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Effect of dietary protein and amino acid levels on performance, carcass characteristics and feed-cost efficiency of starter local Turkeys

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ABSTRACT

Growth performance, carcass yields, organ proportion and feed-cost analysis are parameters used in monitoring the responses of local starter turkeys to different levels of dietary protein and amino-acid combinations for faecal ammonia reduction at a minimal cost. The current research was aimed at adopting precisely, the combination of crude protein and amino-acid which optimizes production with minimal ammonia excretion. Three hundred- and sixty-day old poults were randomly assigned into 3x3 factorial experiment, in a completely randomized design, to determine the response of graded levels of protein and amino acids on growth parameters, carcass yield, cut up parts, internal organ proportions and feed cost benefits analysis of indigenous starter turkeys**.** Each treatment was replicated 4 times with 10 poults per replicate. The turkeys were fed the treatment diets that contained dietary crude protein at 3 levels ($A_1$28%, $A_2$26% and $A_3$24%) and dietary amino acids at 3 levels each (Methionine: B_1 0.15%, 0.25% and 0.35% and Lysine: B_2 0.30%, 0.50%, 0.70%). The study lasted for 56 days during which water and feed were given *ad libitum.* Results showed that the final weight of T_3 turkeys was significantly higher than treatment group 1, 2, 4, 5, 6, 7 and 8 but similar T_9. Turkeys consumed both diet 3 (high CP, Met. and Lys.) and 9 (lower CP and higher Met. and Lys.) turkeys accrued similar gain in weight at the same significant level. However, T_9 attained higher dressed weight, revenue and gross margin. It is, therefore, adopting a precise feeding of indigenous starter turkeys 24% CP at 0.35% Methionine and 0.70% Lysine would be most profitable and environmentally friendly for optimum yields with minimal ammonia excretion.

Keywords*:* Amino-acid, Lysine, Methionine, Protein, Starter Turkey

Proteins are organic compounds used to build the cells, tissues and organs for the body. They are made up of many amino acids of which are essential for growth and production. Cereal grain protein and vegetable feed ingredients that constitute a greater proportion of turkeys' diets are generally acknowledged to contain low level of sulphur containing amino acids and lysine Kan *et al.* (2021). Not only that, these plant proteins are deficient in some of essential amino acids (Day *et al.* 2022). Knowledge of the availability of amino acids in feedstuffs is an important feature of dietary protein quality. Amino acids which are said to be essential such as methionine and lysine etc. cannot be synthesized by poultry and therefore, be fed in order to supply the building blocks needed in the synthesis of body proteins thereby supporting growth. It is imperative to ensure the specific levels of this essential limiting amino-acids in starter local turkeys relatively to different dietary crude protein levels. This approach would enable precision diet formulation, targeted at meeting the nutrient requirements of local turkeys at starter phase. However, several researches have noted that even when essential amino acid requirements are met, crude protein recommendations are not warranted (Adhikari *et al.* 2025). To further add to it, elevated protein diets of poults results increase in ammonia excretion which cumulatively adds to environmental greenhouse effects that are detrimental to both human and animal health (USDA-NRCS. 2003). Therefore, the present study aimed to precisely determine the crude protein and amino-acids combination that would optimize performance, carcass yields, reduce cost of production while reducing the ammonia excreted, since excess protein cannot be stored in animal cells. Hence, a minimum protein requirement could be met without compromising the performance of starter turkeys.

MATERIALS AND METHODS

Ethical approval: The study using turkey was subjected to ethnic approval by the Ethnical Committee and Directorate of Research of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, with reference number: MOUAU//2024/1195.

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Study location and management: The experiment was conducted at the Poultry Unit of Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike lies between latitude $5^0 28'$ North and longitude $7^0 31'$ East, at altitude of 123 m above sea level. It is ecologically situated in the rainforest zone of South-East of Nigeria with annual rainfall of 2177 mm, temperature of 22°C-36°C and relative humidity ranges from 50% to 90% (NRCRI,2000).

