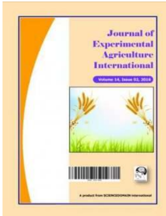

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Carcass, Organs and Economic Evaluation of Broiler Birds Fed Low-protein Diets Supplemented with the Most Limiting Essential Amino Acids in Ideal Protein Concept

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Authors' contributions

This work was carried out in collaboration between all authors. Author FASD other authors in supervising the designed study. Author AKB was an undergraduate student undergoing project work. Results, statistical analyses and discussion of the research findings were done by all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study evaluated the carcass, organs and economic parameters of broiler birds on the 57th day of production considered to be the economic market weight in which ideal protein concept was tested using the most limiting essential amino acids (EAAs), L-Lysine, DL-Methionine, L-Tryptophan and L-Threonine as supplements in low crude protein diets. Two sets of experimental diets were prepared for the two phases of broiler production at broiler starter (BS) and broiler finisher (BF) phases. At the BS phase (0-28 days), crude protein levels were varied from 23.0% in both the control diet (conventional BS diet with plant protein origin and fish meal) and diet 2 with the most

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limiting EAAs to diet 6 with the lowest crude protein of 11.0%. At the BF phase (29-57 days), six dietary treatments in which crude protein varied from 20.0% to 8.0% were used. The average live weight (LW) of 2490.3±25.2g obtained for birds on diet 3 (17.0% CP with EAAs supplementation) was the highest but similar (P>0.05) to the LW values of 2378.3 ± 24.6g, 2370.0 ± 47.9g and 2267.0 ± 53.0g obtained for birds on diets 4 (14.0% CP with EAAs supplementation), diet 2 (20.0% CP with EAAs supplementation) and the control diet 1 (20.0% CP conventional diet with some protein of animal origin), respectively. The average slaughtered weight of 2425.0±19.4g was also the highest value for birds on diet 3 (17.0% CP with EAAs supplementation). The average carcass weight value of 1798.3±21.8g was the highest and obtained for birds on diet 3 (17.0% CP with EAAs supplementation). There were similarities (P>0.05) among weights of most organs investigated. Data obtained were analysed statistically using Minitab (Version 16).

The total net return/bird (gross profit) was highest at N792.06 for birds on 20.0%/17.0% CP for broiler starter/finisher EAAs supplemented diets, respectively. Noteworthy that birds on diet 4 (17.0%/14.0% CP for broiler starter/finisher EAAs supplemented diets, respectively diets with EAA supplementation) had better net returns (gross profit) over the control diet formulated conventionally to contain 23.0%/20.0% CP for broiler starter/finisher diets at minimum Lys & Met supplementation.

Keywords: Reduction of crude protein; essential amino acids; low crude protein diets.

1. INTRODUCTION

Dietary crude protein (CP) requirements are somewhat of a misnomer as the requirement is based on the amino acids content of the protein. Once digested and absorbed, amino acids are used as the building blocks of structural proteins (muscle, skin, ligaments), metabolic proteins, enzymes, and precursors of several body components. Because body proteins are constantly being synthesized and degraded, an adequate amino acid supply is critical to support growth or egg production [1].

The best way to reduce N in poultry excreta is to lower the amount of CP that is fed by supplementing diets with amino acids. Reductions in the non-essential amino acid pool, coupled with supplying a more “ideal” amino acid profile in the diet can substantially increase the efficacy of overall N retention by the bird. On a practical basis, however, bird performance can be hindered by these lower CP diets due to a number of factors that tend to be associated with dietary CP and amino acid reductions.

The application of the concept of the ideal protein in feed formulation makes it possible to adjust the supply of the indispensable amino acids to the requirements of animals in order to avoid deficiencies and limit excesses. These excesses, which are mainly caused by protein-rich raw materials, such as soybean meal, provide some amino acids which go beyond the animal's requirements; they have therefore to be catabolised by animals and they are at the origin of the excretion of nitrogen compounds which are transformed into nitrates in the environment [2].

