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Growth performance, flock uniformity and economic indices of broiler chickens fed low crude protein diets supplemented with lysine

Ojediran, T.K.[@]; Fasola, M.O.; Oladele, T.O.; Onipede, T.L. and Emiola, I.A.

Department of Animal Nutrition and Biotechnology. Ladoke Akintola University of Technology. Ogbomoso. Nigeria.

SUMMARY

This study was carried out to evaluate the growth performance, flock uniformity and economic returns from feeding broiler chicken with low protein diets supplemented with lysine. One hundred and fifty unsexed day-old Abor-acre strain broiler chicks were used in a six-week feeding trial. Five experimental diets were formulated: Diet T1 which served as the control contained 22.22 % crude protein (CP) and lysine inclusion of 0.50% while diets T2 –T5 had 16.6 % CP and between 0.60-0.90 % lysine inclusion with same level of methionine. Significant differences (p<0.05) were observed for final weight, weight gain, feed intake and feed-gain ratio at the starter phase (1-3 weeks) and combined phases (1-6 weeks) while at the finisher phase, only the final weight was significantly influenced by the dietary treatments (p<0.05). Feed cost per kg of weight gain increased linearly with the lysine inclusion (p<0.05) while the income and profit per bird, and economic efficiency of gain (EEG) increased from T1-T5. Birds fed diets T2 and T3 compared favourably with birds fed on the control diet (T1) for final weight, weight gain and feed-gain ratio at all phases. Optimum production with least input is possible using a 16 % LCP diet supplemented with high dietary lysine for broiler production as it would translate to higher profit margin.

Additional keywords

Amino acid.
Chicken.
Profit.

Crecimiento, uniformidad e índices económicos de pollos de engorde alimentados con dietas bajas en proteína bruta suplementadas con lisina

RESUMEN

Este estudio se llevó a cabo para evaluar el crecimiento, la uniformidad del lote y retornos económicos de la alimentación de pollos de engorde con dietas bajas en proteína suplementadas con lisina. Se utilizaron ciento cincuenta pollos de engorde Abor-Acre de una semana de edad, sin sexar, en un ensayo de alimentación de seis semanas. Se formularon cinco dietas experimentales: la dieta T1 que servía como control contenía 22,22 % de proteína bruta (CP) y 0,50 % de lisina; las dietas T2-T5 tenían 16,6 % de CP y entre 0,60-0,90 % de lisina con el mismo nivel de metionina (0,25 %). Se observaron diferencias significativas (p<0,05) para el peso final, la ganancia de peso, la ingesta de alimento e índice de transformación, en la fase de inicio (1-3 semanas) y las dos fases combinadas (1-6 semanas). En la fase de acabado, el peso final fue significativamente influido por los tratamientos dietéticos (p<0,05). El costo de alimento por kilogramo de aumento de peso aumentó linealmente con la inclusión de lisina (p<0,05), mientras que los ingresos y la ganancia por ave, así como la eficiencia económica de la ganancia (EEG) aumentaron de T1 a T5. Las aves alimentadas con las dietas T2 y T3 mejoraron a las aves alimentadas con la dieta de control (T1) para peso final, ganancia de peso e índice de transformación, en todas las fases. La producción óptima de pollos de engorde con menos insumo, se consiguió con una dieta LCP 16% suplementada con alto nivel de lisina dietética lo que se traduciría en mayor margen de beneficio.

Palabras clave adicionales

Aminoácidos.
Pollos.
Beneficio.

Information

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ojedirantaiwo@gmail.com

INTRODUCTION

Least cost feed formulation and profit maximization has always been the target and compelling task confronting feed nutritionist and poultry producers globally. Meeting the demand of the increasing population in the face of scarce feedstuffs, hike in price of the available ones and the consciousness of environmental pollution is of utmost concern to researchers especially in the developing nations. According to McGill (2009), it is becoming increasingly important to find new ways to stay competitive within the industry and decrease the costs of production as much as possible while producing a high quality product for consumers (Teguia and Beynen, 2004).

