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Effects of Dietary Protein, Energy and Lysine Intake on Growth Performance and Carcass Characteristics of Growing Japanese Quails

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ABSTRACT

The present study was performed to investigate the effect of dietary levels of protein, energy and Lys on growth performance and carcass traits of growing Japanese quails during 1-5 weeks of age. A factorial design 3×2×2 arrangement was performed including three levels of crud protein (CP; 22, 23.5 and 25%), two levels of metabolizable energy (ME; 2900 and 3000 kcal ME kg^{-1}) and two levels of total lysine (Lys; 1.3 and 1.45%). Live Body Weight (LBW) at 3 weeks of age and Body Weight Gain (BWG) during 1-3 weeks of age were significantly ($p\leq0.01$) maximized when chicks were fed 22% CP compared to those received 23.5 and 25% CP. LBW at 3 and 5 weeks of age as well as BWG through 1-3 and 1-5 weeks of age were statistically ($p\leq0.05$) decreased with increasing dietary energy from 2900-3000 kcal ME kg^{-1} diet. LBW at 3 weeks of age and BWG during 1-3 weeks of age were maximum when chicks were fed 1.45% Lys compared with group received 1.3% Lys level. Interaction between protein and energy levels significantly ($p\leq0.01$) affected LBW at 3 weeks of age and BWG through 1-3 weeks of age. Also, LBW at 5 weeks of age and BWG through 1-5 weeks of age were statistically ($p\leq0.05$) influenced by the interaction between ME and Lys levels. Increasing dietary ME level from 2900 to 3000 caused significant improvements in FCR at all studied ages except period 1-3 weeks of age. The present results did not show any significant effect on all carcass characteristics due to different dietary CP, ME and Lys or their interactions, except carcass percentage was higher in chicks fed diet contained 1.3% Lys. Also, giblet percentage was significantly ($p\leq0.01$) affected by energy levels and the interaction among dietary CP, ME and Lys levels. Moreover, dressing percentage was significantly ($p\leq0.01$) influenced by CP and Lys levels. It can be concluded that, diet formulated in 22% CP, 2900 kcal ME kg^{-1} and 1.3% Lys can adequately ensure the growth performance in Japanese quails.

Key words: Japanese quails, crude protein, metabolizable energy, lysine, performance, carcass

INTRODUCTION

Japanese quail (*Coturnix coturnix* Japonica) belongs to the order Galliformes and the family Phasianidae like the chicken (Karaalp, 2009). The Japanese quail possesses several advantages, such as rapid growth, early sexual maturity, high rate of egg production and a short generation interval (Hemid *et al.,* 2010). Protein source of high quality with adequate amino acid balance is one of the most important nutrients for quail (Alagawany *et al*., 2014a). There are some differences in the nutritional requirements of quail as determined by various authors. Da Trn *et al.* (2003) evaluated five dietary Crude Protein (CP) levels (16, 18, 20, 22 and 24%) in the rearing period of

Japanese quail and concluded that protein levels had no effects on feed conversion and feed conversion ratio. They added that a crude protein requirement for rearing period of Japanese quail is 23.08%.

Lysine (Lys) is the second limiting amino acid after methionine in a corn-soybean based diet and most scientists use Lys as the basis to which all other amino acids are related when generating an "ideal balance", furthermore Lys and sulfur amino acids are known to exhibit specific effects on carcass composition (Corzo *et al*., 2002; Alagawany and Mahrose, 2014).

Essential amino acid recommendations by NRC (1994) for Japanese quail are largely based on studies that conducted at least 5 to 6 years before 1994's but, the meat production performance of Japanese quails has also been improved during recent years due to genetic selection. Therefore, there is need of updating optimal nutritional requirements of Japanese quails with the improvement in genetic makeup to exploit production potentiality (Kaur *et al*., 2008).

The response of growing quails to dietary levels of essential amino acids at different energy levels on growth and immunity were investigated by Kaur *et al.* (2008). They concluded that the optimum level of dietary Metabolizable Energy (ME) is 2700 kcal kg^{-1} with 25.83% CP for optimum feed conversion during 0-5 weeks of age. Generally, the crude protein content in diets of growing quails ranges from 24-27% (NRC., 1994; Baldini *et al*., 1950; Shrivastav and Panda, 1999; Mosaad and Iben, 2009). Therefore, the main objectives of the present study were to evaluate the effects of different dietary levels of CP, ME and Lys on the growth performance and carcass characteristics of growing Japanese quail during the experimental period (1-5 weeks of age).

