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PROTEIN EFFICIENCY AND NITROGEN UTILIZATION OF BROILER PRODUCED IN A 42-DAY GROWTH PERIOD ON CHANGING TIME OF PHASE FEEDING REGIME

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ABSTRACT

The protein efficiency ratio and nitrogen utilization of broiler chickens produced on changing times of phase feeding regimes was determined using 160-day-old, Abor acre broiler chicks. The chicks were divided into five groups of four replicates on weight equalization basis. Each group was randomly assigned to five broiler chicken phase feeding regime at changing times as follows: T1 (control) had starter phase (0 - 28 days), and finisher phase (29 - 42 days); T2 had starter phase (0 - 7 days) and finisher phase (8 - 42 days); T3 had starter phase (0 - 14 days) and finisher phase (15 - 42 days); T4 had starter phase (0 - 8 days), grower phase (9 - 21 days), and finisher phase (22 - 42 days); and T5 had starter phase (0 - 21 days) and finisher phase (22 - 42 days) in a completely randomized design (CRD) experiment. The nutrient composition of the starter, grower, and finisher diets were analyzed. Data on protein efficiency ratio (PER) and nitrogen utilization were calculated from growth performance parameters measured using appropriate formulas. The study lasted 42-day. Data obtained were subjected to analysis of variance (ANOVA) and were significant differences were observed the means were separated using the Duncan's New Multiple Range Test (DNMRT). Results indicated that birds on T4 recorded significantly ($p < 0.05$) higher PER than other groups except T2. Birds on T4 recorded significantly higher ($p < 0.05$) nitrogen efficiency (40.29), nitrogen retention (54.41 g), lower nitrogen intake (135.06 g), and higher excretion (80.65 g) values. It is concluded that starter durations of no more than 8 days significantly improved protein efficiency ratio, lowered nitrogen intake, reduced nitrogen excretion, and improved nitrogen efficiency.

Keywords: Broiler chicken, phase feeding, changing time, nitrogen utilization.

Introduction

The poultry industry has economic, social, and cultural benefits and is pivotal in the supply of animal protein for family nutrition in the developing world. However, the availability and cost of high-quality feeds, feed ingredients, and feeding techniques affects the efficiency of this sector (Pomar *et al.*, 2021; Awa *et al.*, 2023). It could raise production costs, interfere with farmers' ability to make profit, and increase emissions of ammonia gas and nitrogen excretion (Adewale *et al.*, 2018). For instance, the cost of a long-term, consistently high crude protein diet used in broiler production affects farmers' profits and also leads to environmental pollution in the form of ammonia gas emission linked to litter ammonia volatilization, infection spread, contaminations that cause odour, and even animal death (USDA/NCS, 2012; Vilela *et al.*, 2020; Pomar *et al.*, 2021). There are nevertheless, tools

to optimize nitrogen use in broiler chicken production. As reported by Tickle *et al.* (2014) modern broiler chickens are almost at the limit of their functional capacity which means that there is limited potential for further improvements in industrial efficiency and meat production. Any tool therefore, that aims to enhance the productivity of broiler chickens must have the potential to increase the protein efficiency ratio, decrease nitrogen intake, raise nitrogen retention, increase nitrogen efficiency, lower nitrogen excretion, reduce production costs, and minimise the negative effects of production on the environment for both humans and other animals (Belloir *et al.*, 2017). In order to achieve this such tool should prioritise feed design, feed nutritional management techniques, and biosecurity initiatives (USDA/NCS, 2012 and Pomar *et al.*, 2021).

Broiler producers especially in Nigeria generally follow the 8-week two phase feeding regime, which consists of a starter phase (0 – 3 or 4 weeks) and a finisher phase (4 or 5 – 8 weeks) (Okoli and Udedibie, 2016; Belema *et al.*, 2018). Given that modern broiler chickens are well-adapted to consume diets high in protein and energy to reach market weight in less than six weeks of rearing and have the capacity to multiply 50 times in body weight after hatching, these feeding plans are likely less economical (Knowles *et al.*, 2008; Tickle *et al.*, 2014).

Furthermore, studies show that the multiple-phase feeding regime is superior in terms of feed cost, feed utilization/efficiency, reduction of feed waste, reduction in nitrogen excretion, improvement in production efficiency and increased production phase cycle (Saleh *et al.*, 1996; Lesson and Summers, 2005; Anyigor and Etuk, 2018). Nutrition and feeding management strategies should therefore target the early maturity of the supply organs at the expense of demand organs (Christensen, 2009). This can be achieved by changing time of phase feeding regime (Saleh *et al.*, 1996; Mohsen *et al.*, 2019).