Experimental Poults, design, duration and diets: Three hundred and sixty (360) day old local turkey poults were used for this experiment. The poults were subjected to the same management condition. They were allowed free access to feed and water *ad libitum* using feeding and

Table 1. Treatment diets combination of different levels of protein and amino acids fed local starter Turkeys

Treatment	Factor A (CP%)	Factor B_1 (methionine %)	Factor B_2 (lysine %)	Treatments
1.	A1 28%CP	B1a 0.15%	B2a 0.3%	A1B1aB2a
2.		B1b 0.25%	B2b 0.5%	A1B1bB2b
3.		B1c 0.35%	B2c 0.7%	A1B1cB2c
4.	A2 26% CP	B1d 0.15%	B2d 0.3%	A2B1dB2d
5.		B1e 0.25%	B2e 0.5%	A2B1eB2e
6.		B1f 0.35%	B2f 0.7%	A2B1fB2f
7.	A3 24%CP	B1g 0.15%	B2g 0.3%	A3B1gB2g
8.		B1h 0.25%	B2h 0.5%	A3B1hB2h
9.		B1i 0.35%	B2i 0.7%	A3B1iB2i

A: CP level (A_1:28%CP, A_2:26%CP, A_2:24%CP); B_1: Methionine (B_1: 0.15%, 0.25%, 0.35%), B_2: Lysine (0.3%, 0.54%, 0.7%); a, b, c…...i: Factor B_1&$_2$ replications; $A_1B_1aB_2$ etc: levels of treatment diet combination.

Table 2. Percentage composition of experimental diets fed local starter Turkeys

Diets CP (%) M (%) Ingredients (kg) L (%)	T_1 28 0.15 0.30	T_2 28 0.25 0.50	T_3 28 0.35 0.70	T_4 26 0.15 0.30	T_5 26 0.25 0.50	T_6 26 0.35 0.70	T_7 24 0.15 0.30	T_8 24 0.25 0.50	T_9 24 0.35 0.70
Maize	38.00	38.00	38.00	40.00	40.00	40.00	45.00	45.00	45.00
Wheat Offal	4.00	3.00	3.00	6.05	6.25	5.65	6.70	6.85	6.85
Palm Kernel Cake	2.00	2.00	2.00	4.00	4.00	4.00	5.00	5.00	5.00
Soybean Meal	47.05	47.75	47.45	41.00	40.50	40.80	34.35	33.90	33.06
Fish Meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.25	0.35	0.15	0.25	0.35	0.15	0.25	0.35
Lysine	0.30	0.50	0.70	0.30	0.50	0.70	0.30	0.50	0.70
Total	100	100	100	100	100	100	100	100	100
Chemical/Lab. analysis									
Crude Protein (%)	28.00	28.02	28.01	26.22	26.04	26.07	24.22	24.05	24.01
ME(Kcal/kg)	2837	2837	2829	2824	2815	2812	2849	2840	2832
Methionine (%)	0.58	0.69	0.78	0.57	0.66	0.77	0.54	0.64	0.73
Lysine (%)	1.57	1.89	2.00	1.48	1.66	1.84	1.32	1.54	1.72

T_1: A_1 28%CP, B_1a 0.15%, B_2a 0.3%; T_2: A_1 28%CP, B_1b 0.25%, B_2b 0.5%; T_3: A_1 28%CP, B_1c 0.35%, B_2c 0.7%; T_4: A_2 26%CP, B_1d 0.15%, B_2d 0.3%; T_5: A_2 26%CP, B_1e 0.25%, B_2e 0.5%; T_6: A_2 26%CP, B_1f 0.35%, B_2f 0.7%; T_7: A_3 24%CP, B_1g 0.15%, B_2g 0.3%; T_8: A_3 24%CP, B_1h 0.25%, B_2h 0.5%; T_9: A_3 24%CP, B_1i 0.35%, B_2i 0.7%. CP: Crude protein; B1: Methionine; B2: Lysin, *1kg of premix contains: vitamins A (5,000.000 I.U), Vitamin D3 (1,000.000 I.U). Vitamin E (16,000mg), Vitamin K3 (800mg), Vitamin BI (1,200mg) Vitamin B2 (22,000gm), Niacin (22,000mg), Calcium pantothenate (4,600mg), Vitamin B12 (10mg) Folic acid (400mg), Biotin (32mg) Choline chloride (260,000mg), Manganese (948,000mg), Iron (40,000mg), Zinc (32,000mg), Copper (3,400mg) Lodine (600mg), Cobalt (120mg), Selenium (48mg) Anti-oxidant (48,000mg).