MATERIALS AND METHODS

This study was conducted at Quail Research Farm, Department of Poultry, Faculty of Agriculture, Zagazig University, Egypt. All the experimental procedures were carried out according to the Local Experimental Animal Care Committee and approved by the ethics of the institutional committee. Birds were cared for using husbandry guidelines derived from Zagazig University standard operating procedures.

Birds, experimental design and diets: This work was carried out to determine the crude protein, energy and Lys requirements of growing Japanese quail. The maximum and minimum ambient temperature recorded daily at noon (12.00 pm) ranged between 32-37°C while the relative humidity was ranged between 58-68%. A factorial design arrangement 3×2×2 was performed included three levels of CP (22, 23.5 and 25%), two levels of energy (2900 and 3000 kcal ME kg^{-1}) and two levels of total Lys (1.3 and 1.45%). A total number of 648 unsexed one week-old Japanese quail were randomly assigned into 12 treatment groups, (54 chicks in each group). Each group of birds was subdivided into three replicates, each of 18 chicks. Each replicate was housed in one cage (90×40×40 cm). The diets were fed as a mash and calculated according to NRC (1994) which is presented in Table 1. Vaccination and medical program were done according to the different stages of age under supervision of a veterinarian.

Chicks were grown in brooders with raised wire floors and were reared under the same managerial and hygienic conditions. The lighting pattern was 23 hr light: 1 h dark. Feed and water were *ad-libitum* throughout the experimental period (1-5 weeks of age). All chicks received feeds from placement until 35 days of age in mash form, according to its treatment.

Data collection and egg parameters: Birds were weighed individually at weekly intervals. Mortality was recorded daily. Feed consumption was measured per pen weekly. Feed consumption

Table 1: Composition and calculated analysis of the experimental basal diets

	Crude protein (22%)				Crude protein (23.5%)				Crude protein (25%)			
	2900 (kcal kg^{-1})		3000 (kcal kg^{-1})		2900 (kcal kg^{-1})		3000 (kcal kg^{-1})		2900 (kcal kg^{-1})		3000 (kcal kg^{-1})	
Ingredients	Lys (1.3%)	Lys (1.45%)	Lys (1.3%)	Lys (1.45%)	Lys (1.3%)	Lys (1.45%)	Lys (1.3%)	Lys (1.45%)	Lys (1.3%)	Lys (1.45%)	Lys (1.3%)	Lys (1.45%)
Yellow corn	61.6	61.8	63.82	63.67	58.6	58.4	58.6	58.6	55.8	55.65	55.83	55.68
Soybean meal (44%)	26.8	26.8	22.4	22.4	30.4	30.4	27.03	26.88	30.7	30.7	27.5	27.5
Corn gluten meal (60%)	-	-	3.44	3.44	0.89	0.94	3.44	3.44	3.5	3.5	5.8	5.8
Wheat bran	1.35	1.2	-	-	-	-	-	-	-	-	-	-
Cotton seed oil	-	-			-	-	0.85	0.85	-	-	0.85	0.85
Protein concentrate (45%)[1]	10	10	10	10	10	10	10	10	10	10	10	10
Dl- Methionine	0.15	0.15	0.14	0.14	0.11	0.11	0.08	0.08	-	-	-	-
L-Lys HCl	0.1	0.25	0.2	0.35	-	0.15	-	0.15	-	0.15	0.02	0.17
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated analysis[2]												
CP (%)	22.1	22.2	22	22	23.5	23.5	23.6	23.5	25	25	24.99	24.98
ME kcal/kg	2945	2945	3031	3030	2940	2940	3034	3031	2950	2945	3040	3035
Ca (%)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Avail. P (%)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Lys (%)	1.3	1.45	1.3	1.45	1.3	1.45	1.3	1.45	1.3	1.45	1.3	1.45
Met.+Cys. (%)	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.97	0.98	0.98