Changing time-of-phase feeding regimes is a precision feeding and nutrition tool that allows for optimal use of nutrients. It also reduces costs and improves nitrogen utilization efficiency (Pomar *et al.*, 2021). Any nutritional management tool/tools employed to maximize the nutrient bioavailability in broiler diets which can precisely meet the broiler growth requirements at all stages of growth should be considered for economic and environmental sustainability (Anggraeni *et al.*, 2020). This study

therefore assessed the protein efficiency and nitrogen utilization of broiler chickens produced in a 42-day growth on changing times of phase feeding regime.

Materials and Methods

The study was conducted between February and March 2023 at the Poultry Unit of the School of Agriculture and Agricultural Technology Teaching and Research Farm, Federal University of Technology, Owerri, Nigeria. Broiler chicken starter, grower and finisher diets were formulated and the nutrient composition determined (AOAC, 2019). Metabolisable energy (ME) was computed as described by El Hag (2022). (Table 1).

One hundred and sixty (160) unsexed, day-old Arbor Acre broiler chicks used for this study were divided into five groups of 32 chicks, and each group replicated four times with 8 chicks per replicate on equal-weight basis. Each replicate was housed in a deep litter compartment measuring 1.6 m x 1.0 m with wood shavings as litter in an open-sided poultry house. The groups were randomly assigned to the five experimental broiler feeding regimes (treatments) in a completely randomized design (CRD) experiment. The treatments regimes were as follows: T1 (control) starter (0 -28days) finisher (29 -42 days); T2 starter (0-7 days), finisher (8 - 42 days); T3 starter (0 - 14 days), finisher (15- 42 days); T4 starter (0 – 8 days); grower (9 - 21 days) and finisher (22 – 42 days), and T5 starter (0- 21 days); finisher (22-42 days). Feed and water were offered *ad libitum* in two tranches at the same time daily (8. 00 am and 4.00 pm). The study lasted for 42 days.

Table 1: Gross composition of experimental broiler diets.

Ingredients	Broiler Starter	Broiler Grower	Broiler Finisher
Maize	50.00	57.00	62.70
Soya beans meal	27.5	28.5	27.8
Palm kernel cake	11.00	8.5	4.00
Fish meal	8.00	3.00	2.5
Bone meal	1.50	1.5	1.5
Vitamin/mineral	0.25*	0.25**	0.25***
Salt	0.25	0.25	0.25
Oyster shell	1.00	1.00	0.25
Lysine	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Total	100.00	100.0	100.00

*Micro-mix® broiler starter vitamin/mineral premix contains /2.5 kg: Vitamin A, 12,500,000.00IU ; vitamin D3, 2,500,000.00IU; vitamin E, 40,000.00mg; vitamin K3, 2,000.00mg; Vitamin B1, 3,000.00mg; Vitamin B2, 5,500.00mg; niacin, 55,000.00mg; calcium pantothenate, 11,500.00mg; vitamin B6; 5,000.00mg; vitamin B12, 25mg; chlorine chloride, 500,000.00mg; folic acid, 1,000.00mg; biotin, 80,000.00mg; manganese, 120,000.00mg; iron, 100,000.00mg; zinc, 80,000.00mg; copper, 8,500.00mg; iodine, 1,500.00mg; cobalt, 300.00mg; selenium,120.00mg; and antioxidant, 120,000.00mg.

**Micro-mix® broiler grower vitamin/mineral premix contains /2.5 kg: Vitamin A, 10,000,000I.U ; vitamin D3, 2,000,000.00I.U; vitamin E, 20,000.00mg; vitamin K3, 2,000.00mg; Vitamin B1, 3,000.00mg; Vitamin B2, 5,000.00mg; niacin, 45,000.00mg; calcium pantothenate, 10,000.00mg; vitamin B6; 4,000.00mg; vitamin B12, 20mg; chlorine chloride, 300,000.00mg; folic acid, 1,000.00mg; biotin, 80,000.00mg; manganese, 120,000.00mg; iron, 80,000.00mg; zinc, 80,000.00mg; copper, 8,500.00mg; iodine, 1,500.00mg; cobalt, 300.00mg; selenium,120.00mg; and antioxidant, 120,000.00mg.