In the implementation of the concept of the ideal protein, feed-use amino acids are indispensable ingredients to optimize the balance of amino acids in feed formulas – meeting objectives of performance, profitability and respect for the environment. The reduction of nitrogen input to farms, reduces protein diets and lower the nitrogen output to the environment [3, 4]. Therefore the present research study is aimed at evaluating the carcass and organs characteristics as well as the economic benefits of broiler production using low protein diets supplemented with most limiting EAAs in broiler nutrition.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out in the Poultry Unit of the Teaching and Research Farm (T & RF) of Ekiti State University, Ado-Ekiti with geographical coordinates of 7^o 38’0” North, 5^o 13’ 0” East The T &RF and a tropical humid climate with distinct wet and dry seasons. The rainy season spans over seven months starting from March/early April to October with a dry spell in August. Temperature in this area is fairly uniform throughout the year with little deviation from the mean annual of 27^{o}c. The topography is moderately sloppy with the highest point having the slope of not greater than 6%. The main vegetation is grass but activities like bush fallowing influences vegetation. The experiment was carried out between March and June, 2016. Further laboratory analyses were carried out at the Animal Production and Health Sciences Laboratories of Ekiti State University and The Federal University of Technology, Akure.

2.2 Site Preparation

Prior to the arrival of broiler chicks, the poultry house and metabolism cage were thoroughly washed and fumigated with diskol (a disinfectant containing 4% benzalkonium chloride, 3% glutaraldehyde, 14% formaldehyde, stabilizers, antioxidants and activators). The house was covered to prevent heat loss and brooding equipment installed.

2.3 Sourcing of Pharmaceutical Feed-Grade Amino Acids

Feed-grade L-Lysine, L-Tryptophan and L-Threonine amino acids were ordered from Ajinomoto Animal Nutrition, Ajinomoto North America, Inc., 4020 Ajinomoto Drive, Raleigh, USA. Pharmaceutical-grade amino acids are reputed to be between 99% and 100% pure.

2.4 Experimental Diets

The feed ingredients used in ration formulation were purchased locally from a reputable commercial feed miller. Feed-grade amino acids were sourced as previously discussed. The experimental diets were compounded and manually mixed on the clean floor of the Poultry Section of the Teaching & Research Farm. The dietary treatments were made up of the control diet 1 which had an approximate value of 20.0% crude protein of both plant and animal (fish meal) origins with a substantial supplementation of DL-Methionine and L-Lysine. Diet 2 also had 20.0% all of plant origins with four most limiting EAAs. Diets 3, 4, 5 and 6 contained reduced inclusion levels of crude protein of plant origin at approximate values of 17.0%, 14.0%, 11.0% and 8.0%, respectively. In essence, crude protein was reduced by 3 points across the diets from diet 3 to diet 6. The four most limiting essential amino acids [5] in broilers were supplemented as required in the low crude protein diets.

2.5 Carcass and Organ Characteristics

Two birds from each replicate were slaughtered on the last day of each phase of the experiment. The carcasses were scalded before defeathering and the dressed chicks were later eviscerated. The measurements of the carcass traits: dressed weights, eviscerated weight, thigh, drumsticks, shank, back, necks, wing, belly-fat and head were taken before dissecting out the organs. The organs measured were the liver, lungs, spleen, heart and gizzard. All the carcass traits except the dressed and eviscerated weights were expressed as percentages of the live weight while the organs were expressed in g/kg body weight.

2.6 Cost Implications/Economics Analysis

One of the objectives of this study is to assess the economics of using feed-grade amino acids to supplement for crude protein in the diets of broilers. This will be assessed as described below:

For profitability analysis, it shall be determined as follows:

$$\prod = TR - TC \quad (1)$$

$$TR = P_q{*}Q \quad (2)$$

$$TC - TVC + TFC \quad (3)$$

Where:

$\prod$ = Net profit; TR = Total Revenue from broiler; TC = Total Cost involved; Pq = Price for each phase of broiler production; Q = Total output for each phase of broiler production; TVC = Total Variable Cost involved in the broiler production; TFC = Total Fixed Cost involved in the broiler production.