Although, several researchers have explored the use of non-conventional plant protein feed resources like African yam bean (Raji *et al*., 2016), Cashewnut meal (Akande *et al*., 2015), *Jatropha curcas* seed and kernel meal (Oladunjoye *et al.*, 2014; Ojediran *et al.*, 2014) and Mucuna and kidney bean (Emiola *et al*., 2007), as a replacement for the expensive soybean meal but the attendant antinutritional factors, cost of processing, seasonal availability among others have prompted the possibilities of increasing the levels of amino acids and reducing the crude protein in the diets of poultry (Iyayi *et al.,* 2014), however, the lowest level to which crude protein can be reduced with amino acid supplementation in broiler diets without reducing bird performance is still unknown, and additional research on the subject could yield significantly greater cost savings (McGill 2009).

According to Economic Research Service/USDA (2001), broilers make up a large part of the world poultry meat output with chicken meat accounting for 86%. Selective breeding has made it possible to reduce age at table size from 12 to 8 weeks and now to around 6 weeks when it will have reached over 2 kg live weight (SCAHAW, 2000). The amount of feed needed to achieve this weight gain has been reduced by almost 40% since 1976 (McKay 1997). Nevertheless, Gous (2000) reported that in 1952 it took 90 days and 8.8 kg of feed to produce a 2 kg chicken and by 1978, the performance had been improved so that only 56 days and 4.4 kg of feed were needed to produce a similar chicken. It is now possible to produce a 2 kg broiler in around 35 days, using 3.2 kg of feed. This represents a reduction in slaughter age of about 1.2 d per year.

The progress made over the years revealed that there is still room for development in the production progress especially by optimizing the feeding programme both biologically and economically. The aim of this study was to investigate the effects of lysine supplementation in low crude protein (LCP) diets on the growth performance and economic indices of broiler chicken.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Teaching and Research Farm of the Ladoke Akintola University of Technology, Ogbomoso, Nigeria, located in the derived savannah zone between latitudes 8 15'N and 8 08'N of the equator and longitudes 4 25'E and 4 16'E of the Greenwich meridian. The location has a mean annual temperature of about 26.20°C and the mean annual rainfall of about 1200mm with the relative humidity ranging from 75 – 95%.

Feed formulation

Five experimental diets were formulated: the control (T_1) had maize and soybean meal as the main energy and protein sources respectively while diets T_2- T_5 had maize and cassava meal as the major sources of energy. The crude protein content of diet T_1 was 22.22 % while that of the low crude protein diets ranged between 16.65 % (T_5) to 16.68 (T_2) while the metabolizable energy ranges from 2941.23 to 3047.79 ME (Kcal/Kg). The lysine was incorporated at 0.50% in diet T_1 and was linearly increased in the

Table I. Gross composition of experimental diet (Composición de la dieta experimental).

Ingredients	T_1 (Control)	T_2	T_3	T_4	T_5
Maize	54.20	54.10	54.00	53.90	53.80
Soybean meal	40.00	26.00	26.00	26.00	26.00
Cassava meal	0.00	14.00	14.00	14.00	14.00
Lysine	0.50	0.60	0.70	0.80	0.90
DiCalcium phosphate	2.50	2.50	2.50	2.50	2.50
Limestone	1.70	1.70	1.70	1.70	1.70
Salt	0.25	0.25	0.25	0.25	0.25
Vit/min premix	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25
Titanium dioxide	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutrient composition					
Crude protein (%)	22.22	16.68	16.67	16.66	16.65
ME (Kcal/kg)	2941.23	3047.79	3044.36	3000.93	2997.49
Lysine (%)	1.73	1.44	1.53	1.63	1.72
Methionine (%)	0.58	0.50	0.50	0.50	0.50

Vit/Min: Vitamin-mineral; ME: Metabolizable energy.

[#]2.5 kg premix used supplied vitamin A. 12,500000 iv: vitamin D, 2500000 iv; vitamin E, 40,000 mg; vitamin K3, 2000 mg; vitamin B1, 3000 mg; vitamin B2 5500 mg Niacin, 55 000 mg; calcium pantothenate, 11 500 mg vitamin B6, 5000 mg; vitamin B12, 25 mg; folic acid, 1000 mg; biotin, 80 mg; choline chloride 500 000 mg; manganese, 120 000 mg; iron 100 000 mg; zinc, 80000 mg; copper 8500 mg; iodine 1500 mg; cobalt 3000 mg; selenium 120 mg and anti-oxidant 120 000 mg.