***Micro-mix® broiler finisher vitamin/mineral premix contains /2.5 kg: Vitamin A, 8,000,000I.U ; vitamin D3, 150,000.00I.U; vitamin E, 15,000.00mg; vitamin K3, 1,000.00mg; Vitamin B1, 2,000.00mg; Vitamin B2, 3,000.00mg; niacin, 35,000.00mg; calcium pantothenate, 8,000.00mg; vitamin B6; 3,000.00mg; vitamin B12, 20mg; chlorine chloride, 200,000.00mg; folic acid, 1,000.00mg; biotin, 60,000.00mg; manganese, 90,000.00mg; iron, 60,000.00mg; zinc, 60,000.00mg; copper, 6,500.00mg; iodine, 1000.00mg; cobalt, 250.00mg; selenium,90.00mg; and antioxidant, 90,000.00mg

The Protein efficiency ratio (PER) was calculated as g weight gain/ g protein intake (Kamran *et al.*, 2008). Nitrogen utilisation paramerers were calculated as shown in equations 1 -5.

Nitrogen intake (Nintake) = $FI \times CP \text{ (diet)} \div 6.25$ Equation (1)

Nitrogen retention (Nret.) = $Nbody \times (BWG/1000)$ Equation (2)

Nitrogen efficiency (Neff.) = $100 \times Nret / Nintake$Equation (3)

Nitrogen excretion (Nexc.) = $Nintake - Nret$Equation (4)

Nitrogen excretion/body weight gain (Nexc/BWG) = $Nexc/ BWG \times 1000$Equation (5).

Where the following were determined per pen, FI= Feed intake; BWG = body weight,

N = nitrogen; Nbody = 29 g/kg)

(Aletor *et al.*, 2000; Bregendahl *et al.*, 2002, ITAVI, 2013; Belloir *et al.*, 2017).

Means of data collected were subjected to One Way Analysis of Variance (ANOVA). Significantly means were separated using Duncan's New Multiple Range Test (DMRT) (R-Core Team, 2023).

Results and Discussion

The calculated and determined nutrient (proximate, metabolize energy, mineral and amino acids) composition of the experimental broiler chicken diets are presented in Table 2. Determined metabolizeable energy (ME), and a significant number of the calculated and determined crude protein (CP), mineral, and amino acid values of the experimental broiler starter, grower and finisher diets were similar and in line with the Nigerian Industrial Standards (NIS) recommendations of the Standards Organization of Nigeria (SON, 2019). In few cases however, amino acid variations were observed to be at variance with the recommendations of the NIS for each feed type. Variations in nutrient composition of broiler chicken diets could result from different factors ranging from the source, processing and storage of feed ingredients, feed production process and the method of analysis (Moss *et al.*, 2020).

Table 2: Calculated and determined nutrient composition of experimental broiler diets

Nutrients (%)	Starter Diet		Grower Diet		Finisher Diet	
	Calculated	Determined	Calculated	Determined	Calculated	Determined
ME (Kcal/kg)	3048.30	2980.00	3101.10	2990.00	3206.71	3000.00
Crude protein	23.12	21.21	20.47	20.18	19.04	18.78
Ether extract	6.89	3.39	6.84	4.88	7.85	5.68
Crude fibre	4.24	6.21	4.14	5.42	3.52	5.68
NFE	NA	70.80	NA	75.83	NA	76.04
Ash	3.64	9.72	2.76	7.18	3.08	8.08
Calcium	1.25	2.08	1.10	1.90	1.07	1.86
Phosphorus	0.96	0.33	0.89	0.32	0.87	0.31
Sodium	0.11	0.24	0.11	0.22	0.11	0.21
Lysine	2.01	0.96	1.92	0.68	1.94	0.74
Methionine	0.68	0.57	0.56	0.65	0.63	0.69

ME = Metabolisable Energy; NFE = Nitrogen Free Extract

The Protein Efficiency Ratio (PER) and Nitrogen Utilization parameters of broiler chickens on changing time of phase feeding regimes are presented in Table 3. The results obtained from this study showed that birds on diets T2 and T4 produced similar ($p>0.05$) and significantly ($p<0.05$) higher PER than others. Nitrogen excretion and nitrogen excretion per kg body weight gain of broiler chickens produced on changing time of phase feeding regimes were

similar ($p>0.05$) among the groups. However, birds on (T2 and T4,) which had the shortest duration of starter diet (7 and 8 days, respectively) recorded lower nitrogen intake (135.55 g and 135.06 g) values and also excreted lower amount (87.31 g and 80.65 g, respectively) of nitrogen within the 42 days duration of the study.