The equations above will be used to determine the profitability of the broiler production. The profitability level of the broiler production using feed-grade amino acids will be compared with that of feed with conventional diets in the control experiments.

3. RESULTS AND DISCUSSION

3.1 Carcass Characteristics and Organs Weights of Matured Birds at Slaughter

Carcass characteristics at slaughter (day 57) of broiler birds fed varying crude protein levels with amino acids supplementation is presented in Table 2.

Table 1. Requirement for crude protein and the most rate limiting amino acids for broilers [5]

	Weeks of age		
Nutrients, %	**0 -3**	**3-6**	**6-8**
Crude protein	23.00	20.00	18.00
Methionine	0.59	0.38	0.32
Total sulfur			
Amino acids	0.90	0.72	0.60
Lysine	1.10	1.00	0.85
Threonine	0.80	0.74	0.68
Tryptophan	0.20	0.18	0.16
Isoleucine	-.80	0.73	0.62
Arginine	1.25	1.10	1.00
Valine	0.90	0.82	0.70

The average live weight (LW) of 2490.3±25.2g obtained for birds on diet 3 (17.0% CP) was the highest but similar (P>0.05) to the LW values of 2378.3 ± 24.6g, 2370.0 ± 47.9g and 2267.0 ± 53.0g obtained for birds on diets 4 (14.0% CP), 2 (20.0%) and the control diet 1, respectively. The LW value of 1823.8±20.9g obtained for birds on diet 5 (11.0%) was also similar (P>0.05) to the LW value of 2267.0±53.0g and 1386.8±31.6g obtained for birds on diet 6 (8.0% CP). The average slaughtered weight of 2425.0±19.4g was the highest value for birds on diet 3 (17.0% CP) but similar (P>0.05) to 2325.8±23.3g, 2324.5±41.3g and 2193.5±67.0g obtained for birds on diets 4 (14.0% CP), 2 (20.0% CP) and the control diet 1, respectively in declining order.

Table 2. Experimental diets for chicks fed varying crude protein levels with amino acids supplementation at broiler starter phase (1 – 28days)

Ingredients	**Control**	**Crude protein reduction/amino acids supplementation**				
	Diet 1	**Diet 2**	**Diet3**	**Diet 4**	**Diet 5**	**Diet 6**
	CP (23%)	**23.0% CP**	**20.0% CP**	**17.0% CP**	**14.0% CP**	**11.0% CP**
Maize (11% CP)	56.4	56.7	56.7	56.7	56.7	56.7
Soyabean meal (45% CP)	36.0	39.0	32.0	25.0	18.0	11.0
Fish meal (72% CP)	3.0	-	-	-	-	-
Rice husk	-	-	5.0	5.0	11.0	16.0
Palm oil	-	-	2.0	5.0	6.0	8.0
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.3	0.3	0.3	0.3	0.3	0.3
**Premix	0.5	0.5	0.5	0.5	0.5	0.5
Amino acid supplementation						
Lysine	0.15	1.5	1.5	1.5	1.5	1.5
Methionine	0.15	1.0	1.0	1.0	1.0	1.0
Threonine	-	1.0	1.0	1.0	1.0	1.0
Trytophan	-	0.5	0.5	0.5	0.5	0.5
Calculated composition						
Crude Protein, %	23.3	23.0	19.8	16.6	13.7	10.8
*ME (Kcal/Kg)	2893.3	2889.7	2884.0	2960.1	2872.5	2866.8
Crude Fibre, %	3.9	4.1	3.8	3.4	7.4	9.0
Fat, %	3.8	3.6	3.5	3.3	3.1	2.9
Proximate Composition						
Crude Protein	23.1	23.3	18.9	16.9	14.2	11.3
Crude Fibre, %	3.9	4.1	3.8	3.4	7.4	9.0
Fat, %	3.8	3.6	3.5	3.3	3.1	2.9
MC, %	9.35±0.08	9.42±0.04	9.46±0.06	9.43±0.03	9.36±0.06	9.34±0.05

