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Effect of *Ad-libitum*, Split and Restricted Feeding on Performance, Digestibility and Welfare of Broiler Chickens

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Authors' contributions

This work was carried out in collaboration between all authors. Author GOA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author RTB performed the statistical analysis and managed the analyses of the study. Authors OGL and ADO contributed ideas that led to the study. All authors concerned read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to assess the performance, welfare and digestibility of broilers fed varying forms of feeding regimes. The objective of this work research was investigate the possibility of improving growth performances, digestibility and welfare of broilers using *ad libitum*, split and restricted feeding.

Formulated diet was given in four different forms *Ad-libitum* (Treatment 1) twice a day meal/split feeding (Treatment 2) thrice a day feeding (Treatment 3) 3 hours restriction feeding (Treatment 4). Experimental design was completely randomized design. 240 broilers were randomly allotted to four treatments with 6 replicates and 10 birds per replicate. Birds were weighed weekly to evaluate their performances, faeces was collected on day 42, to determine digestibility and rectal temperature was taken as a measure of bird's wellbeing.

Results showed that there were no significant differences ($p \geq 0.05$) in performance of birds across treatments but values from birds fed *Ad-libitum* were higher. Rectal temperature (RT) differ at week

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4, birds fed 3 hours restricted feeding had the highest RT (41.62℃) while the least RT were from birds fed *Ad-libitum* (41.20℃). Significant differences were obtained in digestibility and nutrient utilization of broilers with respect to feeding regimes. Crude protein (CP) digestibility was significantly higher in birds fed 3 hours restriction (81.91%) while birds fed *Ad-libitum* had the least (46.76%). The digestibility of crude fibre was higher in birds fed 3 hours restricted feeding regime (86.77%) the least was from birds fed thrice a day feeding regime (62.66%). A similar trend was obtained for digestibility of gross energy.
Ad-libitum feeding had the highest non-significant performance values but split feeding optimized feed and nutrient utilization thereby enhancing performance and minimizing nutrient waste at the same time.

Keywords: Ad-libitum; broiler; digestibility; restricted feeding; rectal temperature.

1. INTRODUCTION

Since feed cost represents about 70% of the total cost of broiler production, the focus has largely been on improvements in feed efficiency. Thus, bird selection is performed using optimized and easily digestible diets thus providing no information about the ability of the birds to digest more complex diets. Improving the digestive capacity of poultry could allow the incorporation of a higher proportion of lower quality feedstuffs and thus reduce the competition between human and poultry for the same food/feed materials.

Any attempt to improve commercial poultry production and increase its efficiency needs, therefore, to focus on better utilization of available feed resources [1]. Restricting the daily feed offered for some time and stimulating compensatory growth [2,3,4,5,6] is one of the means to reduce feed cost. Feed restriction during the growing period in broiler chickens lowers body weight and carcass fat and improves feed efficiency with compensatory growth during refeeding [7]. In laying traits, feed restriction during rearing decreases adult body weight, delays age of sexual maturity and decreases mortality [8] and decreases the number of the heavy follicles at the onset of laying [9]. Feed restriction in brown layers between 6-18 weeks of age increases egg production with a little increase in feed consumption in the laying period and without affecting egg quality traits [10].

The benefits of feed restriction include reduced mortality as it slows down fast growth to reduce mortality [11], including preascites and ascites [12]. Feed restriction decreases mortality caused by "sudden death syndrome" [13]. It also encourages compensatory growth which enables full recovery of body weight [14]. Zhan et al. [15,16,17] reported that the feed restriction increases feed intake. The higher feed intake can be related to the hypertrophy of the gastrointestinal tract that occurs after the restriction period, when the birds are fed *ad libitum*. Feed restriction improves feed efficiency in chickens which could be attributed to reduced overall maintenance requirements caused by a transient decrease in basal metabolic rate. However, the improved feed efficiency can also be related to higher feed intake and to the hypertrophy of the gastrointestinal tract that occurs after the restriction.