[1]The concentrate contains: Crude protein 45%, M.E. 2664 kcal kg^{-1} deit, Calcium 6.9%, Phosphorus 2.8%, Lys 2.6% and Methionine+Cystine 2.4%, [2]Calculated according to NRC (1994)

and feed conversion ratio (feed intake/weight gain) were adjusted for mortality. Five chicks of each group were sampled randomly for carcass evaluations at 5 weeks of age, fasted overnight, weighed and slaughtered by sharp knife to complete bleeding, then weighed. Their feathers were plucked manually, eviscerated by hand. Whole carcass, abdominal fat pad (excluding the gizzard fat), empty gizzard and proventriculus, liver and heart, were excised and weighed individually. The carcass yields were calculated as a percentage of the pre-slaughter live body weights of quail chicks. The slaughter traits studied were giblets (liver, gizzard and heart) and dressing percent (carcass weight plus giblets weight)×100/pre-slaughter g.

Statistical analysis: Analysis of variance for data was accomplished using the SAS General Linear Models Procedure (SAS., 2002) on a 3×2×2 factorial design basis according to Snedcor and Cochran (1982) by adopting the following model:

$$X_{ijkl} = \mu+P_i+E_j+L_k+PE_{ij}+PL_{ik}+EL_{jk}+PEL_{ijk}+E_{ijkl}$$

where, X_{ijkl} = The trait under study, μ = General mean, P_i = Fixed effect of CP (22, 23.5 and 25%), E_j = Fixed effect of ME levels of energy (2900 and 3000 kcal ME kg^{-1}), L_k = Fixed effect of Lys level (1.3 and 1.45%), PE_{ij} = Interaction between CP and ME, PL_{ik} = Interaction between CP and Lys levels, EL_{jk} = Interaction between ME and Lys levels, PEL_{ijk} = Interaction among CP, energy and Lys levels and E_{ijkl} = Random error. Differences among treatment means within the same factor were tested using Duncan's New Multiple Range test (Duncan, 1955). All percentages were converted to the corresponding arcsine prior to statistical analysis.

RESULTS AND DISCUSSION

Growth performance: Results in Table 2 indicated that, the analysis of variance showed a significant ($p\leq 0.01$) effect on LBW at 3 weeks of age and BWG during 1-3 weeks of age due to different protein level. It could be noticed that, the highest values of LBW at 3 weeks of age and BWG during 1-3 weeks of age were achieved by chicks fed 22% CP compared to other levels. However, LBW at 5 weeks of age and BWG through 3-5 weeks of age and during the whole experimental period were not significantly affected.

Results of the current work are in agreement with those reported by Aboul-Ela *et al.* (2004) showed that, the different protein levels (22, 24 and 26%) had no significant influence on LBW and BWG during the growing period (1-6 weeks of age) of Japanese quail. Gheisari *et al.* (2011) indicated that increasing dietary CP in the different stages of growth from very low, medium and high levels significantly ($p\leq 0.05$) increased LBW and BWG of growing Japanese quails. Contradicting results were reported by Tarasewicz *et al.* (2007) found that, quail fed diet containing very low-CP level gave significantly lower LBW than those fed high protein diet.

Data in Table 2 showed that, LBW at 3 weeks-old and BWG through 1-3 weeks of age were statistically ($p\leq 0.05$) decreased with increasing dietary energy from 2900-3000 kcal ME kg^{-1} diet. The results of the current study are in line with the findings of Aboul-Ela *et al.* (2004) who stated that Japanese quail chicks received 2800 and 2900 kcal ME kg^{-1} diet up to 6 weeks of age were superior in LBW than those received 3000 kcal ME kg^{-1}. On the contrary, Gheisari *et al.* (2011) pointed out that there were no significant effects of dietary ME levels (2700 or 2900 kcal ME kg^{-1}) on LBW and BWG.