**ME, metabolizable energy = (0.860+0.629(GE-0.78CF) by Campbell et al., (1986) **Contained vitamins A(10,000,000iu); D(2,000,000iu); E(35,000iu);K(1,900mg); B12 (19mg); Riboflavin(7,000mg); Pyridoxine(3,800mg); Thiamine(2,200mg); D Panthotenic acid(11,000mg); Nicotinic acid(45,000mg); Folic acid(1,400mg); Biotin (113mg); and trace elements as Cu(8,000mg); Mn(64,000mg); Zn(40,000mg); Fe(32,000mg); Se(160mg); I_2(800mg); and other items as Co(400mg); Choline(475,000mg); Methionine(50,000mg); BHT(5,000mg) and Spiramycin(5,000mg) per 2.5kg CP:Crude Protein, ME:Metabolized Energy.*

Table 3. Experimental diets for broilers fed varying crude protein levels with EAA supplementation (finisher phase, 29 – 57days)

Ingredients	Control	Crude protein reduction/amino acids supplementation				
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	CP(20%)	20.0% CP	17.0% CP	14.0% CP	11.0% CP	8.0% CP
Maize	65.4	61.1	56.8	57.3	57.1	59.1
Soyabean meal	28.0	32.0	25.3	19.8	13.0	6.0
Fish meal (72% CP)	2.0	-	-	-	-	-
Rice husk	-	-	8.0	10.0	15.0	20.0
Palm oil	-	-	3.0	6.0	8.0	8.0
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.3	0.3	0.3	0.3	0.3	0.3
*Premix	0.5	0.5	0.5	0.5	0.5	0.5
EAA supplementation						
Lysine	0.15	1.0	1.0	1.0	1.0	1.0
Methionine	0.15	0.7	0.7	0.7	0.7	0.7
Threonine	-	0.7	0.7	0.7	0.7	0.7
Trytophan	-	0.2	0.2	0.2	0.2	0.2
Calculated composition						
Crude Protein, %	19.9	19.9	17.0	14.1	11.0	7.7
**ME (Kcal/Kg)	2893.3	2889.7	2807.16	2890.74	2871.32	2828.23
Crude Fibre, %	3.9	4.1	3.8	3.4	7.4	9.0
Fat, %	3.8	3.6	3.5	3.3	3.1	2.9

**Contained vitamins A(10,000,000iu); D(2,000,000iu); E(35,000iu);K(1,900mg); B12 (19mg); Riboflavin(7,000mg); Pyridoxine(3,800mg); Thiamine(2,200mg); D Panthotenic acid(11,000mg); Nicotinic acid(45,000mg); Folic acid(1,400mg); Biotin (113mg); and trace elements as Cu(8,000mg); Mn(64,000mg); Zn(40,000mg); Fe(32,000mg); Se(160mg); I_2(800mg); and other items as Co(400mg); Choline(475,000mg); Methionine(50,000mg); BHT(5,000mg) and Spiramycin(5,000mg) per 2.5kg; CP:Crude Protein, ME:Metabolized Energy.*

***ME, metabolizable energy = (0.860+0.629(GE-0.78CF) [7].*

The lowest significant (P<0.05) slaughtered weight of 1308.3±38.0g was obtained for birds on diet 6 (8.0% CP). The average dressed weight (DW) of 2341.3±9.2g was the highest for birds on diet 3 (17.0% CP) but similar (P>0.05) to DW values obtained for birds on diet 4 (14.0%CP), 2 (20.0%CP) and the control diet 1 at 2248.8±26.2g, 2244.8±48.9g and 2146.8±54.8g, respectively. The average eviscerated weight also had the highest value of 1976.3±23.5g for birds on diet 3 (17.0% CP) but similar (P>0.05) to the eviscerated weight values of 1897.8±17.7g, 1885.3±49.0g and 1809.8±48.3g for birds on diets 4 (14.0% CP), 2 (20.0% CP) and the control diet 1, respectively. The average carcass weight value of 1798.3±21.8g was the highest and obtained for birds on diet 3 (17.0% CP). However, this carcass weight was similar (P>0.05) to the carcass weight values of 1667.3±17.8g, 1640.0±46.1g and 1573.3±23.3g obtained for birds on diet 2 (20.0% CP), control diet 1 and diet 4 (14.0% CP), respectively.

