Growth Performance, Carcass Traits, and Economy of Broiler Chickens fed Straight Diets with Varying Dietary Protein Levels

ABSTRACT

Protein is an indispensable and expensive nutrient needed in poultry diet to meet their essential nutrient requirement as it plays a vital role in structural and protective tissue formation and maintenance, growth, body repairs and egg formation. Compounding and feeding of straight diet to broilers by local farmers will help to ameliorate problems of malnutrition, disturbed growth and loss observed in Nigerian villages due to seasonal shortage of commercial feed to broilers before they reach maturity. The growth Performance, carcass traits, and economy of broiler chicken fed straight diets with varying dietary levels of protein were evaluated. Four diets were compounded and tagged diets 1, 2, 3, and 4 with four Crude protein (CP) levels of 18, 20, 22, and 24%, respectively with a constant Metabolizable energy (ME) level of 3200 kcalME/KgDM. One hundred and twenty 0ne-day old chicks were randomly allotted to four dietary treatments with 30 birds per treatment. Each treatment was replicated 3 times and each replicate had 10 birds. The birds were fed experimental diets for 7 weeks. Significant differences were observed in daily feed intake, daily Body Weight Gain (BWG), final body weight, daily ME intake, daily protein intake, protein and energy efficiency ratios, but feed conversion ratio, percentage of dressed weight, thigh and internal organs besides gizzard, spleen, and pancreas were similar. It was concluded that feeding broiler chicken with diet containing 18% crude protein and 3200 kcalME/kgDM for 7weeks gave the optimal performance of live weight (2259.00 g) with the least cost of feed intake per Kg BWG (₦426.22 or 0.60USD). Optimal performance per dressed weight (2,125.33 g) was obtained for broilers fed diets containing 20% CP and 3200 KCalME/KgDM with the highest revenue per dressed weight (₦2,087.60 or 2.94USD), and the highest gross margin (₦1,280.00 or 1.80USD).

Keywords: Broiler chickens, Dietary protein, Growth performance, Nutrient requirement, Profitability analysis

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1. INTRODUCTION

Poultry is one of the most widely eaten types of meat globally and it provides nutritional food rich in essential amino acids (high-quality protein), vitamins, minerals, and essential fatty acids that are essential for body nourishment and recuperation from ailments. It has often been reported that feeding accounts for over 70% of the total cost of egg and broiler production (Afolabi, 2009; Oluyemi and Robert, 2003) which implies that efforts and research to increase poultry meat and egg production should be geared toward improving feed formulation and quality.

Protein is an indispensable and expensive nutrient needed to formulate a poultry diet that will meet their essential nutrient requirement (NRC, 1994). Protein plays a vital role in structural and protective tissue in the body of animals and is relevant to enzymes and tissue function (NRC, 1994). The proteins are the major constituents of soft tissues of the animal body, are the major components of enzyme systems, and are involved in the synthesis of body tissues that enhance growth, body repairs, maintenance, and also for egg formation (NRC, 1994). Proteins are physically and functionally complex molecules that perform many salient important roles in animals by maintaining the cellular shape and its physical strength transporting oxygen, serving as antibodies that search for foreign invaders, as enzymes that catalyze reactions that generate energy, produce and degrade biomolecules, replicate and transcribe genes, process messenger RNAs among others (Murray *et al.*, 2009; Pond *et al.*, 1995).

Report of NRC (1994) gave a recommendation of 3,200 kcal Metabolizable energy (ME) per kg dry matter as the optimum requirements for energy by broiler chicken and 23, 20, and

18% protein at the pre-starter (0-3weeks), starter (3-6 weeks) and finisher (6-8 weeks) phases. It had been reported that protein requirement incurred 45% of the total cost of poultry production (Ahmad *et al.*, 2006). There is a need to increase farmers' profit from broiler chicken production by enhancing optimal productivity through the use of optimal levels of protein in their feed especially those raised in the tropics on the same diet or straight diet from day-old to table size when their meat is due for consumption. The works of Chemjor (1998) and Magala *et al*., (2012) with local chickens of Kenya and Uganda respectively showed that variations in the dietary protein influenced the performance of intensively raised chickens. Apart from the genetic constitution of birds, it's possible that the prevailing environmental condition may affect their growth performance, carcass yield and profitability of broiler chicken when fed different dietary levels of protein as sole diet.