watering troughs as required by starter turkeys. New castle disease vaccine (NDV) was administered intraocular to the poults at first day to prevent an early infection of new castle disease virus. The second dose of NDV (lasota) was orally administered on the 7th day and final lasota was given at 21days of their age. Coccidiostat was given orally between 14-17 days of age. Fowl pox vaccine was administered at seven weeks of age. Antibiotics and anti-stress drugs were also routinely applied. Foot-dip containing mixture of water and disinfectant was provided at the entrance of the poultry house to prevent disease transfer from outsiders to the pens. Electric bulbs were provided as source of light during night hours for illumination and *ad libitum* feeding. The turkey pen was highly aerated with wire gauze for cross ventilation. The experiment was 3 x 3 factorial in Completely Randomized Design (CRD) with 5 poults/m^2 as stocking density. Nine experimental diets formulated in meshed form were based on the recommendation of (NRC, 1994) for nutrient requirements of turkey poults (0-8 weeks). Factor A contained dietary crude protein at 3 levels (A_1 28%, A_2 26% and A_3 24%) and factor B contained dietary amino acids at 3 levels each (Methionine: B_1 0.15%, 0.25% and 0.35% and Lysine: B_2 0.30%,0.50%,0.70%), giving a total of nine (9) treatment combinations in each phase. The treatments replicated four (4) times with 10 poults per replicate. The experiment lasted for 56 days.

Performance characteristics: The initial live weight of the turkey poults was recorded at day old. Weekly weighing of turkeys was carried out to determine the final weight and daily weight gain and daily weighing of feed to determine daily feed intake and feed conversion ratio (FCR).

Carcass yield cut up parts and internal organ proportions: At the end of 56 days feeding trial, three turkeys from each replicate with approximate body weights equal to the mean weight of the birds in the pen were randomly selected; the dressed weight was taken and the dressing percentage computed. The percentage of carcass cut up parts and internal organs proportion were also determined.

Feed cost-benefit analysis: Economics of production parameters were computed at sixteen (16) weeks of the study to evaluate profitability of the experiment. The calculation of cost of diets was obtained by adding up the cost of securing each individual feedstuff per gram of diet. Cost of producing turkeys was realized by averaging the cost of feed intake by each turkey for the entire production period, while the cost per kg of feed was determined by proportion of each ingredient in the diet times cost per kg of ingredients divided by hundred. Also, cost per weight gain was determined by dividing the cost of production by the weight gain.

Statistical analysis: All data generated from the study were subjected to Analysis of Variance (ANOVA) for a 3x3 Factorial in Completely Randomized Designed. The treatment means that were significantly different was separated using New Duncan Multiple Range Test (Duncan, 1955). Computer package for Social Sciences (SPSS) Windows 10.0 (2012) was used for data analysis.

RESULTS AND DISCUSSION

Growth performance of starter local Turkeys: The interaction effect of 9 treatment diets on growth parameter of starter local turkeys is presented in Table 3. The initial body weight of the local poults in the all the treatment groups were similar ($p > 0.05$), and ranged from (43.67 – 44.00 g) per poult. The final weight of turkeys fed diet 3 was significantly higher ($p < 0.05$) than turkeys fed diets 1, 2, 4, 5, 6, 7 and 8 but similar ($p > 0.05$) to those fed diet 9. The final weight of same CP levels increased with increased methionine and lysine levels across the treatment diets. This observation suggested that high methionine and lysine with low protein are adequate to support the growth

Table 3. Interaction effect on performance of starter turkeys fed levels of crude protein and essential amino acids

