STM JOURNALS

International Journal of
Biochemistry and Biomolecule Research

Volume 1, Issue 1, 2023
January–June
DOI (Journal): 10.37591/IJBBR

https://journals.stmjournals.com/ijbbr/

Research IJMBR

Effect of Energy, Lysine and Energy/Lysine Ratio on Growth Performance Nutrient Digestibility and Serum Profile of Growing Locally Adapted Turkey

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Abstract

This study investigated the effects of different levels of energy, lysine and energy/lysine ratios on growth performance, nutrient digestibility, and serum biochemical indices of locally adapted turkeys. The experiment lasted for 28 days. A total of one hundred and forty-four, 4-weeks old locally adapted turkey poults were completely randomized to six dietary treatments in a 2×3 factorial arrangement, replicated twice at 12 poults per replicate. Six diets were formulated. Diets 1 to 3 contained 2900 kcal/kg metabolizable energy (ME) (12.14 MJ/kg ME) while diets 4 to 6 contained 3000 kcal/kg ME (12.56 MJ/kg ME). The dietary lysine levels at the different energy levels are 13.50 g/kg, 15.00 g/kg, and 16.10 g/kg, respectively at 260 g/kg crude protein (CP) level. The resultant energy/lysine (E/Lys) ratios of diets 1 to 6 were 9:1, 8.1:1, 7.5:1, 9.3:1, 8.4:1 and 7.8:1 respectively. The daily feed intake and feed conversion ratio (FCR) of locally adapted turkeys were significantly (P<0.05) influenced by energy × lysine interaction. There was a significant (P<0.05) effect of energy/lysine ratio on crude fiber (%) digestibility while the energy × lysine interaction effect was observed on the dry matter (%), crude protein (%) and crude fiber (%) digestibility coefficient of locally adapted turkey's diets. There was no significant effect (P>0.05) of energy, lysine, energy/lysine ratio, and energy × lysine interaction on the final body weight (g/bird) and daily weight gain (g/bird) across all dietary treatments. There was a significant (P<0.05) effect of energy on crude fiber (%) and ether extract digestibility. There were significant (P<0.05) lysine, energy/lysine ratio, and energy × lysine interaction effects on the serum creatinine level of locally adapted turkeys in this study. Turkeys with an energy level of 3000 kcal/kg ME (12.56 MJ/kg ME), lysine level of 15.00 g/kg, and E/Lys ratio 8.4:1 had the highest final body weight (1205.40 g/bird), daily weight gain (30.05 g/bird) and feed intake (56.77 g/bird).

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Received Date: December 31, 2022
Accepted Date: January 11, 2023
Published Date: January 31, 2023

Citation: Akinsuyi M.A., Fatufe A.A. Effect of Energy, Lysine and Energy/Lysine Ratio on Growth Performance Nutrient Digestibility and Serum Profile of Growing Locally Adapted Turkey. International Journal of Biochemistry and Biomolecule Research. 2023; 1(1): 1–8p.

Keywords: Locally adapted, nutrient requirements, energy/lysine ratio, poults, lysine, energy

INTRODUCTION

The growth rate of turkeys is affected by the dietary supply of essential amino acids (AAs) such as lysine (Lys), methionine (Met), and arginine (Arg) [1]. The high-performance potential of current breeds of turkey requires a high protein and amino acid supply [2]. Dietary lysine is usually the second limiting amino acid for poultry-fed corn-soybean meal diets and lysine are particularly important in improving performance, especially in

breast meat yield [3]. Lysine is used as the reference amino acid for the ideal amino acid profile because more information is known about its concentration in feedstuffs. Aduku (1993) [4] and NRC (1994) [5] recommended 15.00 g/kg total lysine at 2750 metabolizable energy (ME) and 2900 ME respectively, while Olomu (1995) [6] recommended 16.00 g/kg total lysine at 2800 ME for turkeys of age 4 to 8 weeks. Nutritionists and producers have been using lysine supplements to meet the amino acid needs of turkey over time [7].

Studies carried out with turkeys recently, suggested that dietary lysine supplementation is effective for increasing carcass yield and reducing body fat deposition [8, 9]. Other researchers have achieved the regulation of different metabolic processes with the use of AAs such as lysine [10, 11].

Estimates for energy, lysine and energy/lysine ratio required for locally adapted turkeys are few in the tropics. To economically formulate diets for current genetic strains of turkey in the tropics, there must be information on the response of turkeys to dietary energy, lysine and energy/lysine ratio.