The average relative weights of heads for birds on the control diet, diets 1 (20.0% CP), 2 (20.0% CP), 3 (17.0% CP) and 4 (14.0% CP) were similar (P>0.05) at 3.1±0.2g, 2.9±0.2g, 2.9±0.2g and 3.0±0.3g, respectively. The highest value for the relative weight of wing was 8.8±0.2g obtained for birds on the control diet but similar (P>0.05) to the relative weight of wing values of 8.5±0.1g and 8.5±0.4g obtained for birds on diet 2 (2.0% CP) and diet 5 (11.0% CP), respectively. The thigh had the highest average relative weight of 12.1±1.1g for birds on the control diet albeit similar (P>0.05) to 11.2±0.4g, 10.8±0.6g, 10.6±0.7g, 10.5±0.6g and 10.3±0.7g, for birds on diets 4 (14.0% CP), 2 (20.0% CP), 6 (8.0% CP), 3 (17.0% CP) and 5 (11.0% CP), respectively. The highest average relative breast muscle weight of 24.3±2.6g was obtained for birds on diet 3 (17.0% CP) albeit similar (P>0.05) to the average relative breast muscle weights of 23.4±2.0g, 22.6±1.5g, 21.7±1.9g and 20.6±3.2g for birds on diets 4 (14.0% CP), 2 (20.0% CP), 1 (control diet) and 5 (11.0% CP), respectively. The lowest average breast muscle weight of 18.0±2.6g was obtained for birds on diet.

Table 4. Carcass characteristics at slaughter (day 57) of broiler birds fed varying crude protein levels with amino acids supplementation

Parameters	Control		Crude protein reduction/Amino acids supplementation			
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	20.0% CP	20.0% CP	17.0% CP	14.0% CP	11.0% CP	8.0% CP
Live weight, g	2267.0±53.0^{ab}	2370.0±47.9^{a}	2490.3±25.2^{a}	2378.3±24.6^{a}	1823.8±20.9^{bc}	1386.8±31.6^{c}
Slaughtered weight, g	2193.5±67.0^{ab}	2324.5±41.3^{a}	2425.0±19.4^{a}	2325.8±23.3^{a}	1776.8±19.7^{b}	1308.3±38.0^{c}
Dressed weight, g	2146.8±54.8^{ab}	2244.8±48.9^{a}	2341.3±19.2^{a}	2248.8±26.2^{a}	1711.8±19.0^{bc}	1268.8±29.1^{c}
Eviscerated weight, g	1809.8±48.3^{a}	1885.3±49.0^{a}	1976.3±23.5^{a}	1897.8±17.7^{a}	1410.3±15.7^{b}	1005.0±22.1^{c}
Carcass weight, g	1640.0±46.1^{a}	1667.3±17.8^{ab}	1798.3±21.8^{a}	1573.3±23.3^{ab}	1271.3±15.0^{bc}	899.0±20.5^{c}
Head, gKg^{-1}	3.1±0.2^{b}	2.9±0.2^{b}	2.9±0.2^{b}	3.0±0.3^{b}	3.6±0.6^{ab}	3.9±0.3^{a}
Wing, gKg^{-1}	8.8±0.2^{a}	8.5±0.1^{ab}	7.4±0.5^{c}	7.8±0.3^{bc}	8.5±0.4^{ab}	7.9±0.4^{bc}
Neck, gKg^{-1}	0.04±0.1	0.05±0.1	0.05±0.1	0.05±0.1	0.05±0.1	0.05± 0.1
Thigh, gKg^{-1}	12.1±1.1^{a}	10.8±0.6^{ab}	10.5±0.6^{ab}	11.2±0.4^{ab}	10.3±0.7^{b}	10.6±0.7^{ab}
Drumstick, gKg^{-1}	10.3±1.5	10.3±0.4	10.4±1.0	10.3±0.3	10.1±0.9	9.8±0 .1
Breast, gKg^{-1}	21.7±1.9^{a}	22.6±1.5^{ab}	24.3±2.6^{a}	23.4±2.0^{a}	20.6±3.2^{ab}	18.0±2.6^{b}
Back, gKg^{-1}	14.1±1.2	14.2±0.4	13.2±1.0	13.4±0.8	13.7±1.2	14.6± 1.3
Shank, gKg^{-1}	0.04±0.1	0.05±0.1	0.04±0.1	0.04±0.1	0.04±0.1	0.04± 0.1