Thus, the purpose of this study was to investigate the dietary levels of protein that will enhance growth performance, carcass traits and at the same time reduce the cost of production of broiler chicken especially when fed as sole diet from day one to table size.

2. MATERIALS AND METHODS

2.1 Ethical approval

The study was conducted after ethical approval and research committee of the Department of Animal Science, University of Uyo, Uyo, Nigeria.

2.2 Study area

The experiment was carried out at the Poultry unit of University of Uyo Teaching and Research farm, Uyo, Akwa Ibom State, Nigeria. It has an average monthly rainfall range of 200 mm to 800 mm with average monthly temperature and annual relative humidity of 28-36°C and 71% to 88%, respectively. Sunshine is between 1400-1500 hours per year (WWO, 2021).

2.3 Study design, Experimental Animals and Management

One hundred and twenty, one-day-old chicks of Arbor Acre broiler strain were purchased from a reputable distributor in Uyo, Akwa Ibom State, Nigeria and used in the present study. On arrival after hatching, the chicks were weighed and recorded as their initial body weight. They were housed on a partitioned deep litter house for brooding and rearing. Four experimental diets which contained 18, 20, 22, and 24% Crude protein (CP) levels and 3200 KCalME/kgDM were formulated at the beginning of the study and used throughout the study. The diets constitute the treatments and each dietary treatment was replicated three times with 10 chicks allocated per replicate and 30 birds per treatment in a completely randomized experimental design. The feeds were formulated using the Algebraic and the trial-and-error method (Olomu, 1995). Gross composition of the diets is as presented in Table 1. The chicken had access to feed and fresh water *ad libitum* throughout the study period on a deep with 24 hours lightening. The feeding trial lasted for seven weeks from the day of arrival. They were vaccinated against Newcastle and Gumboro diseases following a prepared and scheduled routine vaccination regime for humid tropical southern rainforest of Nigeria. Newcastle vaccine was given intra-ocularly on the first day and orally on the 21st day of age; while Gumboro (IBD) vaccine was administered on the 7th and 28th day of age orally. The vaccines were produced in Nigerian Veterinary Research Institute, Vom in Nigeria. Birds in all treatments were given similar standard routine management practices such as drug administration and maintenance of cleanliness within and

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outside the poultry houses. The Research and ethic committee of the Department of Animal Science granted approval for the use of the birds, poultry house and its facilities for the study.

2.3 Data collection

The day-old broiler chicks were weighed on the first day (recorded as the initial body weights) and thereafter every week until the end of the experiment. From these values, the daily Body weight gain (BWG), final BWG and total BWG were estimated. Measured quantity of feed was given to the chicken on daily basis and the quantity consumed was also noted and calculated by deducting the leftover (if any) from the quantity served. This was used to obtain the Daily feed intake (DFI) as well as Total feed intake (TFI) per bird at the end of the feeding trial. Daily protein intake (DPI) was calculated by multiplying the percentage CP in the feed by the daily feed intake and the ratio of DFI to daily BWG was used to calculate the Feed conversion ratio (FCR). Feed efficiency ratio (FER) was obtained using the ratio of total BWG to TFI and the Protein efficiency ratio (PER) was obtained using the ratio of BWG to protein consumed. The energy efficiency ratio (EER) was calculated using the ratio of BWG to metabolizable energy consumed. Economic analysis of broiler production was based on the cost of the diets dictated by the prevailing market price of feed ingredients at the time of purchase. This information was used to compute the cost of feed intake per kg body weight gain for each diet, revenue per dressed bird, and the gross margin.

