantly different (P<0.01)

In the present study, birds fed *ad libitum* and the two feed restricted groups recorded no mortality throughout the period of the experiment. This can be attributed to proper management, airy and well-ventilated housing and good hygienic conditions offered the birds during the observed period. The results of this study contradicts those of Mahmood et al. [27] who reported higher mortality in birds fed *ad libitum* than the feed restricted birds. According to the authors, feed restricted birds produced less heat when compared to birds fed *ad libitum*.

The rearing cost of broilers kept under different feed restriction regimen, that is, *ad libitum*, 85% *ad libitum* and 75% *ad libitum* were $3.235, $3.218 and $3.469, respectively (Table 4). The selling price per bird was $5.819, $5.816 and $5.375, respectively for *ad libitum,* 85% *ad libitum and* 75% *ad libitum* .However, the net profit per broiler for birds fed *ad libitum,* 85% *ad libitum and 75% ad libitum* was $2.584, $ 2.598 and $1.906, respectively.

Table 4. *Economics of broiler production kept under different feed restriction regimen*

Description	Feed Restriction		
	100%	85%	75%
Cost/chick ($)	1.56	1.56	1.56
Feed consumed (kg, 11-49days)	4.09	4.04	4.00
Feed cost ($/kg)	0.7	0.7	0.7
Total feed cost ($)	2.863	2.828	2.807
Cost of medication ($/bird)	0.7	0.7	0.7
Miscellaneous ($)	1.0	1.0	1.0
Total cost of production ($/kg)	3.235	3.218	3.469
Average live weight (kg)	1.862	1.861	1.72
Selling price ($/kg)	3.125	3.125	3.125
Selling price ($/bird)	5.819	5.816	5.375
Net profit ($/bird)	2.584	2.598	1.906

$=₦150 (Nigerian currency)

With regard to economics of production, it was evident that net profit per broiler was highest for 85% *ad libitum* than control and 75% *ad libitum.* The present result indicates that it is economical and profitable to raise broilers with 85% *ad libitum* without compromising the quantity of meat produced. The result supports the observation of Novelle et al. [22] who asserted that level of feed restriction caused some economic advantage over *ad libitum* feeding by enhancing feed utilization. It is also interesting to note that mortality in this group was also zero; live weight was also at par with control birds in addition to reduced feed cost obtained in this group.

4. Conclusion

The result of the present study showed that milder feed restriction such as 85% *ad libitum* at second week post-hatch

is beneficial, economical and practicable, and has no detrimental effects on birds' welfare and performance. This implies that the phenomenon of catch-up growth depends on the level or degree of feed restriction imposed. Growth rate was as good as the control birds, and they utilized the feed given efficiently. In addition, no mortality was recorded and there was higher net profit per bird than control birds. In contrast, severe feed restriction in this study, that is, 75% *ad libitum* resulted to smaller body weight, poorer feed efficiency and lower net profit per bird. For profit maximization in this zone, It is suggested that Arbor Acre and 85% *ad libitum* for short-term during starter phase could be considered.

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