Diets	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	SEM
CP (%)	28	28	28	26	26	26	24	24	24	
M (%)	0.15	0.25	0.35	0.15	0.25	0.35	0.15	0.25	0.35	
Parameters L (%)	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7	
IW(g/poult)	43.67	43.85	43.90	43.88	43.90	43.85	43.88	43.95	44.00	0.04
FW(g/poult)	1240^{abc}	1350^{abc}	1435^{a}	1085^{c}	1215^{abc}	1230^{abc}	1120^{bc}	1202^{abc}	1385^{ab}	31.25
ADFI(g/poult)	104.7^{a}	104.3^{a}	105.0^{a}	95.67^{c}	103.00^{a}	98.67^{bc}	$98.00b^{c}$	101.0^{ab}	103.3^{a}	0.72
DWG(g/poult)	22.34^{b}	19.04^{c}	24.84^{a}	18.59^{c}	20.91^{b}	21.45^{b}	19.22^{c}	21.27^{b}	23.95^{a}	0.42
WG (g/poult)	1251^{b}	1066^{c}	1391^{a}	1041^{c}	1171^{b}	1186^{b}	1075.7^{c}	1191^{b}	1341^{a}	23.67
FCR	4.67^{bcd}	5.50^{a}	4.23^{d}	5.20^{ab}	4.90^{bc}	4.67^{bcd}	5.10^{ab}	4.73^{bcd}	4.57^{cd}	0.08
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

a,b,c,d,; Means in the same row followed by different superscripts are significantly ($p < 0.05$) different. SEM: Standard error of Mean. IW: Initial weight, FW: Final weight, ADFI: Average daily feed intake, ADWG: Average daily weight gained, WG: Weight gained, FCR: Feed conversion ratio. T_1: A_1 28%CP, B_1a 0.15%, B_2a 0.3%; T_2: A_1 28%CP, B_1b 0.25%, B_2b 0.5%; T_3: A_1 28%CP, B_1c 0.35%, B_2c 0.7%; T_4: A_2 26%CP, B_1d 0.15%, B_2d 0.3%; T_5: A_2 26%CP, B_1e 0.25%, B_2e 0.5%; T_6: A_2 26%CP, B_1f 0.35%, B_2f 0.7%; T_7: A_3 24%CP, B_1g 0.15%, B_2g 0.3%; T_8: A_3 24%CP, B_1h 0.25%, B_2h 0.5%; T_9: A_3 24%CP, B_1i 0.35%, B_2i 0.7%. CP: Crude protein; B1: Methionine; B2: Lysin, of poults at the same level with high protein, methionine and lysine. This observation indicated improvement in amino acid balance and efficiency of utilization, which could be attributed to synthesis of protein and its eventual deposition in the turkeys' muscle (Eze *et al.* 2025). Similar findings were reported by Konieczka *et al*. (2022), who noted growth performance improvement in turkeys fed increased levels of lysine and methionine. Also, Kareem *et al*. (2025) reported that reduced-protein diets adequately supplemented with limiting amino acids-maintained broiler growth performance. Tian *et al.* (2016) observed a nitrogen-sparing action of amino acids such as methionine which was brought about by an enhanced protein synthesis when diets were supplemented with essential amino acids.

The feed intake of turkeys on diet 3 was significantly higher ($p < 0.05$) than those fed diets 4, 6 and 7 whereas those turkeys fed diet 4 had the least value. This trend was probably because the dietary energy reduced with increase in level of methionine and lysine except diet 6, reduced with increase of methionine and lysine. It could be linked to compensatory feed consumption in response to variations in dietary energy concentration and improved amino acid balance. Similar reports were given by Saleh *et al.* (2021), who found that amino acid supplementation in reduced-protein diets influenced feed intake and growth response in broiler chickens reared under high ambient temperatures.

The weight gain increased with increase in the levels of methionine and lysine. The weight gain of diet 3 was significantly higher ($p < 0.05$) than those of other treatment groups with minimal FCR. The feed conversion ratio of diet 2, 4 and 7 were not significantly different ($p > 0.05$) but were significantly higher ($p < 0.05$) than other treatment groups. This may be due to enhancement in the availability of amino acid which reduced amino acid imbalance in the diet. Konieczka *et al*. (2022) also noted that increased dietary methionine and lysine goes with improved turkey performance and gut integrity, while Ojewola *et al*. (2023) observed improved feed efficiency in broilers supplemented with methionine and lysine. No mortality was recorded during the study, which further showed that the various diets adequately supported the health and survivability of the poults during the feeding trial.