This study, therefore, was conducted to determine the extent to which a lower (13.50 g/kg) and higher (16.00 g/kg) levels of dietary lysine to the NRC (1994) [5] lysine recommended level of 15.00 g/kg at different energy levels will affect turkey performance within 4 to 8 weeks of age in the tropics.

MATERIALS AND METHODS

The experiment was carried out at the Turkey Unit of the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife. One hundred and fifty day-old locally adapted turkey poults were fed isocaloric diets containing 2800 kcal/kg ME, 300 g/kg crude protein (CP), and 16.00 g/kg of lysine, as per nutrient requirements of turkeys for the first phase [5] from a day-old to 4 weeks of age. Birds were brooded with electricity using incandescent bulbs and supplemental heat using heat produced from burning charcoal in pots.

At 29 days of age, one hundred and forty-four, four-week-old locally adapted turkeys were randomly selected, weighed, and distributed in a completely randomized design into six experimental diets, replicated twice with twelve birds per replicate in a 2×3 factorial arrangement. The floor pen dimensions were approximately 14 m^2 each. The initial BW of poults was 363.0–364.7 g. Diets were formulated with two levels of metabolizable energy and three levels of dietary lysine. The amino acid content of basal diets was determined and was then mixed with the required amount of lysine. Diets 1 to 3 contained 2900 kcal/kg ME (12.14 MJ/kg ME) at 13.50 g/kg, 15.00 g/kg and 16.10 g/kg lysine and 260 g/kg CP levels; diets 4 to 6 contained 3000 kcal/kg ME (12.56 MJ/kg ME) at 13.50 g/kg, 15.00 g/kg and 16.10 g/kg lysine and 260 g/kg CP levels. The corresponding energy/lysine (E/Lys) ratio of diets 1 to 6 were 9:1, 8.1:1, 7.5:1, 9.3:1, 8.4:1 and 7.8:1 respectively. Experimental diets were produced in the feed mill of the Obafemi Awolowo University Teaching and Research Farm. Feed additives were not added to the experimental diets.

The experimental diets are presented in Table 1. Water and feed were provided *ad libitum.* Body weight gain and feed consumption were recorded fortnightly and weekly respectively. Mortality was recorded as it occurred, and the weight of dead birds was taken, and the weights of dead birds were used to adjust average body weight gain (BWG), daily feed intake (DFI), and feed conversion ratio (FCR). A nutrient digestibility trial was carried out when poults were 6 weeks old following the standard procedure of the total fecal collection method. Daily feed intake, daily weight gain, and feed conversion ratio (FCR; g of feed/g of BWG) for the experimental period were calculated. The proximate analyses of the experimental diets and fecal samples were carried out as described by AOAC (2002) [12]. Blood samples were collected at 6 weeks of age from the wing vein using hypodermic needles and syringes into collection test tubes without EDTA (anticoagulant). The plasma was removed after centrifuging for 15 min at 380 g and 4°C and preserved at – 22°C until analysis. Data were analyzed using factorial analysis of variance (ANOVA) of the general linear model of SAS (2008) [13] package for Windows. This study lasted for four weeks.

Table 1. Composition of the experimental diets of turkey fed varying energy, lysine and energy/lysine ratios (4 to 8 weeks).

Metabolizable energy (kcal/kg)	**2900**			**3000**		
Lysine levels (g/kg)	13.50	15.00	16.10	13.50	15.00	16.10
Energy/lysine ratio	9:1	8.1:1	7.5:1	9.3:1	8.4:1	7.8:1
Experimental diets	1	2	3	4	5	6
Ingredients (g/kg)						
Maize	424.00	418.50	440.00	481.10	420.00	430.30
SBM	410.00	440.00	487.10	424.00	470.00	472.00
Wheat offal	95.30	70.00	30.00	24.00	38.50	27.00
Fish meal	30.00	30.00	10.00	30.00	20.00	20.00
Palm oil	10.00	10.00	-	10.00	20.00	18.00
Bone meal	20.00	20.00	20.00	20.00	20.00	20.00
Premix	5.00	5.00	5.00	5.00	5.00	5.00
Salt	5.00	5.00	5.000	5.00	5.00	5.00
Methionine	0.60	0.40	0.60	0.70	0.50	0.50
Lysine	0.10	1.10	2.30	0.20	1.00	2.20
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated nutrient values						
ME (kcal/kg)	2907.0	2921.83	2910.83	3007.58	3000.47	3003.74
Crude protein (g/kg)	260.60	260.20	260.90	260.40	260.30	260.30
Ether extract (g/kg)	36.00	35.90	36.10	36.30	35.50	35.60
Crude fiber (g/kg)	43.50	43.20	43.10	39.50	42.40	41.80
Methionine (g/kg)	4.50	4.50	4.50	4.50	4.50	4.50
Lysine (g/kg)	13.50	15.00	16.10	13.50	15.00	16.10
Calcium (g/kg)	10.20	10.20	9.10	10.20	9.60	9.60
Phosphorus (g/kg)	7.00	7.10	6.70	6.90	6.90	6.90