NOTE: 1 ₦ = 0.0029 € (SEPT 2016)

low protein diets to 0.90% in diet T_5 as shown on **table I**.

EXPERIMENTAL BIRDS, DESIGN AND MANAGEMENT

One hundred and fifty day old broilers chicks of Abor-acre strain bought from a reputable farm were used for this feeding trial. The broilers were fed on conventional feed during the first week to allow for acclimatization on a deep litter before being weighed on the eighth day and then randomly assigned into five dietary/treatment groups such that each dietary treatment had 30 birds each in a completely randomized design. The experiment lasted for six (6) weeks. The experimental feed and water were supplied *ad libitum*. Routine vaccination and necessary medication schedule as applicable to the experimental location were administered. Records of the feed intake were taken daily, body weight gain on weekly basis and mortality records were also taken. At the last week of the experiment an indigestible marker, Titanium dioxide (TiO_2), was included in the diets to monitor digestibility of the feed.

Data collection. Growth performance and flock uniformity

Data were collected and recorded on daily basis on the feed offered, left over, feed intake and weekly basis on body weight and flock uniformity. All measurements were in grams (g) except otherwise stated. The growth parameters were estimated as follow:

Average daily feed intake (ADFI) (g/bird/day) = cumulative feed intake/(number of birds x number of days);

Average daily gain (ADG) (g/bird/day) = final weight gain-initial weight/number of days;

Feed-gain ratio (FGR) = cumulative feed intake (kg)/total weight gain (kg);

Flock uniformity % = 100 - (standard deviation (g)/average body weight (g) × 100).

Economic indices

Economic parameters were calculated thus:

Feed cost/kg = Sum (quantity of each ingredient x unit cost of each ingredient);

Feed cost per kg weight gain (₦) = Feed cost x total feed intake (kg)/total weight gain;

Income per kg weight gain bird (₦) = Selling price per bird/total weight gain (kg);

Profit per kg weight gain (₦) = Income per kg weight – feed cost/kg weight gain;

Economic efficiency of growth (EEG) = Profit per kg weight gain x 100/feed cost per kg weight gain.

Statistics

All data collected were subjected to analysis of variance using SAS package (SAS 2000) while, the means were separated with Duncan multiple range test using of the same package.

Table II. Growth performance and flock uniformity of broilers fed on low crude protein diets supplemented with lysine (Crecimiento y uniformidad de un lote de pollos de engorde alimentados con dietas de bajo contenido de proteína bruta suplementadas con lisina).

Parameters	T_1	T_2	T_3	T_4	T_5	p-value	SEM	R^2
Starter phase (1-3 weeks)								
IW (g/b)	165.00	163.00	162.00	163.00	165.00	0.99	2.15	0.02
FW (g/b)	692.00^{a}	655.00^{ab}	629.00^{ab}	528.00^{c}	587.00^{bc}	0.004	17.5	0.76
WG (g/b)	527.00^{a}	492.00^{a}	468.00^{ab}	365.00^{c}	418.00^{bc}	0.002	17.2	0.78
ADG (g/b/d)	37.60^{a}	35.20^{a}	33.40^{ab}	26.00^{c}	29.90^{bc}	0.002	1.23	0.78
ADFI (g/b/d)	71.20^{ab}	71.50^{a}	68.60^{ab}	67.40^{b}	68.20^{ab}	0.12	0.62	0.49
FGR	1.89^{c}	2.04^{bc}	2.07^{bc}	2.61^{a}	2.29^{b}	0.003	0.08	0.78
FU (%)	87.90	90.40	84.90	83.30	87.90	0.28	1.09	0.37
Finisher phase (4-6 weeks)								
FW (g/b)	2060.00^{a}	2020.00^{a}	1918.00^{ab}	1843.00^{b}	1842.00^{b}	0.04	31.1	0.60
WG (g/b)	1368.00	1365.00	1289.00	1315.00	1258.00	0.27	18.6	0.38
ADG (g/b/d)	65.20	64.90	61.40	62.60	59.90	0.27	0.89	0.38
ADFI (g/b/d)	135.00	132.00	128.00	126.00	126.00	0.22	1.48	0.41
FGR	2.07	2.04	2.08	2.02	2.10	0.83	2.02	0.13
FU (%)	89.00	88.10	86.30	85.90	87.60	0.75	0.77	0.16

[a,b]means the superscript differs significantly at ($p<0.05$) within the same row.
IW= Initial weight; FW= Final weight; WG= Weight gain; ADG= Average daily gain; ADFI=Average daily feed intake; FGR= Feed:gain ratio; FU= Flock uniformity.