Table 2: Live body weight and body weight gain of quails as affected by CP, ME and Lys levels and their interactions

Treatments	Live body weight (g) 1st week	3rd week	5th week	Daily body weight gain (g) 1-3 weeks	3-5 weeks	1-5 weeks
	(X̄±SE)					
Protein levels (%)	NS	**	NS	**	NS	NS
22	32.97±0.018	112.12±0.554[a]	187.60±1.031	5.65±0.039[a]	5.39±0.079	5.52±0.036
23.5	32.99±0.027	110.39±1.034[b]	188.00±0.596	5.52±0.074[a]	5.54±0.046	5.53±0.021
25	32.97±0.020	108.71±0.520[c]	186.67±1.034	5.40±0.036[b]	5.56±0.058	5.48±0.036
Energy levels (kcal kg^{-1})	NS	*	NS	*	NS	NS
2900	32.97±0.012	111.04±0.754[a]	187.73±0.651	5.57±0.053[a]	5.47±0.039	5.52±0.023
3000	32.99±0.022	109.77±0.570[b]	187.12±0.823	5.48±0.040[b]	5.52±0.064	5.50±0.029
Lys levels (%)	NS	**	NS	**	NS	NS
1.30	32.98±0.019	109.02±0.569[b]	186.96±0.666	5.43±0.040[a]	5.56±0.047	5.49±0.032
1.45	32.98±0.016	111.79±0.625[a]	187.89±0.802	5.62±0.044[b]	5.43±0.055	5.53±0.028
Interaction effects						
Protein×Energy	NS	**	NS	**	NS	NS
22×2900	32.96±0.024	112.34±0.682[a]	188.20±1.156	5.67±0.048[a]	5.41±0.097	5.54±0.041
22×3000	32.99±0.027	111.90±0.934[a]	187.00±1.788	5.63±0.065[a]	5.36±0.134	5.50±0.063
23.5×2900	32.98±0.009	112.81±1.299[a]	189.06±0.984	5.70±0.092[a]	5.44±0.049	5.57±0.035
23.5×3000	33.01±0.056	107.96±0.829[b]	186.95±0.386	5.35±0.060[b]	5.64±0.055	5.49±0.015
25×2900	32.98±0.030	107.96±0.889[b]	185.93±0.985	5.35±0.063[b]	5.56±0.040	5.46±0.035
25×3000	32.96±0.031	109.45±0.418[b]	187.42±1.877	5.46±0.029[b]	5.56±0.115	5.51±0.066
Protein× Lys	NS	NS	NS	NS	NS	NS
22×1.30	32.95±0.011	110.88±0.819	187.78±1.786	5.56±0.057	5.49±0.127	5.52±0.063
22×1.45	32.99±0.034	113.35±0.272	187.42±1.213	5.74±0.018	5.29±0.086	5.51±0.043
23.5×1.30	33.04±0.048	108.35±0.949	186.95±0.503	5.37±0.068	5.61±0.062	5.49±0.018
23.5×1.45	32.95±0.011	112.42±1.473	189.06±0.930	5.67±0.104	5.47±0.059	5.57±0.033
25×1.30	32.94±0.016	107.81±0.806	186.17±0.902	5.34±0.057	5.59±0.035	5.47±0.032
25×1.45	33.01±0.034	109.60±0.462	187.18±1.949	5.47±0.033	5.54±0.115	5.50±0.069
Energy×Lys	NS	NS	**	NS	NS	*
2900×1.30	32.96±0.012	109.37±0.906	186.09±0.673[b]	5.45±0.064	5.47±0.070	5.46±0.023[b]
2900×1.45	32.99±0.022	112.70±0.949	189.37±0.821[a]	5.69±0.068	5.47±0.042	5.58±0.029[a]
3000×1.30	33.00±0.037	108.66±0.723	187.84±1.113[ab]	5.40±0.052	5.65±0.053	5.53±0.040[a]
3000×1.45	32.98±0.026	110.88±0.742	186.40±1.227[b]	5.56±0.052	5.39±0.104	5.47±0.043[b]
Protein×Energy×Lys	NS	NS	NS	NS	NS	NS
22×2900×1.30	32.94±0.016	111.40±1.172	189.40±1.713	5.60±0.083	5.35±0.206	5.48±0.061
22×2900×1.45	32.97±0.050	113.28±0.270	190.00±0.721	5.73±0.021	5.48±0.032	5.60±0.026
22×3000×1.30	32.97±0.016	110.37±0.156	189.15±3.338	5.52±0.092	5.62±0.144	5.57±0.118
22×3000×1.45	33.01±0.055	113.43±0.540	184.84±0.450	5.74±0.035	5.10±0.006	5.42±0.104
23.5×2900×1.30	32.99±0.001	110.15±0,991	187.18±0.901	5.51±0.070	5.50±0.006	5.50±0.032
23.5×2900×1.45	32.97±0.016	115.46±0.631	190.93±0.721	5.89±0.043	5.39±0.096	5.64±0.026
23.5×3000×1.30	33.09±0.097	106.56±0.540	186.71±0.631	5.24±0.032	5.72±0.083	5.48±0.025
23.5×3000×1.45	32.93±0.008	109.37±1.082	187.18±0.540	5.46±0.077	5.55±0.038	5.50±0.019
25×2900×1.30	32.94±0.027	106.56±1.082	184.68±0.180	5.25±0.078	5.58±0.064	5.51±0.006
25×2900×1.45	33.02±0,046	109.37±0.901	187.18±1.804	5.45±0.066	5.55±0.065	5.50±0.065
25×3000×1.30	32.93±0.024	109.06±0.721	187.65±1.352	5.43±0.052	5.61±0.045	5.52±0.048
25×3000×1.45	32.99±0.059	109.84±0.450	187.18±3.969	5.48±0.030	5.52±0.251	5.50±0.140

