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INFLUENCE OF TIMING AND DURATION OF FEED RESTRICTION ON GROWTH AND ECONOMIC PERFORMANCE OF FINISHER BROILER CHICKENS

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ABSTRACT

The study investigated different feed restriction programs during an 8-week broiler chicken growing cycle as a management strategy for reducing cost of production. Initially, 90 Hubbard day-old chicks fed *ad libitum* a commercial starter feed supplying 24% crude protein and 3000 kcal of ME/kg for 4 weeks. Thereafter, they were randomly allotted to five different feed restriction programs (R0, R5, R56, R67 and R57) utilizing finisher diets supplying 19% crude protein and 2850 kcal of ME/kg from 5-8 weeks. Each program had three replicates and six birds per replicate. Unrestricted (R0) was the control where birds fed *ad libitum*. In R5, birds were restricted the 5^{th} week; R56, 5^{th} and 6^{th} weeks; R67, 6^{th} and 7^{th} weeks, and R57, 5^{th} and 7^{th} weeks. However, all the feed-restricted birds fed *ad libitum* in the 8^{th} week. Feed restriction involved feeding one-third feed intake of R0 birds starting from 14.00 to 18.00 h daily and performance parameters recorded. Feed restriction negatively affected growth performance as the severity of restriction increased. Final body weight, carcass weight, average daily gain and average daily feed intake were similar (P>0.05) for R0 and R5 but higher than R56, R67 and R57. However, feed restriction did not significantly affect (P>0.05) carcass and breast yields or feed conversion ratio except for R67, the least (P<0.05) feed efficient. Feed cost, cost of production and revenue declined as the period of restriction increased. However, profit or profit/kg live weight, economic efficiency (EE) of feed and relative EE of feed were highest for R0 followed by R5, R56, R57 and R67 in that order. Generally, birds restricted for 1 week performed better than those restricted for 2 weeks and birds restricted continuously for 2 weeks before the last week of re-alimentation and slaughter were inferior to others. These results suggest that the duration and timing of feed restriction can reduce cost in broiler meat production without seriously affecting performance or economics of production depending on the restriction program applied.

Key words: Broilers, Economic efficiency, Feed restriction

INTRODUCTION

The high proportion of feed in the cost of poultry production is well established. Generally, feed accounts for 55-75% of cost of production [1]. This high proportion is due to the type and quality of feed ingredients in the feed, several of which are foods utilized by man and therefore expensive. The challenge is to optimize animal performance while reducing dietary cost. As a result, the quest to reduce dietary cost and improve profitability has resulted in the development of various strategies. Such include use of alternative feed ingredients, exogenous enzymes, growth promoters, genetic selection, feeding programs/formulations and phase feeding (starter/grower/finisher).

Feed restriction is a conventional strategy employed in modern broiler breeder industry to lessen fat accretion and avoid reproduction and health complications [2] but not in modern broiler meat industry where feeding is *ad libitum*. However, *ad libitum* feeding has been implicated in mortality and health problems such as ascites, tibial dyschondroplasia, necrosis of the femoral head, angular and torsional long bone deformities, perosis, spinal deformities, obesity and Sudden Death Syndrome [1, 3, 4]. Nevertheless, negative effects of feed restriction include chronic hunger [2], boredom and feeding frustration [5], increased aggression [6] and overdrinking [7]; and the expression of these behaviours is positively correlated with the level of restriction imposed [7, 8]. Negative physiological effects include adrenal hypertrophy and persistent increase in corticosterone secretion after 24 h restriction or feed-off days [9, 10] or increased susceptibility to *Staphylococcus aureus* after 48 h [11].

In addition, feed restriction provides the opportunity to take advantage of compensatory growth. Compensatory growth classically refers to the period of rapid growth, relative to age, exhibited by mammals and birds after a period of nutritional restriction [12]. The factors most critical to compensatory growth include the age at which the restriction is applied, the sex and genotype of the animal, the length and severity of the restriction and the quality and length of re-feeding of the re-alimentation diet [13, 14].

Undoubtedly, any feed restriction program will have to consider age effects. Mench [4] indicated that the effects of feed restriction would be more severe in young birds due to high metabolic requirements resulting from rapid growth at this stage. Marks [15] found that the main increase in growth rate manifests primarily in the first four weeks after hatching. Further, Adedokun *et al.* [16] reported higher utilization of amino acids (indicated by higher endogenous amino acid (EAA) flows) for broiler chicks less than four weeks than older birds; and Renema *et al*. [17] recommended full feeding of broiler breeder chicks for several weeks before any restriction program for adequate frame size, vigorous growth and uniform flock body weight. Therefore, this study will investigate effects of feed restriction on old birds or finisher broiler chickens.