The aim of the present research was to investigate the possibility of improving growth performances, digestibility and welfare of broilers using *ad libitum*, split and restricted feeding starting at day 14 to day 28 of age and thereafter *ad libitum* as compensatory growth till 42nd day.

2. MATERIALS AND METHODS

The research was carried out at the Poultry unit, Teaching and Research Farm of the University of Ibadan, Ibadan Oyo state, Nigeria. Ibadan lies on the longitude 4°15' East of the Greenwich Meridian and latitude 8°15' North-East of the Equator. The altitude is between 300 and 600 meters above sea level. The mean annual temperature is about 27℃ while that of rainfall is 247 mm.

250 unsexed day old Abor acre breed of broilers were purchased from CHI farms located in Ibadan. The birds were allotted such that each treatment had 10 birds per replicate.

Two basic diets comprising of the starter and finisher diets were formulated. The gross composition of the experimental diets is shown in Tables 1 and 2. The birds were given their experimental diets as stated according to the experimental treatment design. Clean water was given *ad libitum* after the daily routine of

observing the birds, removal of dead birds if available, leftover of the feed and water offered to each replicate the previous day is removed.

The birds were weighed on commencement of the experiment to obtain the initial weight and 10 birds were randomly selected and assigned to each of the four treatments of 6 replicates each making a total of 240 birds.

Treatment 1- *Ad-libitum*, Treatment 2-Morning and Evening (twice/split/meal feed) Treatment3-Morning, afternoon and evening (thrice), Treatment4-Restricted feeding (3 hours interval).

Samples of each diet fed to the birds (starter and finisher) were analyzed to determine the dry matter, Crude protein, Crude fiber, Ether extract and Nitrogen free Extract according to the method of AOAC (2000).

The experimental design was completely randomized design.

3. PERFORMANCE CHARACTERISTICS OF BROILERS

Feed consumption per day was obtained by weighing a known quantity of feed for all replicate in well labeled feeders at the beginning of the day. The left over the next morning is weighed to obtain feed consumed for the corresponding day by difference. The average feed intake per bird is determined by dividing by the number of birds.

The initial weights of the birds were taken at the commencement of the research work. Subsequently weights were taken on weekly basis and difference between mean weights for two successive weeks was calculated to obtain the average weight gain of birds per week. The final body weight was also taken to ascertain the performance of the birds at six weeks.

Feed conversion ratio was calculated as a ratio of total quantity of feed consumed per bird in Kg and the mean body weight gain in kg.

> Feed Conversion = (Total quantity of feed consumed per bird in Kg/ Mean body weight gain in kg)

Faeces were collected daily and stored at 4℃. The total faeces per day was weighed and recorded. Thereafter it was homogenized and samples taken for freezing.

At the end of each experimental period the samples were polled and mixed. Sub-samples were taken and dried at 60℃.

The dried faeces were milled through 1 mm screen prior to chemical analysis.

> Total tract nutrient digestibility (%) = {(Nutrient intake - Nutrient output / Nutrient intake) X 100%}
>
> Nutrient intake = (Amount of feed consumed within the period X% Nutrient analyzed in excreta)

Nutrient output = Total weight of excreta voided X% Nutrient analyzed in excreta. The chemical composition was determined according to the methods of [18].

Table 1. Gross composition of starter diet

Ingredients	Quantity
Maize	58.00
Groundnut cake	33.00
Soyabean meal	4.60
Fish meal (72%)	0.50
Full fat soya	3.00
Oyster shell	0.50
Di-calcium phosphate	2.50
Salt	0.25
Methionine	0.15
L –lysine	0.25
Premix	0.25
Total	100.00
Calculated values	
Crude protein (%)	23.11
Metabolizable energy (kcal/kg)	3005.31
Crude fibre (%)	3.82
Calcium	1.02
Ether extract	3.86
Available phosphorus (%)	0.55

3.1 Rectal Temperature

Rectal body temperature, also known as normothermia or euthermia, this depends on the place in the body at which the measurement is made, the time of day, as well as the activity level of the person bird. This was taken by inserting a clinical thermometer in the rectum of the bird until the final value of the thermometer is attained.