2.4 Statistical analysis

Data obtained were subjected to Analysis of Variance (ANOVA) and their means were separated by the Duncan Multiple Range Test Option of SPSS (Version 2017) at $p = 0.05$.
The following model was adopted

$Yij = \mu + t_i + e_{ij}$

μ : overall mean

t_i : Effect of dietary protein treatment

e_{ij} : error incurred while applying the treatment

Table 1. Gross compositions of experimental diets with varying dietary protein levels

Treatments	**1**	**2**	**3**	**4**
Protein levels (%)	**18**	**20**	**22**	**24**
Feed ingredients (%):				
Maize	61.80	63.05	52.00	52.00
FFSBM	22.00	29.00	35.00	38.00
Fishmeal	2.00	2.00	2.00	4.00
Wheat offal	7.10	0.70	4.00	-
Palm oil	2.65	0.80	2.55	1.55
Bone ash	3.50	3.50	3.50	3.50
NaCl	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Total	100	100	100	100
Calculated nutrients:				
ME (kcal/kgDM)	3202	3200	3208	3207

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Crude protein	18.04	20.02	22	24
Ether extract	3.32	3.16	2.96	2.91
Crude fibre	3.73	3.05	3.71	3.21
Calcium	1.47	1.48	1.50	1.61
Total phosphorus	0.87	0.86	0.92	0.95
Lysine	1.20	1.36	1.52	1.71
Methionine	0.54	0.57	0.61	0.66

FFSBM: Full fat soybean meal, ME: Metabolizable energy, DM: Dry matter

* Premix supplied per kg starter diet: Vitamin A (15000 IU), Vitamin D3 (13000 IU), Thiamine (2 mg), Riboflavin (6 mg), Pyridoxine (4 mg), Cobalamin (0.05 g), Biotin (0.08 mg), Choline chloride (0.05 g), Manganese (0.096 g), Iron (0.024 g), Copper (0.006 g), Iodine (0.014 g), Selenium (0.24 mg), Cobalt (0.024 mg), and antioxidant (0.125 g)

3. RESULTS

3.1 Growth performance

The growth performance of broiler chickens fed varying dietary levels of protein from weeks one to seven is presented in Table 2. The initial body weights (39.04 g-39.39 g) of chicks were similar across diets ($p > 0.05$). There were significant differences in the daily feed intake, total feed intake/bird, daily body weight gain, final body weight, daily metabolizable energy intake (MEI), daily protein intake, protein efficiency ratio, and energy efficiency ratio of broiler chicken studied which increased significantly ($p < 0.05$) with increasing dietary crude protein level. No significant differences were observed in the initial body weight, feed conversion ratio, and feed efficiency ratio ($p>0.05$).

Experimental birds fed with diets 1, 2, and 3 were similar for feed intake (75.18 g, 78.42 g, and 82.64 g, respectively) just as those on diets 3 (82.64 g), and 4 (88.47 g) were also similar ($p > 0.05$). Feed intake was observed to increase with increasing levels of dietary CP.

Daily BWG (35.74-45.39 g) varied significantly across treatments with birds fed the diet with the 24% CP having the highest value that was also similar to those on a 22% CP diet ($p<0.05$). The protein efficiency ratio decreased with increasing levels of dietary CP with diet 1 having the highest value (2.64, $p<0.05$). The feed conversion ratio was similar across board with birds on diet with 24% CP having the least value (1.97, $p > 0.05$).

Birds on diet with 24% protein showed significantly ($P < 0.05$) higher body weight, daily metabolizable energy intake, daily protein intake, and energy efficiency ratio. Daily MEI increased significantly ($p > 0.05$) with increasing levels of dietary protein.

Table 2. Growth performance of Arbor Acre broiler chickens fed varying dietary levels of protein

Treatments	**1**	**2**	**3**	**4**	
Crude protein Levels (%)	**18**	**20**	**22**	**24**	**SEM**
Performance parameters:					
Initial body weight (g)	39.04	39.04	39.17	39.39	0.19
Daily feed intake (g)	75.18^{b}	78.42^{b}	82.64^{ab}	88.47^{a}	1.94
Total feed intake/bird (kg)	3.68^{b}	3.84^{b}	4.05^{ab}	4.33^{a}	0.09