Skip-a-day, in which feed rations calculated to achieve desired body weights are fed on alternate days and limited every day, in which half of the skip amount is fed daily are the two most commonly used commercial restriction programs [4]. Other methods are variations of these two programs. Generally, feed allocations are 60-80% or 25-50% less than the bird would consume *ad libitum* during rearing and laying, respectively [2].

Considering the foregoing, the purpose of this study was to adapt appropriate aspects of the broiler breeder feed restriction strategy to broiler meat production and evaluate effects on growth performance and economics of production by manipulating feed delivery schedules and the timing and duration of restriction. The expectation is to provide broiler meat producers (more especially smallholder farmers) with information that may enable flexibility in decision-making regarding feeding strategy in times of feed shortages or high cost of feed.

MATERIALS AND METHODS

Experimental procedure and management of birds

The experiment was conducted at the Poultry Unit, Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife. Before the study started, one hundred day-old Hubbard broiler birds purchased from a commercial hatchery were brooded (under electric hoods) for 3 weeks, and fed standard commercial starter diet *ad libitum* until 4 weeks of age. Starter feed provided in mash form contained 24% crude protein (CP) and 3000 kcal of ME/kg. After the *ad libitum* period, 90 broiler birds randomly allotted to five treatments fed finisher diets (of the same commercial brand) supplying 19% CP and 2850 kcal of ME/kg from 5-8 weeks. Each treatment was replicated three times with six birds per replicate on floor pens (with wood shavings) providing 0.3 m^2 per bird in an open-sided wire gauze-covered poultry house with asbestos roof and concrete floor. The first treatment was the control where birds were fed *ad libitum* or unrestricted for 8 weeks. The second treatment comprised of birds restricted of feed only in the 5^{th} week. The third treatment involved restriction of feed in the 5^{th} and 6^{th} weeks; the fourth treatment had restriction of feed in the 6^{th} and 7^{th} weeks, and the fifth treatment, restriction in the 5^{th} and 7^{th} weeks. However, all the birds in the feed-restricted treatments fed *ad libitum* in the 8^{th} week and water supplied *ad libitum* to all treatments for the duration of experiment. Standard routine management and medication schedules were carried out. Feed restriction strategy involved feeding for one-third (14:00-18:00 h daily) of the usual feeding period (~ 06:00-18:00 h daily, which is the day length period) one-third of the quantity of feed fed the unrestricted birds. Therefore, birds were restricted quantitatively and for 4 h and not fed under artificial lighting. The choice of one-third quantity unrestricted feed intake was an adaptation of the feed restriction to one-third of *ad libitum*-fed growers of the same age in broiler breeders [18, 19]. Similarly, time of feeding (14:00-18:00 h) was to correspond to one-third of total possible feeding time and near when birds would be less active (zero daylight) in order to reduce weight loss due to physical activity.

Performance parameters

Parameters considered for evaluation were average daily weight gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR), mortality, carcass and breast yields and economics of production. Chickens in each pen were weighed individually at the beginning of the experiment, then weekly, and at the end of the experiment. Feed consumption per pen was recorded weekly after the total feed given per week was corrected for feed left over. Average daily gain, ADFI, and FCR were calculated from the data obtained. At the end of the experiment, two birds were selected randomly from each pen, starved of feed for 24 hours, killed by cutting the jugular vein, exsaguinated, defeathered and eviscerated. Carcass yield calculated as dressed weight per unit live weight excluded all the organs, head, feathers, neck and shanks. Breast yield was calculated per unit carcass weight. Economics of production parameters were feed cost/kg feed, feed cost/kg gain, cost of production/kg gain, and profit (benefit)/kg gain.

Analysis of data

Differences in feed restriction effects between treatments were analyzed with the 2-way analysis of variance using the General Linear Model procedure of SAS [20]. The data was treated as a completely randomized design with week of restriction as the main treatment effect and replicates as another factor. The replicate was considered as another factor in order to increase the sensitivity of the experiment by reducing the residual error. The model used was:

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

where: Y_{ijk} = Performance parameters, μ = overall mean, D_i = Deprivation effect, R_j = Replicate effect and ε_{ijk} = residual error. Differences in feed deprivation effects were resolved by Duncan's multiple range test of the SAS statistical package. P-values <0.05 were considered statistically significant.