Table III. Growth performance and flock uniformity of broilers fed on low crude protein diets supplemented with lysine (1-6 weeks) (Crecimiento y uniformidad del lote, de pollos de engorde alimentados con dietas bajas en proteína bruta suplementadas con lisina (1-6 semanas)).

Parameters	T_1	T_2	T_3	T_4	T_5	P-value	SEM	R^2
IW (g/b)	165.00	163.00	162.00	163.00	165.00	0.99	2.15	0.02
FW (g/b)	2060.00^a	2020.00^a	1918.00^{ab}	1843.00^b	1842.00^b	0.04	31.1	0.60
WG (g/b)	1895.00^a	1857.00^a	1757.00^{ab}	1680.00^b	1677.00^b	0.04	30.6	0.61
ADG (g/b/d)	54.10^a	53.10^a	50.20^{ab}	48.00^b	47.90^b	0.04	0.87	0.61
ADFI (g/b/d)	109.00	108.00	104.00	103.00	103.00	0.14	1.07	0.47
FGR	2.02^b	2.04^{ab}	2.08^{ab}	2.14^a	2.14^a	0.09	0.02	0.53
FU (%)	89.00	88.10	86.30	85.90	87.70	0.75	0.77	0.16

^{a,b}means the superscript differs significantly at (p<0.05) within the same row.

IW= Initial weight; FW= Final weight; WG= Weight gain; ADG= Average daily gain; ADFI=Average daily feed intake; FGR= Feed:gain ratio; FU= Flock uniformity.

RESULTS AND DISCUSSION

Results

Table II shows the growth performance and flock uniformity of broilers fed low crude protein diets with AA (lysine) supplemention. At the starter phase, significant values (p<0.05) were observed between final weight, weight gain, feed intake and feed gain ratio while the flock uniformity was not significantly influenced (p<0.05). The highest (p<0.05) final weight (692.00 g), weight gain (527.00 g) and average daily gain (37.60 g) was observed in birds fed the control diet while the lowest were recorded in birds fed T_4. Birds fed T_4 had a final weight of 528.00 g, weight gain of 365.00g and average daily gain of 26.00 g. Although, Birds fed diets T_2 and T_3 compared (p>0.05) with birds fed the control diet (T_1) in terms of final weight (655.00 g and 629.00 g vs 692.00 g), weight gain (429.00 g and 468.00 g vs 527.00 g), average daily gain (35.20 g and 33.40 g vs 37.60 g) respectively. The pattern of feed intake is such that those on the control diet was similar to those on the other diets, although, birds on T_2 (71.50g) was significantly different (p<0.05) from those fed T_4 (67.40 g). Nevertheless, Birds fed T_4 (2.61) had the highest feed-gain ratio while those on control diet (1.89) had the lowest. Birds on T_2 (2.04) and T_3 (2.07) had a comparable feed-gain ratio with those fed the control diet. Also, Birds on control diet (1.89) had the least feed-gain ratio while those on the T_4 (2.61) had the highest value.

At the finisher phase, only the final weight was significantly influenced (p<0.05) by the dietary treatments (p<0.05). Birds on the control diet had the highest (2060.00 g) final weight, although, not significantly different (p>0.05) from those on T_2 (2020.00 g) while birds fed T_4 (1843.00 g) and T_5 (1842.00 g) had the least.