a, b, c, Means within a row with different superscript are significantly different (P<0.05).

Table 5. Relative weights of organs at slaughter (day 57) of broiler birds fed varying crude protein levels with amino acids supplementation

Parameters gKg^{-1}	Control		Crude protein reduction/amino acids supplementation			
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	20.0% CP	20.0% CP	17.0% CP	14.0% CP	11.0% CP	8.0% CP
Liver	1.08±0.94^{b}	0.96±0.44^{b}	2.07±0.41^{ab}	2.19±0.27^{ab}	2.66±1.04^{a}	2.63±0.37^{a}
Kidney	1.96±0.56	2.01±0.62	2.21±0.91	2.23±0.56	2.21 ±0.45	2.01±0.32
Heart	0.47±0.21	0.43±0.08	0.37±0.07	0.37±0.16	0.53± 0.09	0.59±0.10
Gizzard	0.25±0.03^{b}	0.25±0.02^{b}	0.25±0.04^{b}	0.27±0.04^{b}	0.33±0.06^{ab}	0.37±0.03^{a}
Lungs	3.16±0.32	3.23±0.34	3.32±0.41	3.41±0.54	3.31± 0.64	3.43±0.24
Intestines	0.63±0.13	0.62±0.14	0.68±0.23	0.54±0.07	0.75±0.22	0.85±0.17
Proventriculus	0.37±0.06^{b}	0.37±0.10^{b}	0.49±0.16^{ab}	0.41±0.09^{b}	0.48±0.17^{ab}	0.72±0.05^{a}

a, b, c, Means within a row with different superscript are significantly different (P<0.05).

Table 6. Economic analyses of matured broiler birds fed varying crude protein levels with amino acids supplementation

Parameters	Control	Crude protein reduction/amino acids supplementation				
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**
	23.0% CP	**23.0% CP**	**20.0% CP**	**17.0% CP**	**14.0% CP**	**11.0% CP**
Cost of experimental diets (N/kg)	121.51	137.51	133.71	133.40	128.28	122.48
Total feed intake (kg/bird)	3.15	3.00	3.38	3.07	2.81	2.01
Cost of feed intake/bird (N/bird)	382.76	412.53	451.94	409.54	360.47	246.18
Cost of starter broiler at dob (N/bird)	250.00	250.00	250.00	250.00	250.00	250.00
Total cost of production/bird (N/bird)	632.76	662.53	701.94	659.54	610.47	496.18
Ave. body wt. at 57th day of age(kg/bird)	2.27	2.37	2.49	2.38	1.82	1.39
Cost of 1kg of poultry meat (N/kg)	600.00	600.00	600.00	600.00	600.00	600.00
Total revenue/bird (N/bird)	1,362.00	1,422.00	1,494.00	1,428.00	1,092.00	834.00
Total net returns/bird (N/bird)	729.29	759.47	792.06	768.46	481.53	337.82

**The cost of each diet is the average cost of the broiler starter and finisher diets.*
**Uniform cost such as medication and labour are not considered*