RESULTS

Table 1 shows the effects of feed restriction on growth performance and carcass characteristics of broilers. Final body weights of broilers restricted for 2 weeks were lower (P<0.05) than birds restricted for 1 week or no restriction. Body weight gain decreased (P<0.05) as the duration of feed restriction increased. Birds re-alimented for only 1 week (R67) before slaughter had the lowest (P<0.05) body weight gain. Feed intake decreased (P<0.05) as the duration of feed restriction increased and restriction for 2 weeks severer than for 1 week, which was not significantly different (P>0.05) from fully fed birds. Feed restriction did not affect (P>0.05) efficiency of feed utilization except in birds that had only 1 week re-alimentation. Expectedly, the effect of feed restriction on carcass weight followed the same trend as final body weight. Feed restriction did not affect (P>0.05) carcass and breast percentages. There was no abnormal behaviour or mortality throughout the duration of the experiment.

Table 2 shows the economics of production for restricted finisher broilers. Predictably, total feed costs and total cost of production followed the trend of quantity of feed consumed as the cost of feed reduced as restriction increased. The highest revenue derived from full-fed birds because they had the highest final body weights, followed by birds restricted for 1 week and then for 2 weeks. The least revenue derived from birds re-alimented for just 1 week. Profit or profit/kg live weight followed the same trend as revenue but birds re-alimented for just 1 week turned a loss. Full-fed birds recorded the highest value of economic efficiency (Profit/total feed cost x 100) followed by birds restricted for 1 week, almost double birds restricted for 2 weeks but seven times more than birds re-alimented for just 1 week.

DISCUSSION

The reduction in all growth performance parameters as the severity of feed restriction increases is a direct outcome of feed restriction [21, 22]. Nutrients needed for growth and tissue accretion come from feed, therefore, feed restriction should impede growth. However, compensatory growth usually occurs on re-alimentation due to a complex interplay of hormonal and nutritional factors [14, 22, 23].

Restricted birds under this study probably were not able to compensate fully due to shortness of the period of the restriction or period re-alimentation. Ryan [13] reports that the period of restriction must be long enough to ensure adaptation to the lower plane of nutrition in order for compensatory growth to be realized. In this study (Table 1) birds with longer restriction periods (R56, R67 and R57) only showed partial compensation compared to birds mildly restricted (R5) because of differences in final body weight ($P<0.05$) compared to unrestricted birds of the same age. Complete compensation occurs when the animal is able to attain the same weight for age as unrestricted counterparts [14, 24, 25]. Therefore, compensatory growth appears to have been incomplete due to shortness of the re-alimentation period because all the feed restricted birds had significantly lower ($P<0.05$) feed intake than unrestricted birds (R0) except those mildly restricted (R5) and with the longest period to compensate. This contrasts with observations that a higher intake relative to body weight accompanies compensatory growth [25]. Therefore, it appears the re-alimentation period was not long enough for the restricted birds to catch-up on feed intake and therefore compensate fully. Plavnik and Hurwitz [24] report full compensation in broilers previously mildly restricted compared to partial compensation in counterparts severely restricted, and attributed the difference to shortness of the re-alimentation period. Ryan [13] reported such partial compensation could occur when growth studies have ended prematurely foreclosing the opportunity for full compensation. This reason may also explain the inferiority in growth performance observed for birds more severely restricted (R56, R67 and R57) compared to mildly restricted (R5) and unrestricted birds. This is underscored by the fact that birds that had the most severe restriction (R67) were inferior ($P<0.05$) to others in growth performance.

Apart from duration, the time when feed restriction is applied appears to affect performance. The inferior performance of birds on R67 was probably due to their restriction 2 weeks penultimate to the last week of re-alimentation before slaughter. Therefore, probably the maximum period for restriction before re-alimentation to end restriction is 1 week because R57 birds (restricted 1 week prior to last week of re-alimentation before slaughter) were superior to R67 birds but contemporary to R56 birds.

Birds that had the longest period to compensate or mildest restriction (R5) appear to have fully compensated because of the insignificant differences (P>0.05) in final body weight compared with unrestricted birds [14, 24, 25]. In fact, these birds were similar to the unrestricted birds in all growth and carcass characteristics except average daily gain, which may explain the absolute difference in final body weight, which was not statistically significant. This probably provides an opportunity for the use of feed restriction as a strategy to reduce cost of production in broilers since feed cost was lower in restricted birds.