Premix composition to provide the following per kg of diet; vitamin A, 15,000.00 IU; vitamin D3, 3,000,000 IU; vitamin E, 30,000 IU; vitamin K, 3,000 mg; vitamin B1, 3000 mg; vitamin B2, 6000 mg; vitamin B6, 5,000 mg; vitamin B12, 40 mg; biotin, 200 mg; Niacin, 40,000 mg; pantothenic, 15,000 mg; folic acid, 2,000 mg; choline, 300,000 mg; iron, 60,000 mg; manganese, 80,000 mg; copper, 25,000 mg; Zinc, 80,000 mg; cobalt, 150 mg; iodine, 500 mg; solencien, 310 mg; Antioxidant, 20,000 mg. Note: ME, metabolizable energy.

RESULTS AND DISCUSSION

The proximate composition of the experimental diets is shown in Table 2. The analyzed chemical composition of the experimental diets was similar to the calculated values (Tables 1 and 2).

Table 2. Proximate composition of turkey diets with varying energy, lysine and energy/lysine ratio (4 to 8 weeks of age).

Metabolizable energy (kcal/kg)	**2900**			**3000**		
Lysine levels (g/kg)	13.50	15.00	16.10	13.50	15.00	16.10
Energy/lysine ratio	9:1	8.1:1	7.5:1	9.3:1	8.4:1	7.8:1
Experimental diets	1	2	3	4	5	6
Dry matter (g/kg)	921.90	925.00	923.70	921.90	915.30	926.30
Crude protein (g/kg)	262.30	261.50	259.70	260.90	261.70	262.60
Crude fiber (g/kg)	35.40	33.60	33.10	34.60	32.00	34.80
Ash (g/kg)	77.50	85.20	90.20	82.10	87.20	81.70
Ether extract (g/kg)	36.70	40.20	29.20	41.50	51.10	53.00
Nitrogen-free extract (g/kg)	510.00	504.50	511.50	502.80	483.30	494.20

**Values are means of duplicate samples (air-dried basis)*

Growth Performance Characteristics

There was a significant *(P<0.05)* energy × lysine interaction effect on the DFI and feed conversion ratio (FCR) in this study. The daily feed intake was also significantly *(P<0.05)* influenced by the dietary lysine and energy levels. The daily feed intake was significantly *(P<0.05)* higher for locally adapted turkeys on diet 5 (3000 kcal/kg ME, 15.00 g/kg Lys. Level, 8.4:1 E/Lys ratio) compared to other dietary treatments. The FCR was significantly *(P<0.05)* higher for locally adapted turkeys on diet 3 (2900 kcal/kg ME, 16.10 g/kg Lys. level, 7.5:1 E/Lys ratio) compared to the FCR of turkeys on diets 1 (2900 kcal/kg ME, 13.50 g/kg Lys. level, 9:1 E/Lys ratio) and 6 (3000 kcal/kg ME, 16.10 g/kg Lys. level, 7.8:1 E/Lys ratio) respectively (Table 3).

There was no significant effect *(P>0.05)* of energy/lysine ratio and energy × lysine interaction on the final body weight (g/bird) and daily weight gain (g/bird) across all dietary treatments. Final body weight and daily weight gain were better on diets 5 (3000 kcal/kg ME, 15.00 g/kg Lys. level, 8.4:1 E/Lys ratio), 6 (3000 kcal/kg ME, 16.10 g/kg Lys. level, 7.8:1 E/Lys ratio) and 1(2900 kcal/kg ME, 13.50 g/kg Lys. level, 9:1 E/Lys ratio) in decreasing order. The better FBW and DFI on diet 5 are indicative of translating higher feed intake into weight gain. The higher daily weight gain and final body weight recorded for poults on 5 (3000 kcal/kg ME, 15.00 g/kg Lys. Level, 8.4:1 E/Lys ratio) in this study can be attributed to higher feed consumption of the diet in agreement with the report of Erener et al. (2003) [14].