Carcass yield and cut parts parameters: Presented in Table 4 is the interaction effect on carcass yield and cut-part of starter local turkeys fed 9 treatment diets. There were significant differences ($p < 0.05$) among the parameters examined (Table 4). The dressed weight of turkeys on diet 3 was similar ($p > 0.05$) to those of diet 1, 5 and 9 but significantly higher ($p > 0.05$) than those of diet 2, 4, 6, 7 and 8. The cut-part of all the treatment diets followed no definite pattern. There was significant difference ($p < 0.05$) between the percentage breast weight of turkeys fed diets 4 and those fed diets 1, 3 and 5 but similar ($p > 0.05$) to those fed diets 2, 6, 7, 8 and 9. The thigh weight of the turkeys fed diet 3 were significantly ($p < 0.05$) higher than other treatment groups, whereas diet 5 had the least value. The drumstick weight of turkeys fed diet 3 was significantly ($p < 0.05$) higher than those of diets other treatment groups. The back-cut weight of the turkeys fed diet 4 was significantly ($p < 0.05$) higher than other treatment groups, followed by those fed diet 8 whereas diet 6 had the least value. The wing weight of turkeys were significantly ($p < 0.05$) higher in diet 2 followed by diet 8 while diet 1 had the least value.

Dressed weight and carcass cut-part characteristic differences reported among treatments showed that the various dietary crude protein, methionine, and lysine levels initiated nutrient utilization and development of muscle in the starter local turkeys (Eze *et al.* 2025). The diet 3 resulted in efficient conversion of nutrient and enhanced muscle accretion due to dietary limiting amino acids adequate supplementation. This observation further reaffirmed that when low crude protein diets fortified with

Table 4. Interaction effect on carcass yield and cut-parts of starter Turkeys fed levels of crude protein and essential amino acids

Diets CP (%) M (%) Parameters L (%)	T_1 28 0.15 0.3	T_2 28 0.25 0.5	T_3 28 0.35 0.7	T_4 26 0.15 0.3	T_5 26 0.25 0.5	T_6 26 0.35 0.7	T_7 24 0.15 0.3	T_8 24 0.25 0.5	T_9 24 0.35 0.7	SEM
LW(g/poult)	1295^{a}	1110^{ab}	1435^{a}	1085^{ab}	1215^{ab}	897b	112^{ab}	1235^{ab}	1385^{a}	42.78
DW(g/poult)	800.00^{ab}	650.00^{e}	850.00^{a}	700.00^{d}	800.00^{ab}	750.00^{c}	650.00^{e}	750.00^{e}	840.00^{a}	13.93
DP (%)	61.78^{ab}	58.60^{b}	59.34^{b}	64.53^{a}	64.48^{a}	61.02^{ab}	61.26^{ab}	60.84^{ab}	60.76^{ab}	0.53
Breast (%)	26.08^{b}	29.37^{ab}	27.59^{b}	32.70^{a}	26.24^{b}	29.32^{ab}	30.26^{ab}	28.85^{ab}	29.69^{ab}	0.51
Thigh (%)	14.63^{f}	15.32^{e}	16.41^{a}	13.93^{g}	13.38^{h}	15.32^{e}	15.69^{c}	15.77^{b}	15.51^{d}	0.18
DS (%)	16.34^{b}	15.22^{f}	16.47^{a}	15.52^{e}	14.08^{i}	15.87^{d}	16.21^{c}	15.21^{g}	14.93^{h}	0.14
BC (%)	21.15^{d}	21.35^{c}	19.76^{g}	21.83^{a}	19.36^{h}	18.16^{i}	20.89^{e}	21.39^{b}	20.35^{f}	0.22
Wings (%)	15.18^{i}	20.29^{a}	16.95^{g}	15.37^{h}	18.27^{d}	17.27^{f}	18.48^{c}	19.92^{b}	17.94^{b}	0.33