The economic relevance of these results is that feed costs and cost of production declined with the severity of the restriction (Table 2) because feed intake declined correspondingly. This is so because feed accounts for 55-75% of cost of production [1] and feed restricted birds generally eat less than unrestricted birds [26]. However, cost of production was not inversely related to profit or profit/ kg live weight because final live weight of restricted birds were significantly less than (P<0.05) unrestricted except birds mildly restricted. Relative economic efficiency and economic efficiency of feed reinforces these results (Table 2). Regardless of the statistical parity of final live weight of mildly restricted with unrestricted birds, they are still inferior in absolute terms with respect to profit or profit/ kg live weight, which are the most important considerations in broiler meat production. Nevertheless, discriminate restriction for one or two weeks as obtained in this study probably provides the opportunity to hedge against unfavorable situations such as feed shortages or high cost of feed.

CONCLUSION

Data from this study indicates feed restriction may be a good potential strategy to reduce cost of feed in broiler meat production or to counter feed shortages or high cost of feed. However, further studies needs to fine-tune and establish such feed restriction management strategy most appropriate to broiler meat production. For example, broiler meat producers may need to increase rearing period beyond 8 weeks in order for birds to completely compensate and thereby realize profit parity with birds fed ad libitum but at a lower cost.

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Table 1: Growth performance and carcass characteristics of finisher broilers restricted of feed at different periods

	Restriction (weeks)[1]						
Parameters	**R0**	**R5**	**R56**	**R67**	**R57**	**SEM**	**P value**
Final weight, g	1548.3^{a}	1393.9^{ab}	1210.0^{bc}	1033.3^{c}	1133.9^{c}	57.76	0.01
Average daily gain, g	38.7^{a}	32.7^{b}	25.9^{c}	20.0^{d}	25.0^{c}	1.81	0.0001
Average daily feed intake, g	136.4^{a}	133.7^{a}	96.2^{b}	87.9^{b}	92.1^{b}	6.35	0.006
Feed conversion ratio	3.5^{b}	3.6^{b}	3.7^{b}	4.4^{a}	3.7^{b}	0.1	0.045
Carcass weight, g	975.0^{a}	925.0^{ab}	800.0^{bc}	650.0^{d}	700.0^{cd}	37.38	0.003
Carcass %	70.4	69.3	66.6	65.4	66	0.74	0.16
Breast %	28.4	28.4	36.7	32.9	27.4	1.83	0.5

^{abcd}Means on the same row with different superscripts are significantly different (P>0.05)

[1]R0 = no restriction; R5 = restricted week 5; R56 = restricted week 5 and 6; R67 = restricted week 6 and 7; R57 = restricted week 5 and 7.

SEM=Standard error of mean

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Table 2: Economics of production for finisher broilers restricted of feed at different periods

	Restriction (weeks)[1]				
Parameters[2]	**R0**	**R5**	**R56**	**R67**	**R57**
Feed consumed, Kg	5.43	5.04	4.48	4.53	4.18
Feed price, N/Kg	96.00	96.00	96.00	96.00	96.00
Total feed cost, N	521.28	483.84	430.08	434.88	401.28
Cost of chicks, N	150.00	150.00	150.00	150.00	150.00
Miscellaneous cost[3], N	100.00	100.00	100.00	100.00	100.00
Total cost, N	770.80	733.84	679.79	685.07	651.38
Final live weight, kg	1.55	1.4	1.21	1.03	1.13
Sales price, N/ kg live weight	700.00	700.00	700.00	700.00	700.00
Revenue, N	1085.00	980.00	847.00	721.00	791.00
Profit, N	314.20	246.16	167.21	35.93	139.62
Profit/kg live weight, N	202.71	175.83	138.19	34.88	123.56
Economic efficiency (EE) of feed[4],%	60.27	50.88	38.88	8.26	34.79
Relative EE of feed[5],%	100.00	84.41	64.50	13.71	57.73

[1]R0 = no restriction; R5 = restricted week 5; R56 = restricted week 5 and 6; R67 = restricted week 6 and 7; R57 = restricted week 5 and 7.

[2]N = Naira; $1 = N150.

[3]Miscellaneous cost = medications and vaccines, labour, litter and brooding expenses.

[4]Economic efficiency of feed = (Profit/total feed cost) x 100.

[5]Assumes R0 = 100% relative to R5, R56, R67 and R57.

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