The significantly lower but similar (P>0.05) live weight values obtained for the birds on the lowest 8.0% CP and 11.0% CP at 1386.8±31.6g and 1823.8±20.9g, respectively conformed to previous report. It has earlier been reported that not only are growth rate and feed utilization efficiency dependent on dietary protein and energy levels, but the amount of carcass, abdominal fat are as well [6]. He further postulated that the maximum responses to CP levels are as follows: 1) maximum live BW; 2) maximum feed utilization efficiency; 3) maximum carcass lean mass; and 4) minimum carcass fat. The changes in carcass yield (weight of salable product/live BW) caused by changing the dietary protein level may be on the order of 4%, which is enormous from an economic perspective [7,8].

Neck, drumstick, back and shank all had similar (P>0.05) for values for birds on all the experimental diets including the conventional control diet in which 23.0% CP with minimal methionine and lysine supplementation. However, most carcass characteristics such as slaughtered weight, dressed weight, eviscerated weight, carcass weight, head, thigh and breast muscle had values similar (P>0.05) for birds on the control diet (20.0% CP conventional diet with animal protein source and minimal methionine and lysine supplementation), diet 2 (20.0% CP diet with essential amino acids supplementation) and diet 3 (17.0% CP diet with essential amino acids supplementation). Several previous studies seem to have validated the importance of essential amino acids in poultry low protein feed supplementation [9,10,11,12]. However, the amount of essential amino acids required depends on factors such as dietary CP content, main dietary feed ingredients, and broiler strain, age, and sex [12]. Previous report [12] that carcass yield, breast meat yield, thigh yield, abdominal fat, and relative liver and heart weights were not affected by the treatments agreed with the present result. Also for organs, only liver, gizzard and proventriculus had slight variations among treatment means. Several previous studies [7,8,13] had varying levels of corroboration with the present.

3.2 Economic Analysis of Production Cost

The total net return/bird (gross profit) was highest at N792.06 for birds on diet 3 (20.0%/17.0% CP for broiler starter/finisher diets) followed by N768.46, N759.47, N729.29, N481.53 and N337.82 for birds on diets 4 (17.0%/14.0% CP for broiler starter/finisher diets), 2 (23.0%/20.0% CP for broiler starter/ finisher diets), control diet 1 (23.0%/20.0% CP for broiler starter/finisher diets at minimum Lys & Met supplementation), diets 5 (14.0%/11.0% CP for broiler starter/finisher diets) and 6 (11.0%/8.0% CP for broiler starter/finisher diets), respectively. Noteworthy that birds on diet 4 (17.0%/14.0% CP for broiler starter/finisher diets with EAA supplementation) had a better net returns (gross profit) over the control diet formulated conventionally to contain 23.0%/20.0% CP for broiler starter/finisher diets at minimum Lys & Met supplementation. It has been suggested [5] that maximum technical performance may or may not result in maximum economic efficiency. In certain experiments showing the responses to protein level (despite the lower protein diets being better balanced), it as surmised that the real consideration should be, “Is the cost of the additional protein at least offset by the additional returns from increased growth rate or less feed per unit of salable product” [6]? It has been concluded that achieving maximum growth and production, however, may not always ensure maximum economic returns, particularly when prices of protein sources are high. If decreased performance can be tolerated, dietary concentrations of amino acids may, accordingly, be reduced somewhat to maximize economic returns [6].

It was opined that the emphasis of amino acid and protein research should be on developing equations that can be used to relate inputs (costs) and outputs (performance) to maximize profits under various environmental conditions with each genetic stock [6].

From the economic analyses of broiler production in this study, facts abound that precision feeding of essential amino acids in place of crude protein especially at 17.0%/14.0% CP for broiler starter/finisher diets with EAA supplementation was cost effective and had more net returns. However, the fact that most synthetic essential amino acids used in livestock feeding are not commercially available in the developing countries including Nigeria makes the prices exorbitant and therefore the feasibility of using these amino acids may not be cost effective in these countries. It is therefore pertinent to emphasize that essential amino acid balance and total amino acid levels (CP or essential plus nonessential amino acids) should be considered to optimize growth and to maximize profits.