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Daily body weight gain (g)	35.74^{c}	36.45^{bc}	41.24^{ab}	45.39^{a}	1.36
Final body weight (g)	1790.13^{c}	1825.20^{bc}	2060.00^{ab}	2263.60^{a}	66.88
Daily ME intake (kcal/kg)	240.58^{b}	250.93^{b}	264.45^{ab}	283.08^{a}	6.20
Daily protein intake (g)	13.53^{d}	15.69^{c}	18.18^{b}	21.23^{a}	0.99
Feed conversion ratio	2.10	2.16	2.00	1.97	0.04
Feed efficiency ratio	0.48	0.47	0.50	0.51	0.01
Protein efficiency ratio	2.64^{a}	2.32^{b}	2.27^{b}	2.14^{b}	0.06
Energy efficiency ratio	0.15^{b}	0.15^{ab}	0.15^{ab}	0.16^{a}	0.002

$^{a-d}$ Means along the same row with different superscripts are significantly different ($p < 0.05$).
SEM = Standard error of mean.

3.2 Carcass traits

The carcass traits of broilers fed varying dietary levels of protein is as shown in Table 3. The body live weight, plucked weight, dressed weight, percentage of dressed weight, thigh, and breast muscle of experimental chicken whose carcass were studied were not significantly ($p>0.05$) different. Significant differences were observed in the percentage plucked weight, drumstick, shank, wing, back, and ($p<0.05$). Birds fed the diet with 24% CP had higher values of percentage drumstick, shank, and wings. Birds on diets with 18-22% CP had higher values for percentage plucked weight, breast, back, and neck.

Table 3. Carcass traits of Abor acre broiler chickens fed varying dietary levels of protein

Treatments	**1**	**2**	**3**	**4**	
Protein levels (%)	**18**	**20**	**22**	**24**	**SEM**
Carcass traits:					
Body Live weight (g)	2259.00	2221.67	2399.33	2610.33	84.14
Plucked weight (g)	2118.67	2039.33	2233.67	2423.00	78.53
Plucked weight (%)	93.78^{a}	91.74^{b}	93.09^{ab}	92.87^{ab}	0.32
Dressed weight (g)	1845.67	2125.33	1955.33	2125.67	106.26
Dressed weight (%)	81.70	80.49	81.50	81.47	0.44
Drumstick (%)	8.82^{b}	9.77^{b}	9.45^{b}	10.91^{a}	0.27
Thigh (%)	9.81	9.45	10.37	11.18	0.36

Shank (%)	2.60[b]	2.88[b]	3.50[a]	3.63[a]	0.15
Breast (%)	24.94	23.75	25.74	24.09	0.48
Wing (%)	7.16[b]	7.52[ab]	7.29[b]	8.42[a]	0.20
Back (%)	19.98[a]	17.55[b]	16.33[bc]	15.38[c]	0.55
Neck (%)	4.32[a]	3.82[ab]	3.80[ab]	3.25[b]	0.17

[a-c] Means along the same row with different superscripts are significantly different ($p < 0.05$).
SEM = Standard error of mean

The internal organs of broilers fed varying dietary levels of protein are shown in Table 4. Significant differences were observed in the percentage of gizzard, spleen, and pancreas($p<0.05$) but there were no significant differences in the percentage of heart, liver, small intestine, large intestine, lungs, and trachea ($p>0.05$).

Feeding the birds with diets containing 18 and 24% CP had the highest gizzard weight which decreased when fed diets with 20 and 22% CP. The highest spleen weights were obtained for chickens fed diets with 18 and 20% CP when compared to those on diets with 20 and 24% CP ($p > 0.05$). Birds on diet with 20% CP had the significantly ($p > 0.05$) highest pancreas weight followed by those on 22, 24, and 18% CP in that order.