Data generated were subjected to one-way analysis of variance (ANOVA) using [19] package and means were separated using SAS

MICRO of the same software at 5% level ($p<0.05$) of significance.

Table 2. Gross composition of finisher diet

Ingredients	Quantity
Maize	56.50
Groundnut cake	9.50
Wheat offal	10.00
Fish meal (72%)	0.30
Full fat soya	20.00
Oyster shell	1.00
Di-calcium phosphate	1.95
L-lysine	0.10
Salt	0.25
Methionine	0.15
Premix	0.25
Total	100.00
Calculated values	
Crude protein (%)	19.72
Metabolizable energy (kcal/kg)	3000.39
Crude fibre (%)	3.79
Calcium	1.12
Ether extract	5.51
Available phosphorus (%)	0.45

4. RESULTS

Table 3 showed the effect of various feeding regimes on the growth performance of broilers. The effect of feeding regimes had no statistical differences ($p > 0.05$) for feed conversion ratio (FCR) between birds fed *Ad-libitum* and those fed twice or thrice or those fed under 3 hours restriction period. Birds fed under the 3 hours restriction had the highest FCR mean value of 2.161, followed by those fed thrice with mean value of 2.151 and those fed *Ad-libitum* had the lowest FCR mean value of 1.937.The feeding regimes had no significant effect ($P > 0.05$) on the final weight gain of bird under *Ad-libitum*, twice feeding, thrice feeding and those under 3hours restriction period. Birds in the *Ad-libitum* feeding regime had higher weight gain value of 1.288 kg at 6 weeks period, while those fed thrice daily had the lowest mean value of 1.207 kg at 6 weeks. There were no statistical differences p (> 0.05) between birds fed *ad-libitum*, twice, thrice and 3 hours restriction in relation to their initial weight per bird. Bird's initial weight mean values at week two ranged between of 0.073 kg, to 0.083 kg for all the treatments. *Ad-libitum* birds had the highest mean values of 0.083 kg as Initial weight per birds. Furthermore, feeding regime had no significant effect on the average weight gain per birds per day which range between 0.043 kg to 0.046 kg per bird. The *Ad-libitum* had higher average weight gain of 0.046 kg per bird day and those fed thrice and 3hours restriction had the lowest mean values for average weight gain of 0.043 kg per bird per day. The total feed intake per bird showed no significant differences ($P > 0.05$) between the four treatments. The average feed intake per bird per day throughout the period was not significantly different ($P > 0.05$) for all the treatments.

The obtained different rectal temperatures are shown on Table. 4. There were significant differences ($P < 0.05$) observed in rectal temperatures across the treatments. At week 4, the 3 hours restricted feeding had the highest rectal temperature (41.62℃) while the least rectal temperatures came from birds fed *Ad-libitum* (41.20℃). At week 6, there were no significant differences ($P < 0.05$) in the effect of feeding across all treatments.

The digestibility on Table 5 showed statistical significance in the effect of feeding regimes on broilers across all treatments. The three hour restriction birds' period was able to use the nutrients better with the highest crude protein, crude fibre and gross energy digestibility of 81.91%, 86.77% and 77.76% respectively compared to other feeding regimes which had lower values.

Table 3. Effect of different feeding regimes on broiler performance

Parameter	*AD-libitum*	Twice	Thrice	3hours restriction	Sem
AIW/bird(kg)	0.083	0.081	0.078	0.073	0.00
AWG/bird/day(Kg)	0.046	0.045	0.043	0.043	0.00
AFI/bird/day(Kg)	0.089	0.093	0.092	0.093	0.00
TFI/bird(Kg)	2.479	2.605	2.585	2.600	0.03
FWG/bird(Kg)	1.288	1.252	1.207	1.213	0.02
FCR/bird/day	1.937	2.094	2.151	2.161	0.05