The result of the growth characteristics of broiler chickens fed low crude protein diet with varying levels of lysine supplementation from 1–6 weeks is presented in **table III**. There were no significant differences (p>0.05) in feed intake and flock uniformity but significant differences (p<0.05) were observed in the final weight, weight gain, average daily gain and feed-gain ratio. Birds fed control diet had significantly (p<0.05) higher values for final weight (2060.00 g), weight gain (1895.00 g) and average daily gain (54.10 g) while birds on T_5 had the least (1842.00 g, 1677.00 g and 47.90 respectively). The values obtained for final weight, weight gain and average daily gain of birds showed similar trend of decreases across the diets as the lysine inclusion increases with the low protein diets, although, birds fed T_1-T_3 compared favourably (p>0.05). The feed-gain ratio was significantly influenced (p<0.05) by the dietary treatments: birds on control had the lowest (2.02) while those on T_4 and T_5 (2.14) had the highest, although, birds fed T_2 and T_3 were comparable with birds fed the control taking less feed for a better conversion comparable to those fed T_2 and T_3.

Economic indices of broilers fed low crude protein (LCP) diets with lysine at different phases of growth are shown on **table IV**. The feed cost per kg decreased (p<0.05) with LCP but increased linearly with lysine supplementation. The cost of producing a kilogram of the control diet (₦107.00) is most expensive while that of T_2 (₦98.90) is least costly. Birds on T_2 (1001.00 g) had the highest value (p<0.05) for feed intake while those on T_4 (944.00) had the lowest value comparable to those fed the control diet (996.00 g), T_3 (961.00 g) and T_5 (955.00 g). Birds fed T_4 (₦261.05) had a significantly higher (p<0.05) feed cost per kg weight gain compared with those on the T_2 (₦201.27) which had the lowest cost. A higher income and profit (p<0.05) was recorded on birds fed T_4 while those fed the control diet lowest. The economic efficiency of gain (EEG) of birds on LCP diets ranges from 304.54 – 324.08 which was

Table IV. Economic indexes of broilers fed on low crude protein diets supplemented with lysine at different phases of growth (Índices económicos de pollos de engorde alimentados con dietas bajas en proteína bruta suplementadas con lisina en diferentes fases de crecimiento).

Parameters	T_1	T_2	T_3	T_4	T_5	p-value	SEM	R^2
Starter phase (1-3 weeks)								
Feed cost/kg (₦)	107.00^{a}	98.90^{c}	99.40^{bc}	99.90^{bc}	100.50^{b}	0.00	0.78	0.95
Feed intake (g/b)	996.00^{ab}	1001.00^{a}	961.00^{ab}	944.00^{b}	955.00^{ab}	0.12	8.73	0.49
WG(g/b)	527.00^{a}	492.00^{a}	468.00^{ab}	365.00^{c}	418.00^{bc}	0.002	17.17	0.78
FC/(kg)WG (₦)	201.87^{bc}	201.27^{c}	205.76^{b}	261.05^{a}	229.88^{ab}	0.005	7.11	0.75
Income/bird(₦)	75.99^{c}	81.32^{bc}	86.45^{bc}	110.84^{a}	96.04^{ab}	0.004	3.77	0.76
Profit/bird(₦)	55.80^{c}	61.20^{bc}	65.90^{bc}	84.70^{a}	73.10^{ab}	0.004	3.09	0.76
EEG	276.56^{b}	304.54^{a}	319.22^{a}	324.08^{a}	317.35^{a}	0.01	5.45	0.71
Finisher phase (4-6 weeks)								
Feed cost/kg	107.00^{a}	98.90^{c}	99.40^{bc}	99.90^{bc}	100.50^{b}	0.00	0.78	0.95
Feed Intake (g/b)	2825.00	2780.00	2685.00	2653.00	2636.00	0.22	10.5	0.41
WG (g/b)	1368.00	1365.00	1289.00	1315.00	1258.00	0.27	18.6	0.38
FC/(kg)WG (₦)	220.00^{a}	202.00^{b}	206.00^{ab}	201.00^{b}	210.00^{ab}	0.13	2.64	0.48
Income/bird(₦)	87.70	88.30	93.20	91.30	95.50	0.28	1.29	0.37
Profit/bird(₦)	65.70^{b}	68.10^{ab}	72.50^{ab}	71.20^{ab}	74.50^{a}	0.15	1.23	0.46
EEG	298.00^{b}	337.00^{a}	351.00^{a}	353.00^{a}	353.00^{a}	0.01	6.73	0.69

^{a,b}means the superscript differs significantly at (p<0.05) within the same row.
WG= Weight gain; FC=Feed cost; EEG= Economic efficiency of growth.

significantly higher (p<0.05) than those fed control diet (276.56).