Table 4. Internal organs of Abor Acre broiler chickens fed varying dietary levels of protein

Treatments	**1**	**2**	**3**	**4**	
CP levels (%)	**18**	**20**	**22**	**24**	**SEM**
Internal organs (%):					
Heart	0.38	0.41	0.39	0.39	0.01
Liver	1.93	2.43	1.71	1.76	0.12
Gizzard	2.16[a]	1.80[b]	1.57[b]	1.91[ab]	0.08
Spleen	0.07[ab]	0.09[a]	0.04[b]	0.05[b]	0.01
Pancreas	0.22[b]	0.35[a]	0.27[ab]	0.26[ab]	0.02
Small intestine	5.51	5.10	5.25	4.85	0.19
Large intestine	0.52	0.81	0.74	0.73	0.06
Lungs	0.46	0.49	0.59	0.54	0.02
Trachea	0.11	0.09	0.05	0.09	0.01

[ab] Means along the same row with different superscripts are significantly different ($p < 0.05$).

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SEM: Standard error of mean.

3.3 Economy of production

The economy of broiler chicken fed varying levels of protein is as shown in Table 5. The least cost of feed intake per kg BWG (₦426.22 or 0.60USD) was obtained for birds on an 18% CP diet despite the least FCR obtained for birds on 24% CP. Cost of feed intake per kg BWG was not significantly different ($p > 0.05$) across treatments. The Cost of feed intake per bird (₦746.39 or 1.05USD - 1003.77 or 1.41USD) increased significantly across treatments as the dietary protein increased ($p < 0.05$). The revenue per dressed chicken also varied significantly from ₦1568.82 or 2.21USD in chickens fed the diet with 18% CP to ₦2087.60k or 2.94USD in those fed diets CP ($p < 0.05$). Broilers fed 24% CP that had significantly highest BWG, final body weight, and daily protein intake, but showed a lower gross margin than those fed 20% dietary protein ($p < 0.05$). The significantly highest gross margin (₦1,280.70k or 1.8USD) was obtained for birds fed diet with 20% CP ($p < 0.05$) while the gross margin for those on other diets was similar ($p > 0.05$). The least gross margin (₦771.12 or 1.09USD) was obtained for birds-fed diets with 22% CP.

Table 5. The economy of Abor Acre broiler chickens fed varying dietary levels of protein

Treatments	**1**	**2**	**3**	**4**	
Crude protein levels (%)	**18**	**20**	**22**	**24**	**SEM**
Economic Parameters (₦ & USD,$):					
Cost/Kg of feed	202.64 ($0.29)	210.13 ($0.3)	219.98 ($0.31)	231.64 ($0.33)	-
Cost of feed intake/bird	746.39^{c} ($1.05)	806.90^{bc} ($1.14)	890.92^{b} ($1.25)	1003.77^{a} ($1.41)	32.02
Cost of FI/kg BWG	426.22 ($0.60)	453.89 ($0.64)	440.69 ($0.62)	457.10 ($0.64)	7.57
Revenue/Dressed bird	1568.82^{b} ($2.21)	2087.60^{a} ($2.94)	1662.03^{ab} ($2.34)	1806.82^{ab} ($2.54)	84.46
Gross margin	822.43^{b} ($1.16)	1280.70^{a} ($1.8)	771.12^{b} ($1.09)	803.04^{b} ($1.13)	86.80

$^{a-c}$ Means along the same row with different superscripts are significantly different ($p < 0.05$). SEM: Standard error of mean

4. DISCUSSION

Feed intake was observed to increase with increasing levels of dietary CP. Similar findings were reported by Urdaneta-Rincon and Leeson (2008) who observed that birds fed a low protein diet consumed less feed than those fed 19-23% protein feed. Though FCR was similar across the board, birds on diet with 24% CP had the least FCR value (1.97), an indication that the dietary CP was utilized effectively by the birds at a higher CP level ($p > 0.05$). This was reflected in birds with 24% CP had higher body weight, daily metabolizable energy intake, daily protein intake, and energy efficiency ratio because of the high level of protein and energy in their feed.

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This is supported by the report of Gheisari et al. (2015) that broilers fed with a high level of protein showed high feed intake and weight gain compared to broilers fed with low levels of protein, though the birds with low protein levels tend to possess better feed conversion ratio and feed efficiency ratio.