[a,b,c,d,e,f,g,h,I;] Means in the same row followed by different superscripts are significantly ($p<0.05$) different. SEM=Standard Error of Mean. LW= Live weight, DW= Dressed weight, DP= Dressing percentage, DS= Drum stick, BC= Back cut. T_1: A_1 28%CP, B_1a 0.15%, B_2a 0.3%; T_2: A_1 28%CP, B_1b 0.25%, B_2b 0.5%; T_3: A_1 28%CP, B_1c 0.35%, B_2c 0.7%; T_4: A_2 26%CP, B_1d 0.15%, B_2d 0.3%; T_5: A_2 26%CP, B_1e 0.25%, B_2e 0.5%; T_6: A_2 26%CP, B_1f 0.35%, B_2f 0.7%; T_7: A_3 24%CP, B_1g 0.15%, B_2g 0.3%; T_8: A_3 24%CP, B_1h 0.25%, B_2h 0.5%; T_9: A_3 24%CP, B_1i 0.35%, B_2i 0.7%. CP: Crude protein; B1: Methionine; B2: Lysin.

methionine and lysine was properly balanced, it could support carcass development comparable to high crude protein diets. Breast muscle growth is specifically linked to lysine whereas biochemical pathways associated with methyl group transfer, protein deposition, and antioxidant metabolism are primer functions of methionine (Attia *et al.* 2020), suggesting improved amino acid balance and enhanced protein utilization. Similar findings were reported by Attia *et al*. (2020), who reported carcass yield and dressing percentage improvement in broilers fed reduced-protein diets supplemented with synthetic amino acids. Recent studies by Saleh *et al*. (2021) and Alagawany *et al.* (2022) also demonstrated that amino acid supplementation in low crude protein poultry diets improved carcass characteristics and nutrient retention efficiency, influencing breast, thigh, and drumstick weights. Similar observations were reported by Lee *et al*. (2020), who found improved carcass cuts and breast muscle yield in broilers fed low crude protein diets adequately fortified with limiting amino acids. The inconsistent pattern observed in some cut-part parameters may be related to differences in nutrient partitioning, genetic variation among the local turkeys, and individual physiological responses to dietary treatments. Similar variations in carcass cut yields have earlier been reported in poultry birds fed diets differing in amino acid concentrations and energy-protein balance (Kareem *et al.* 2025). Overall, the results of the present study suggested that supplementation of methionine and lysine in reduced crude protein diets can improve carcass yield and some economically important cut parts in starter local turkeys without adverse effects on carcass quality.

Internal organ proportions of Turkeys: The Heart weight of turkeys (Table 5) on diet 8 were significantly higher ($p < 0.05$) than other treatment groups. But the heart weight of turkeys on diet of other treatment groups were similar ($p < 0.05$). The lungs weight of turkeys fed diet 8 was significantly ($p < 0.05$) higher than those of diets 2, 3, 4, 5 and 6, but similar ($p > 0.05$) to those fed diets 1, 7 and 9. The proportion of organs of turkeys fed diet 8 were greater than those fed other treatment groups. The kidney weight of turkeys on diets 1, 2, 7, 8 and 9 were similar ($p > 0.05$), but significantly ($p < 0.05$) higher than turkeys on diets 3, 4, 5 and 6. The Gizzard + proventriculus weight of turkeys fed diet 1 was significantly ($p < 0.05$) higher than other treatment groups.

The observed significant differences in internal organ proportion suggested could imply that there were varying digestive metabolic and physiological activity that took place in the organs of turkeys fed these diets, which possibly influenced higher heart and lung weights in poults fed diet 8, was similar to that reported by Alagawany *et al*. (2022). Attia *et al*. (2020) reported that liver activity and nutrient metabolism in poultry was influenced by amino acid supplementation in reduced crude protein diets as observed in the present study. Also, enhanced immune response and digestive activity can be linked to the higher spleen and intestinal weights recorded in poults fed diet 8. Konieczka *et al*. (2022) similarly reported that dietary methionine and lysine supplementation improved gut integrity and physiological responses in turkeys. The kidney size reflected differences in nitrogen metabolism and excretory activities from protein utilization. Kareem *et al.* (2025) noted similar trend in poultry fed varying dietary crude protein and amino acid concentrations. However, the overall effects lacked any detrimental physiological effects.