At the finisher phase, the feed cost per kg weight gain, profit per bird and EEG were significantly influenced (p<0.05). The feed cost per kg weight gain was highest for birds fed control diet (₦220.00) while those on T4 (₦201.00) had the least cost, although the cost of those fed LCP diets ranged between ₦201.00 – ₦201.00. The profit per bird was highest (p<0.05) for birds on T5 (₦74.50) than those fed on control diet which had the lowest (₦65.70) profit while those fed T2 – T4 were comparable which means that it cost less using LCP diets at the finisher phase compared to the starter phase.

Table V shows the economic analysis of broilers fed low protein diets with varying levels of dietary lysine supplemention from 1-6 weeks. Weight gain, feed cost per kg weight gain, income per bird, profit per bird and EEG were significantly influenced (p<0.05) by the dietary treatments. The weight gain was highest in birds fed the control diet (1895.00g), which is comparable (p>0.05) to those on T_2 (1856.67 g) while those fed T_5 (1677.67) had the least value (p<0.05). The weight gain experienced a linear decrease across the diets but was not different (p<0.05) for those fed control diet beyond T_3. Among the bird fed LCP diets, feed cost per kg weight gain increased linearly with lysine supplementation. The feed cost per kg weight gain was highest for birds on T_5 (₦215.39) similar (p>0.05) to those on those fed the control diet (₦215.18) and T_4 (₦214.19) while those on T_2 (₦201.56) had the least (p<0.05). The income from bird fed T_5 (₦71.72) was highest while those on control (₦63.35) was lowest. The profit on birds fed T3 – T5 ranged from ₦47.87 – ₦50.18 but those fed the control diet (₦41.83) had the lowest value. The EEG ranged from 194.48 in birds fed the control diet to 232.80 in those fed T_5, although, birds fed T_2 (221.12) – T_5 (232.80) was significantly different (p<0.05) from those on the control diet. Noticeably, the income and profit per bird, and EEG increases from T_1-T_5, which means that raising broilers on LCP diets from 1-6 weeks would mean an increase in profit correlating to lysine levels.

DISCUSSION

The unequal growth performance at the starter phase corroborates the report of Bregendahl *et al.* (2002) who compared the response of birds offered control (NRC, 1994 recommened 23 %CP) diet to those fed LCP diets with crystalline AA supplementation. Jianlin *et al.* (2004), reported that broiler on low protein diet had depressed body weights and feed-gain ratio compared with those that received the required amount. Although, this study showed that birds fed 16.67-16.68 %CP with 0.60 % - 0.70 % lysine inclusion were comparable with those on control diet but Ojediran *et al.* (2016) noted that 18.26 %CP and 0.55 % lysine inclusion enhanced daily weight gain and resulted in least feed-gain ratio.

Table V. Economic indexes of broilers fed on low crude protein diets supplemented with lysine (1-6 weeks)
(Índices económicos de pollos de engorde alimentados con dietas bajas en proteína bruta suplementadas con lisina (1-6 semanas)).

Parameters	T_1	T_2	T_3	T_4	T_5	p-value	SEM	R^2
Feed cost/kg	107.00^a	98.90^c	99.40^{bc}	99.90^{bc}	100.50^b	0.00	0.78	0.95
Feed intake (g/b)	3821.40	3781.40	3645.40	3597.40	3590.50	0.14	37.5	0.47
Weight gain (g/b)	1895.00^a	1856.67^a	1756.67^{ab}	1680.00^b	1677.67^b	0.04	30.9	0.61
FC/(kg)WG (₦)	215.18^a	201.56^b	206.26^{ab}	214.19^a	215.39^a	0.07	2.03	0.55
Income/bird(₦)	63.35^b	64.75^b	68.50^{ab}	71.52^a	71.72^a	0.04	1.22	0.60
Profit/bird(₦)	41.83^b	44.60^{ab}	47.87^a	50.10^a	50.18^a	0.03	1.01	0.64
EEG	194.48^b	221.12^a	232.06^a	233.86^a	232.80^a	0.01	4.89	0.73

^{a,b}means the superscript differs significantly at ($p<0.05$) within the same row.
FC: Feed cost; EEG: Economic efficiency of growth.