The feed conversion ratio differed statistically across all the dietary treatments and was significantly influenced by energy x lysine (E× Lys) interaction. The FCR (1.54) was significantly better on diet 1 (2900 kcal/kg ME, 13.50 g/kg Lys. level, 9:1 E/Lys ratio). Mortality among birds was not statistically different across dietary treatments but was higher on diet 3 (2900 kcal/kg ME, 16.10 g/kg Lys. level, 7.5:1 E/Lys ratio). These results agreed with the earlier work carried out by Adikari et al. (2016) [15] who observed that mortality does not differ statistically among the breeding birds.

There was no significant effect *(P>0.05)* of energy, lysine and energy/lysine ratio on the final body weight (g/bird), daily weight gain (g/bird), and FCR across all dietary treatments. The results of this study agree with the result of Paweł Konieczka et al. (2021) [16] who indicated that diets with different

Table 3. Growth performance characteristics of locally adapted turkey fed varying energy, lysine and energy/lysine ratio at 4 to 8 weeks of age.

Parameters		Lysine (g/kg)	E/Lys	IBW (g/b)	FBW (g/b)	DWG (g/b/d)	DFI (g/b/d)	FCR	Mortality (%)
Diets	1	13.50	9:1	364.21	1112.45	26.72	41.05^{b}	1.54^{b}	0.00
	2	15.00	8.1:1	363.00	1050.50	24.55	46.39^{b}	1.89^{ab}	0.00
	3	16.10	7.5:1	364.79	1023.40	23.52	47.40^{b}	2.01^{a}	8.33
	4	13.50	9.3:1	364.79	1066.30	25.05	46.06^{b}	1.84^{ab}	4.17
	5	15.00	8.4:1	364.03	1205.45	30.05	56.77^{a}	1.89^{ab}	4.17
	6	16.10	7.8:1	363.00	1132.50	27.48	43.72^{b}	1.59^{b}	0.00
SEM				0.54	21.74	0.76	1.57	0.06	1.57
Mean Sep.	E1			363.00	1062.12	24.97	44.95^{b}	1.82	2.78
	E2			363.60	1134.75	27.54	48.85^{a}	1.78	2.78
P-value	E			0.4942	0.0661	0.0658	0.0414	0.6445	1.0000
	Lys			0.1820	0.4647	0.4849	0.0117	0.2179	0.8503
	E× Lys			0.0895	0.0970	0.1023	0.0242	0.0318	0.2963
	E/Lys	-		0.1472	0.1238	0.1290	0.0112	0.0828	0.6634

Mean within columns with parameters with different superscripts are significantly different (P < 0.05). E/Lys, energy/lysine ratio; Lys, lysine levels; IBW, initial body weight; FBW, Final Body Weight; DFI, daily feed intake; FCR, feed conversion ratio; FC/G, feed cost/gain; ₦, Naira; SEM, standard error of means; E, energy level; Lys, lysine levels; ×, interaction. diets 1 to 3 (E1), 2900 kcal/kg ME; diets 4 to 6 (E2)

levels of lysine and arginine had no significant influence on turkey performance and Jan Jankowski et al. (2020) [11] who reported that FCR was not affected by different dietary lysine levels. Final body weight, daily weight gain, and daily feed intake of locally adapted turkeys were better on the 15.00 g/kg dietary lysine levels inclusion. This is indicative of translating higher feed intake into weight gain. The higher daily weight gain and final body weight recorded for poults on energy level 3000 kcal/kg ME and 15.00 g/kg dietary lysine level in this study can be attributed to higher feed consumption of the diet in agreement with the report of Erener et al. (2003) [14].

This result indicated that the NRC (1994) [5] protein (26.00 g/kg CP) and lysine 15.00 g/kg levels recommended for turkeys of age 4–8 weeks produced better growth performance of locally adapted turkey at a higher energy level; 3000 kcal/kg ME. This supported the assertion of Veldkamp et al. (2005) [17, 18] that dietary energy may be increased above NRC (1994) [5] energy level when dietary lysine levels were adequate to improve feed efficiency. Thus, in the present study, a decrease in dietary lysine content below that recommended by the NRC (1994) [5] did not influence body the final body weight at energy level 2900 kcal/kg ME but compromised the growth performance of turkeys at the energy level 3000 kcal/kg ME.