Feed cost-benefit analysis of Turkeys: The cost of feed per kg and cost per weight gain (Table 6) were all significantly ($p < 0.05$) influenced by methionine and lysine inclusion levels. Numerically, diet 2 had the highest feed cost followed closely by diet 1, 9, 8 and 5 respectively. However, diet 3 had the highest ($p < 0.05$) cost of feed per kg while diet 7 has the least value. There was no significant

Table 5. Interaction effect on internal organ proportion of starter turkeys fed levels of crude protein and essential amino acids

Diets	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	SEM
CP (%)	28	28	28	26	26	26	24	24	24	
M (%) Parameters	0.15	0.25	0.35	0.15	0.25	0.35	0.15	0.25	0.35	
L (%)	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7	
Lw (g/poult)	1295^{a}	1110^{ab}	1435^{a}	1085^{ab}	1215^{ab}	897^{b}	1120^{ab}	1235^{ab}	1385^{a}	42.78
Heart (%)	0.44^{b}	0.46^{b}	0.47^{b}	0.49 ^{b}	0.49^{b}	0.48^{b}	0.47^{b}	0.56^{a}	0. 44^{b}	0.01
Liver (%)	2.26^{ab}	2.43^{a}	2.21^{ab}	2.37 ^{ab}	1.64^{b}	1.94^{ab}	2.29^{ab}	2.32^{ab}	1.78^{ab}	0.08
Lungs (%)	0.66^{a}	0.52^{c}	0.52^{c}	0.43^{d}	0.50^{c}	0.59^{b}	0.70^{a}	0.73^{a}	0.71^{ab}	0.02
Kidney (%)	0.69^{ab}	0.72^{a}	0.60^{d}	0.64^{cd}	0.67^{bc}	0.54^{e}	0.68^{ab}	0.68^{ab}	0.71^{ab}	0.01
Spleen (%)	0.12^{bc}	0.12^{bc}	0.12^{bc}	0.11^{c}	0.09^{d}	0.09^{d}	0.13^{b}	0.16^{a}	0.12^{bc}	0.00
G/Pro (%)	3.81^{a}	3.14^{cd}	2.53^{g}	3.00^{e}	2.77^{f}	3.03^{e}	3.12^{cd}	3.31^{c}	3.54^{b}	0.07
LXSI (%)	5.13^{de}	5.61^{c}	4.86^{de}	6.08^{b}	5.22^{d}	4.81^{e}	4.86^{de}	6.57^{a}	5.04^{de}	0.12

a,b,c,d,e,f,g; Means in the same row followed by different superscripts are significantly ($p<0.05$) different. SEM=Standard Error of Mean. LW= Live weight, Kid= Kidney PRO= Proventriculus, LXS=Large and small intestine. T_1: A_1 28%CP, B_1a 0.15%, B_2a 0.3%; T_2: A_1 28%CP, B_1b 0.25%, B_2b 0.5%; T_3: A_1 28%CP, B_1c 0.35%, B_2c 0.7%; T_4: A_2 26%CP, B_1d 0.15%, B_2d 0.3%; T_5: A_2 26%CP, B_1e 0.25%, B_2e 0.5%; T_6: A_2 26%CP, B_1f 0.35%, B_2f 0.7%; T_7: A_3 24%CP, B_1g 0.15%, B_2g 0.3%; T_8: A_3 24%CP, B_1h 0.25%, B_2h 0.5%; T_9: A_3 24%CP, B_1i 0.35%, B_2i 0.7%. CP: Crude protein; B1: Methionine; B2: Lysine

Table 6. Interaction effect on the feed-cost benefit analysis of Turkeys fed levels of crude protein and essential amino acids