There are also reports that feeding high protein (25% CP) diets at high environmental temperature (around 32℃) during the growing period in broiler chickens improved their body weight gain (Temim *et al*. 1999), helped muscle protein synthesis due to proteolysis reduction (Temim *et al*., 2000) and increase nitrogen excretion, which has a negative environmental impact (Aletor *et al*., 2000). Macleod (1997) indicated that utilization of a high protein diet with excess amino acid was not able to change heat production in the birds but correlates with body protein synthesis.

It had been reported that birds reduce feed intake by 3.6% under heat stress conditions for every increase (1ºC) in environmental temperature from 22 to 32ºC (Ain Baziz *et al*. 1996). This reduction aims to avoid increasing endogenous heat production since heat production is high when feed intake increase (Longo, 2000; Koh and Macleod, 1999; Ain Baziz *et al*. 1996). This is in contrast to what was obtained in this study as feed intake kept increasing with increasing levels of protein because the birds were not subjected to any heat stress. Some of the studies have demonstrated that the reduction in the crude protein levels in the diet does not affect the feed intake of broiler chickens (Blair *et al*., 1999; Sabino, 2001) and this report is contrary to that obtained at present as a reduction in crude protein level affected feed intake. Faria Filho (2003) however, revealed that regulation of feed intake can be linked to the quantity and quality of crude protein content which can be explained by the concentration and balance of amino acids in the diet. In addition, it was confirmed that low-protein (17% CP) diets, formulated according to the ideal protein concept, did not increase feed intake (Faria Filho, 2003).

Ghazanfari *et* al. (2010) reported that low protein intake decreases the percentage of carcass, breast, and thigh and it is contrary to the report gotten in this work as the percentage dressed weight, breast and thigh were similar across treatments.

Birds fed diet with 24% CP had higher values of percentage drumstick, shank, and wings due to the high percentage of digestible crude protein in their feed. Broiler chickens fed diets with 18-22% CP had higher values for percentage plucked weight, breast, back, and neck which corroborates with the report of Gheisari *et al*., (2015) that broilers with low crude protein levels tend to have high percentages of breast muscle, back, and neck. Akinmutimi *et al*. (2018) reported that increasing the total CP level increases carcass yield. Laudadio *et al*. (2012) also indicated that the breast and drumstick yield was significantly higher in birds fed a high protein diet (22.5% CP) compared with those of medium (20.5%CP) and low protein (18.5%CP). Temim *et al*. (2000) also found that a high-protein (25%) diet did not change breast (pectoralis major) and leg (sartorius and gastrocnemius) muscle protein turnover of broiler raised at 22 or 32ºC with diets with 20 or 25% of crude protein.

The non-significant differences in weights of some internal organs (heart, liver, small and large intestine, lung, and trachea) of birds fed different dietary protein levels in this study were similar to what was reported by Wiranata *et al*. (2013) that feeding with different protein levels provides almost the same effect on the growth of internal organs such as the heart, spleen, liver, and gizzard. In contrast, Leeson and Zubair (1997) observed an increase in the weight of the liver in chickens that were fed a high protein (29%CP) diet.

Birds fed 24% CP that had significantly highest BWG, final body weight, daily protein intake might have utilized its nutrients in producing more offal (feathers, small and large intestines, fats and internal organs) than those on other diets that are more economical in producing meat or carcass for human consumption, as the highest revenue per dressed bird and the highest gross margin was obtained for birds fed a diet with 20% protein level.

5. CONCLUSIONS

Feeding Abor acre broiler chickens with diet containing 18% crude protein and 3200kcalME/Kg for 7 weeks gave optimal performance of live weight with the least cost of feed intake per Kg body weight gain.

Optimal performance per dressed weight (2125.33 g) was obtained from broilers fed with diet containing 20% CP and 3200 kcalME/Kg with highest revenue per dressed weight (₦2087.60 or $2.94)) and highest gross margin (₦1280.00 or $1.8).

It is suggested that the optimal level of other nutrients like minerals, vitamins and essential fatty acids required by broiler chicken fed straight diets should be investigated.

Ethical consideration

Ethical issues have been checked by all the authors.

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