Nutrient Digestibility Trial

The result of the nutrient digestibility trial of locally adapted turkey is shown in Table 4. There was a significant *(P<0.05)* effect of energy/lysine ratio on crude fiber (%) digestibility and, energy × lysine interaction on the dry matter (%), crude protein (%), and crude fiber (%). The result agrees with the significant effect of lysine on the performance of male Nicholas turkeys reported by Peñaranda-Ali et al. (2010) [19]. Adegbenjo et al. (2020) [20] affirmed that the digestibility percent rating is good when above 70%; moderate when between 40 and 60% and very low when below 40% as earlier stated by Alimuddin (2000) [21]. Digestibility ratings in this study ranged between 73.16% and 93.96% suggesting a better utilization of diets. Digestibility of crude protein and crude fiber recorded the lowest

Table 4. Nutrient digestibility of locally adapted turkeys fed varying energy, lysine and energy/lysine ratio at 4–8 weeks of age.

Parameters	TRT*	E/Lys ratio	Lys (%)	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ether extract (%)	ME (%)
Diets	1	9.0:1	1.35	89.00^{abc}	86.05^{ab}	82.44^{b}	88.71^{ab}	83.27
	2	8.1:1	1.50	90.22^{abc}	88.71^{a}	82.12^{b}	87.89^{ab}	83.81
	3	7.5:1	1.61	85.34^{c}	73.16^{c}	73.71^{d}	83.93^{b}	81.05
	4	9.3:1	1.35	87.17^{bc}	76.29^{bc}	77.55^{c}	89.80^{ab}	83.78
	5	8.4:1	1.50	90.65^{abc}	86.01^{ab}	81.86^{b}	92.31^{a}	84.45
	6	7.8:1	1.61	92.29^{a}	87.53^{ab}	86.90^{a}	93.96^{a}	84.39
Mean Sep	E1	-	-	88.18	82.64	79.42^{b}	86.85^{b}	82.71
	E2	-	-	90.03	83.28	82.10^{a}	92.03^{a}	84.21
	LYS1	-	-	88.08	81.17	79.99	89.25	83.53
	LYS2	-	-	90.43	87.36	81.99	90.10	84.13
	LYS3	-	-	88.82	80.34	83.31	88.95	82.72
P-value	SEM	-	-	0.3012	2.0528	1.2888	1.1292	0.4620
	E	-	-	0.1461	0.8204	0.0169	0.0162	0.1200
	Lys	-	-	0.2826	0.1437	0.1808	0.8275	0.4300
	E×LYS	-	-	0.0415	0.0259	0.0003	0.1403	0.3532
	E:LYS	-	-	0.0817	0.0621	0.0001	0.0853	0.3041

*Mean within rows with different superscripts are significantly different (P < 0.05). *Diets 1–3 contained 2900 kcal/kg ME, while diets 4–6 contained 3000 kcal/kg ME; E, energy, LYS, lysine, E:LYS, energy/lysine ratio; ×, interaction; SEM, standard error of means, ME, metabolizable energy.*

values 73.16% and 73.71% respectively at the 16.00 g/kg lysine level, 2900 kcal/kg ME, and 7.5:1 E/Lys ratio. There was a significant *(P<0.05)* effect of dietary energy on the crude fiber (%) and ether extract (%) digestibility. There was a significant *(P<0.05)* effect of energy/lysine ratio on crude fiber (%) digestibility and, energy × lysine interaction effect on the dry matter (%), crude protein (%), and crude fiber (%) digestibility. However, nutrient digestibility parameters were not influenced by dietary lysine levels in this study. The non-significant *(P>0.05)* effect of dietary lysine on growth performance and nutrient digestibility in this study was at variance with the significant effect of lysine on the performance of male Nicholas turkeys reported by Peñaranda-Ali et al. (2010) [19].