This shows that at a particular LCP, there is a limit to AA supplementation. Contrary to the observation of Sterling *et al*. (2003), the feed intake of birds on LCP diets with lysine supplementation were comparable with those fed control diet. Kamran *et al*. (2008) after investigating the effect of LCP with constant energy to protein ratio on broiler performance from 1-26 days of age concluded that feed intake increased significantly while weight gain and Feed conversion ratio were adversely affected. This, therefore, may be summarized with the words of Si *et al*. (2004) that the failure to obtain optimum performance could be due to potential toxic effect of AA in excess of requirement, reduced level of potassium or altered ionic balance and lack of sufficient nitrogen pool to provide non-essential or dispersible AA.

On the other hand, it was observed at the finisher phase that the birds could tolerate the LCP diets owing to the non significant differences in weight gain, feed intake, feed-gain ratio and flock uniformity. Birds on LCP diets consumed about 7.18 % less per metabolic body weight leading to improved efficiency of protein retention which is consistent with the report of Swennen *et al*. (2004), although Zarate *et al*. (2003) had earlier confirm that better utilization of protein is a benefit of feeding LCP diets.

The growth performance of birds raised without recess to either starter or finisher phase in this study showed that birds fed 16.67-16.68 %CP with 0.60 % - 0.70 % lysine inclusion respectively were comparable with those on control diet contrary to the report of Iyayi *et al*. (2014) who observed that high level of methionine or lysine supplementation in broilers fed LCP diets does not translate to comparable final weight, weight gain and feed-gain ratio with those fed control diet. This means that optimal protein deposition and rate of growth is colligated with optimum crude protein and amino acid where a level above such does not improve growth (Urdaneta and Leeson, 2004). Observation on feed intake is contrary to the report of Rama Rao *et al*. (2011) who indicated that increased lysine levels led to increased feed intake. Al-saffar and Rose (2002) stated that broiler chickens given a very high dietary concentration of a single amino acid reduce their voluntary feed intake, consequently reducing growth rate and feed conversion efficiency contrary to the report of Corzo *et al*. (2004); Waldroup *et al*. (2005); Aftab *et al*. (2006) and Dean *et al*. (2006). In the same vein, Si *et al*. (2004) and Jiang *et al*. (2005) observed reduced feed intake in broilers fed LCP diets which Austic *et al*. (2000) attributed to the effect of rapid influx of free AA into blood stream causing plasma AA imbalance thus reducing feed intake and consequently weight gain. Also, Sohail *et al.* (2003) and Dean *et al.* (2006) attributed this difference to extent of reduction of CP contents, change in dietary net energy concentration and protein ratio, class and age of birds used as well as the extent to which intact protein sources are kept at constant ratios to minimize AA imbalance.

The feed cost per kg is within the range reported by Ojediran *et al*. (2016) who fortified LCP diets with lysine at the starter phase while the feed cost per kg weight gain was not similar. Moreover, the income per bird, profit per bird and EEG of birds fed LCP diets in this study is higher than those fed control diet. At the finisher phase, the feed cost per kg weight gain in birds fed control was highest, which could be attributed to the higher feed cost per kg while birds on LCP diets recorded higher profit per bird and EEG. This is similar to the result observed when birds were raised from 1–6 weeks. This finding is consistent with the report of Jackson *et al.* (1982) who reported that increasing dietary protein level resulted in higher cost when broilers were fed 16-36 %CP diets. They concluded that despite low cost of the 16 %CP diets, production cost (feed cost per kg weight gain) were increased on higher CP levels. Consequently, Bryden and Li (2004) stated that optimum performance and profitability depends largely on the adequacy of AA contents of the diets.

CONCLUSION

It can therefore be concluded that there is a limit to lysine supplementation in a 16 % LCP diet at various phases. Nevertheless, optimum production with least input is possible using a LCP diet supplemented with high dietary lysine as it would translate to high profit margin.

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