Diets	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	SEM
CP (%)	28	28	28	26	26	26	24	24	24	
M (%)	0.15	0.25	0.35	0.15	0.25	0.35	0.15	0.25	0.35	
Parameters L (%)	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7	
TFI (g/poult)	5859.7^{a}	5798^{a}	5877^{a}	5188^{d}	5779^{a}	5523^{c}	5491^{c}	5646^{b}	5752^{ab}	42.78
Cost/100kg(₦/poult)	16719^{d}	17261^{b}	17713^{a}	16249^{fg}	16681d^{e}	17189^{bc}	15915^{gh}	16354^{f}	16710^{d}	103.23
Cost/kg (₦ /poult)	167.00^{d}	173.00^{b}	177.00^{a}	162.00^{fg}	166.00^{de}	171.00^{bc}	159.00^{gh}	163.00^{f}	167.00^{d}	1.05
Cost/Pd (₦ /poult)	978.56	1003.05	726.90	840.40	959.31	944.46	873.46	920.24	960.64	33.04
WG (g/poult)	1251.00^{b}	1066.00^{c}	1391.00^{a}	1041.00^{c}	1171.00^{b}	1186.00^{b}	1075.67^{c}	1191.00^{b}	1341.00^{a}	23.67
Cost/WG (₦ /poult)	0.78b^{c}	0.94^{a}	0.75^{cd}	0.81^{b}	0.82^{b}	0.81b^{c}	0.81^{b}	0.78b^{c}	0.70^{d}	0.01
Revenue (₦ /poult)	1251.00^{b}	1066.15^{c}	1391.10^{a}	1041.05^{c}	1171.10^{b}	1172.82^{b}	1069.41^{c}	1212.69^{b}	1370.32^{a}	24.57
GM (₦ /poult)	272.44^{bcd}	63.10^{e}	350.87^{ab}	200.65^{d}	211.63^{cd}	228.33^{cd}	195.95^{d}	289.18b^{c}	409.68^{a}	19.92

a,b,c,d,e,f,g; Means in the same row followed by different superscripts are significantly ($p<0.05$) different. SEM=standard error of mean. TFI= Total Feed Intake, Cost/PD= Cost per Production, WG =Weight Gained, WG= Weight Gained, GM= Gross margin. T_1: A_1 28%CP, B_1a 0.15%, B_2a 0.3%; T_2: A_1 28%CP, B_1b 0.25%, B_2b 0.5%; T_3: A_1 28%CP, B_1c 0.35%, B_2c 0.7%; T_4: A_2 26%CP, B_1d 0.15%, B_2d 0.3%; T_5: A_2 26%CP, B_1e 0.25%, B_2e 0.5%; T_6: A_2 26%CP, B_1f 0.35%, B_2f 0.7%; T_7: A_3 24%CP, B_1g 0.15%, B_2g 0.3%; T_8: A_3 24%CP, B_1h 0.25%, B_2h 0.5%; T_9: A_3 24%CP, B_1i 0.35%, B_2i 0.7%. CP: Crude protein; B1: Methionine; B2: Lysin.

difference ($p > 0.05$) among the cost of production of the diets. The cost per weight gained of turkeys on diet 2 were highly significant ($p < 0.05$) than others. Therefore, for a unit cost of treatment diets, diet 3 and 9 significantly ($p < 0.05$) gave the highest ($p < 0.05$) revenue, respectively than other treatment diets. Gross margin analysis indicated that diet 9 and 3 commanded significantly ($p < 0.05$) higher market price per turkey compared to other treatment diets. However, in this trial, diet 9 and 3 gave the best cost benefit respectively. The implication is that diet 9 and 3 proved to be of better economy for the producer than other 7 diets. Addition of methionine and lysine up to 0.35 and 0.70% respectively could also improve turkeys' performance without detrimental effect on animals and also to the producer in term of cost of production.

The observed differences in feed cost and economic returns among the treatments showed that different dietary crude protein and limiting amino-acids influenced not growth performance but production profitability as well. Since cost of feed represents the bulk of poultry expenses, local turkey production sustainability can be achieved through nutrient utilization improvement while reducing production cost. Higher synthetic amino-acids in the test diets increased the production cost, however, diet 3 yielded superior growth performance and efficiency of feed utilization for compensation of added cost feed ingredients. Similar findings were earlier reported by Eze *et al.* (2025) on grower turkeys and Attia *et al.* (2020). The absence of significant differences in overall production cost among treatment groups suggested that amino acid supplementation can be economically justified to improve growth performance and feed efficiency as argued by El-Damrawy *et al.* (2020). The present findings therefore support the use of methionine and lysine supplementation in reduced crude protein diets as a practical nutritional strategy for improving the profitability of local turkey production.

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