AIW = Average initial body weight, AWG = Average weight gain, AFI = Average feed intake, TFI = Total feed intake, FWG = Final weight gain, FCR = Feed conversion ratio

Table 4. Effect of feeding regimes on broiler's rectal temperature

Parameter (°C)	*Ad-libitum*	Twice	Thrice	3 hours Restriction	Sem
Week 4	41.20^{b}	41.26^{ab}	41.38^{ab}	41.62^{a}	0.12
Week 6	41.33	41.67	41.63	41.43	0.23

Means with the same superscript are not significantly different from each other .p(>0.05)
Means with different superscript are significantly different from each other .p(>0.05)
SEM = Standard error means

Table 5. Effect of feeding regimes on broilers apparent nutrient digestibility

Parameter	*Ad-libitum*	Twice	Thrice	3 hours Restriction	Sem
CP (%)	46.76^{d}	52.74^{c}	63.23^{b}	81.91^{a}	7.71
CF (%)	79.22^{b}	86.12^{a}	62.66^{c}	86.77^{a}	5.61
GE (Kcal/Kg)	72.89^{b}	73.25^{b}	59.88^{c}	77.76^{a}	3.85

Means with the same superscript are not significantly different from each other (P >0.05)
Means with different superscript are significantly different from each other (P >0.05)
SEM=standard error means; CP = Crude protein; CF = Crude fibre; GE= Gross energy

5. DISCUSSION

Feed restriction had no significant effect on the final body weight gain of chicks at the end of the experiment between the treatment groups. The result of the study agrees with those of [20,21,22] who observed similar weight gain in feed restricted and *ad libitum* fed birds. However, this result disagreed with that of [23] and Lee and Leeson [24] who reported higher weight gain in feed restricted birds. The lack of significance differences for body weight gain in chicks between the different treatments may be due to the occurrence of compensatory growth during the feeding period in feed restricted birds. Jones and Ferrell, [25] suggested that body weights during feed restriction period might have an important role on the occurrence of compensatory growth when feed is served. The feed efficiency ratios were not affected by the feeding regimes these findings are in agreement with the reports of [26,27,28]; who reported a non-significant effect of feed restriction on feed conversion efficiency. Feed conversion ratio (FCR) is a measure of how well a flock converts feed intake (feed usage) into weight gain. It is also the ability of the livestock to turn feed mass to body mass. Birds that have low feed conversion ratio are considered efficient users of feed. According to [29] who reported that comparison of feed conversion ratio among treatment groups may be of little significance unless the feeds involve are of similar quality and suitability. And this was the case in this study only the time interval of rending the feed to the birds were different. The result showed that birds on *ad libitum* feeding, twice a day feeding, thrice a day feeding in the order of their mention had more ability to turn feed to body mass due to their low feed conversion ratio value than birds on 3 hours restricted feeding though significance was not established at 5% level of probability.

As shown, there were significant differences between the rectal temperature of birds restricted for 3 hours and other treatment birds at week four which could be due to increase in respiratory rate and excitement caused by birds seeing other birds in adjacent pen being fed more regularly.

Feeding regimes had significant differences on apparent nutrient digestibility in broilers as shown. Crude protein, crude fibre and gross energy were higher significantly in birds on3 hours restricted feeding while the least crude protein value came from birds fed *ab-libtum*, the gross energy and crude fibre was significantly lower in thrice a day feeding regime.

Three general management factors that can have additive effects on feed intake of chicks are access to feed and water; environmental stress; and disease challenge [30]. Since the birds were all subjected to the same environmental conditions, the disparity in fed intake cannot be attributed to environmental factors neither to disease challenge because there was none at the time of the study. It can therefore be said that feed intake was directly proportional to weight gain which was clearly demonstrated by birds in the different treatments.

6. CONCLUSION

Ad-libitum feeding had the highest non-significant performance values but split feeding optimized

feed and nutrient utilization thereby enhancing performance and minimizing nutrient wastage at the same time

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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