Serum Profile

The result of serum evaluation is presented in Table 5. There were significant *(P<0.05)* lysine, energy/lysine ratio, and energy × lysine interaction effects on the serum creatinine level of locally adapted turkeys. Serum creatinine level was significantly *(P<0.05)* higher on diet 3 than on other dietary treatments. The high serum creatinine level observed across dietary lysine treatments in this study suggested inefficient protein utilization resulting in muscle wasting [22]. A positive correlation exists between the dietary lysine and serum creatinine levels. This indicated that serum creatinine level increased with higher dietary lysine levels across 2900 kcal/kg ME energy level. The result showed that higher serum creatinine was recorded at the NRC (1994) [5] recommended energy and lysine levels. Locally adapted turkeys on diet 3 (2900 kcal/kg ME, 1.61% lysine, energy/lysine ratio 7.5:1) with the highest serum creatinine level (3.05 mg/dl) recorded the lowest final body weight (1023.40 d/bird) and this suggested that excess serum creatinine level resulted in increased muscle wasting at the low energy/lysine ratio. This suggests that creatinine synthesis as one of the major mechanisms involved in amino acid interaction may have contributed to the transfer of methyl groups provided by methionine for creatinine synthesis. As a result, this leads to methionine deficiency which could be responsible for the decreased growth performance of birds in this study as earlier reported by Jahanian and Khalifeh-Gholi [23].

Table 5. Serum biochemical indices of locally adapted turkeys fed varying energy, lysine and energy/lysine ratio at 4–8 weeks of age.

	TRT*	E/Lys ratio	Total Chol. (mg/dl)	LDL (mg/dl)	HDL (mg/dl)	Creatinine (mg/dl)	Urea (g/dl)	TP (g/dl)	Albumin (g/dl)	Globulin (g/dl)
Diets	1	9:1	133.31	16.54	48.42	0.90^{b}	18.97	6.09	2.22	3.87
	2	8.1:1	154.37	28.88	57.87	0.90^{b}	20.56	7.50	1.98	5.52
	3	7.5:1	157.97	17.19	37.17	3.05^{a}	18.11	5.56	1.76	3.80
	4	9.3:1	148.21	25.95	29.25	1.70^{b}	20.14	5.13	2.07	3.06
	5	8.4:1	108.39	29.01	30.06	1.43^{b}	17.26	4.36	2.41	1.95
	6	7.8:1	110.45	24.99	32.76	1.54^{b}	15.34	6.51	2.07	4.44
Mean Sep	E1	-	148.55	20.87	47.82	1.62	19.21	6.38	1.99	4.40
	E2	-	122.35	26.65	30.69	1.56	17.58	5.33	2.18	3.15
	LYS1	-	140.76	21.24	38.84	1.30^{b}	19.55	5.61	2.15	3.46
	LYS2	-	131.38	28.94	43.97	1.17^{b}	18.91	5.93	2.19	3.74
	LYS3	-	134.21	21.09	34.97	2.29^{a}	16.73	6.03	1.92	4.12
P-value	SEM	-	11.9911	2.0811	4.3544	0.2326	0.5617	0.3652	0.0941	0.4224
	E	-	0.3869	0.1798	0.0787	0.7927	0.4073	0.1076	0.3555	0.1259
	Lys	-	0.9619	0.2359	0.6781	0.0130	0.4662	0.8167	0.5061	0.7553
	E×Lys	-	0.6110	0.5962	0.5278	0.0120	0.5824	0.0639	0.4864	0.1187
	E/LYS	-	0.8308	0.3351	0.3597	0.0126	0.6189	0.1381	0.5707	0.2132

*Mean within columns within parameters with different superscripts are significantly different (P < 0.05). E/LYS–Energy/lysine ratio, Chol. – Cholesterol, LDL –Low-Density Lipoprotein, HDL–High-Density Lipoprotein, TP–Total Protein, E–Energy, LYS–lysine, SEM–Standard Error of Means, × - Interaction, *Diets 1–3 contained 2900 kcal/kg ME at 1.35%, 1.50% and 1.61%, while Diets 4–6 contained 3000 kcal/kg ME at 1.35%, 1.50% and 1.61%.*

CONCLUSION

In conclusion, different energy/lysine ratios, dietary energy, and lysine, levels, did not affect the final body weight (g/bird), daily weight gain (g/bird), and lower energy/lysine ratio is counter-productive to turkey performance. For optimum growth performance of locally adapted turkeys from 4–8 weeks of age, 15.0 g/kg lysine content, 3000 kcal/kg ME (12.56 MJ/kg ME), and energy/lysine ratio 8.4:1 was adequate in the tropics at 260 g/kg CP level.

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