Table 3. Protein Efficiency Ratio and Nitrogen Utilization of Broiler Chicken on Changing Time of Phase Feeding Regime

Parameters	T1 (control)	T2	T3	T4	T5	
Starter duration	0 – 28 d	0 - 7 d	0 – 14 d	0 - 8 d	0 – 21 d	
Grower duration				9 – 21 d		SEM
Finisher duration	29 – 42 d	8 – 42 d	15 - 42 d	22 - 42 d	22 - 42 d	
Protein efficiency ratio	2.60 ^b	2.88 ^a	2.67 ^b	2.98 ^a	2.37 ^c	0.052
Nitrogen intake (g)	140.51 ^a	135.55 ^f	138.69 ^c	135.06 ^g	140.35 ^b	0.473
Nitrogen excretion (g)	94.16	87.31	91.07	80.65	94.03	4.307
Nitrogen excretion/BWG (g)	0.06	0.05	0.06	0.04	0.06	0.003
Nitrogen retention (g)	46.56 ^e	48.24 ^c	47.62 ^d	54.41 ^a	46.32 ^f	0.598
Nitrogen efficiency	33.14 ^{cd}	35.59 ^b	34.34 ^c	40.29 ^a	33.00 ^d	0.574

^{abcdefg} Means within a row with different superscripts are significantly ($p<0.05$) different.

The protein efficiency ratio and nitrogen utilization appear to indicate higher efficiency by broilers on the short starter feeding duration (7 and 8 days) than the long duration (14, 21 and 28 days) resulting in a possible excretion of inefficiently utilised nitrogen from the diet within the longer starter feeding duration. The report of Kamran *et al.*, (2008); Belloir *et al.*, (2017); Anggraeni *et al.*, (2020); Such *et al.*, (2021) similarly indicated that protein efficiency ratio and nitrogen utilization of broiler chicken improved with reduced CP content of the diet on the basis of age which is the main objective of changing time of phase feeding regimes.

Again, Belloir *et al* (2017). reported that the effect of higher feed utilization efficiency was a decrease in nitrogen excretion and volatilization. Saleh *et al.* (1996) also reported that the broiler starter feeding duration for birds grown up to 3.3 kg appear to be no more than 7 days. In this study however, starter duration up to 7 and 8 days produced similar results in terms of nitrogen excretion, excretion/kg body weight gain, nitrogen retention and efficiency indicating a possible higher utilization of nitrogen by the birds.

Nitrogen excretion shows the amount of nitrogen that is unutilized by the birds. Increase in nitrogen retention indicates nitrogen utilized by the body of animals. In this study, nitrogen utilization efficiency appears to be influenced by the duration of the starter phase feeding regimes. For instance, birds on T4 (8 days starter duration) had nitrogen efficiency of 40.29 %. Birds on the control (T1) on the other hand with 28 starter duration recorded the least (33.14%) nitrogen efficiency value (Kamran *et al.*, 2008). This might possibly explain why birds on shorter starter durations (T2 and T4) recorded higher PER than other groups.

Conclusion and Recommendations

This study investigated the impact of changing time of phase feeding regimes on the protein efficiency, nitrogen utilization, of broiler chicken on changing time of phase feeding regime.

The following conclusions were drawn.

- The starter phase duration of not more than 8 days as reflected in T2 (0 - 7 days) and T4 (0 - 8 days) increased protein efficiency ratio compared to other groups. Birds on T4 (0 – 8 d starter, 9 – 21 d grower and 22 – 42 d finisher) however, produced the best protein efficiency ratio.
- Nitrogen utilization parameters such as nitrogen intake, nitrogen excretion, nitrogen retention, nitrogen efficiency of broiler chicken followed similar trend with the protein efficiency ratio. Birds on shorter

duration of the starter phase were more efficient in nitrogen utilization.

Recommendations

Based on these findings, it is recommended that:

- Broiler chickens producers consider implementing a phase feeding regime with an early switch to a higher energy diet similar to T4 (0 – 8 d starter, 9 – 21 d grower and 22 – 42 d finisher) and T2 (0 - 7 d starter and 8 – 42 d, finisher).
- Further research should be explored to determine the long-term effects of the recommended feeding regimes on broiler health, meat quality, and overall sustainability.

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