4. CONCLUSION

i. Except for a few carcass characteristics, most parameters investigated had similar values. It is safe therefore, to conclude that there were minor treatment effects among most investigated carcass characteristics.
ii. The highest net returns of N792.06k were obtained for birds on 20.0%/17.0% CP for broiler starter/finisher with EAAs supplementation.

However, the net returns of N768.46k obtained for birds on 17.0%/14.0% for broiler starter/finisher diets was better and more profitable than for birds on the conventional control diet where fish meal was used as animal protein source with basic methionine and lysine supplementation

5. RECOMMENDATION

From the carcass, organs and economic analyses of broiler production in this study, there is ample evidence that supplementing broiler feeds with feed grade essential amino acids in precision feeding using ideal protein concept is desirable economic and environmental consideration.

However, the fact that most synthetic essential amino acids used in livestock feeding are not commercially available in the developing countries including Nigeria may create a hike in the prices of these items. However, in spite of the foregoing, the economic facts abound in the present study that precision feeding of essential amino acids in place of crude protein especially at 17.0%/14.0% CP for broiler starter/finisher diets with EAA supplementation was cost effective and had more net returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Applegate TJ. Protein and amino acid requirements for poultry. Feed Management Project. 2008; (USDA, NRCS, CIG sponsored program).
   Available:http://www.puyallup.wsu.edu/dairy/nutrient-management/default.asp
2. Ajinomoto Eurolysine SAS. Ideal Amino Acid Profile for Piglets; 2013.
   Available:http://ajinomoto-eurolysine.com/technical-bulletins-download.html
3. Bregendahl K, Sell JS, Zimmerman DR. Effect of low protein diets on growth performance and body composition of broiler chicks. Poult. Sci. 2002;81:1156–1167.
4. Jianlin SF, Fritts CA, Burnham DJ, Waldroup PW. Extent to which crude protein may be used reduced in corn-soybean meal broiler diets through amino acids supplementation. Int. J. Poult. Sci. 2004;3:46-50.
5. NRC. Nutrient requirements of poultry 1994; 9th rev. ed. Natl. Acad. Press, Washington, DC.
6. Pesti GM. Impact of dietary amino acid and crude protein levels in broiler feeds on biological performance. J Appl Poult Res. 2001;18(3):477-486.
   DOI: 10.3382/japr.2008-00105
7. Smith ER, Pesti GM, Bakalli RI, Ware GO, Menten JFM. Further studies on the influence of genotype and dietary protein on the performance of broilers. Poult. Sci. 1998;77:1678–1687.
8. Aviagen. Broilers, Protein and Profit. Ross Tech. 2000; 00/39. Aviagen, Newbridge, Midlothian, Scotland, UK.
9. Mack S, Bercovici D, de Groote G, Leclercq B, Lippens M, Pack M, Schutte JB, VanCauwenberghe S. Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. Br. Poult. Sci. 1999;40:257–265.
10. Law G, Adjiri-Awere A, Pencharz PB, Ball RO. Gut mucins in piglets are dependent upon dietary threonine. Advances in Pork Production. Proceedings of the 2000 Banff Pork Seminar 11:10.
11. Ball RO. Threonine requirement and the interaction between threonine intake and gut mucins in pigs. Symposium of the 2001 Degussa; Banff Pork Seminar. Banff, Alberta. Canada.

12. Barkley GR, Wallis IR. Threonine requirements of broiler chickens: Why do published values differ? British Poultry Science. 2001;42:610-615.
13. Kamran Z, Sarwar M, Nisa M, Nadeem MA, Mahmood S, Babar ME, Ahmed S. Effect of low-protein diets having constant energy-to-protein ratio on performance and carcass characteristics of broiler chickens from one to thirty-five days of age. Poult. Sci. 2008;87(3): 468-474. DOI: 10.3382/ps.2007-00180

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