NS: Not significant, *: $p<0.05$ and **: $p<0.01$, Means bearing different letters in the same column within each factor differ significantly ($p\leq 0.05$)

The LBW at 3 weeks of age and BWG through 1-3 weeks of age were significantly ($p\leq 0.01$) affected due to Lys level in the diets. LBW at 3 weeks of age and BWG during 1-3 weeks of age were statistically ($p<0.01$) improved when chicks fed 1.45% Lys compared to groups received 1.3% Lys. Live BW at 5 weeks of age and BWG throughout 1-5 weeks of age were not significantly affected by Lys levels. These results are in line with findings of Shivazad *et al*. (2013) and Attia (2014) who found that dietary Lys significantly ($p<0.05$) affected LBW at 10, 17 and 24 days of age which increased by increasing Lys level where that of 1.45% was the heaviest one.

Data presented in Table 3 revealed that dietary CP levels did not affect ($p\leq 0.05$) average feed consumption through 3-5 and 1-5 weeks of age, whereas, through 1-3 weeks of age the highest

($p \le 0.01$) feed consumption was observed in the group fed low-CP level when compared with other levels. These results are in disagreement with the finding of Gheisari *et al.* (2011) who found that the highest feed consumption ($p \le 0.05$) was observed in the group fed high level of protein during the second rearing period (15-28 days). Siyadati *et al.* (2011) found that the birds fed on diets containing high crude protein (27%) showed better feed conversion ratio than those fed other diets (24 or 21%).

Dietary CP levels had no significant effect on FCR during all the experimental period studied. But, the better FCR was observed with the birds consumed diet containing higher dietary protein level as compared with the lower dietary protein level (Table 3). The study findings were

Table 3: Feed consumption and feed conversion of quails as affected by CP, ME and Lys levels and their interactions.

Treatments	Daily feed consumption (g)			Feed conversion (g gain/g feed)		
	1-3 weeks	3-5 weeks	1-5 weeks	1-3 weeks	3-5 weeks	1-5 weeks
	($\bar{X}$±SE)					
Protein levels (%)	**	NS	NS	NS	NS	NS
22	12.83±0.177^{a}	22.98±0.275	17.90±0.214	2.26±0.022	4.27±0.074	3.24±0.038
23.5	12.44±0.117^{b}	22.62±0.215	17.53±0.162	2.25±0.020	4.08±0.071	3.16±0.025
25	12.09±0.105^{b}	22.64±0.352	17.37±0.226	2.23±0.023	4.07±0.075	3.16±0.049
Energy levels (kcal kg^{-1})	*	**	**	NS	**	**
2900	12.63±0.108^{a}	23.25±0.237^{a}	17.94±0.160^{a}	2.26±0.018	4.25±0.056^{b}	3.24±0.029^{b}
3000	12.27±0.139^{b}	22.24±0.151^{b}	17.26±0.139^{b}	2.23±0.017	4.03±0.059^{a}	3.13±0.027^{a}
Lys levels (%)	NS	NS	NS	**	NS	NS
1.30	12.41±0.109	22.83±0.240	17.62±0.162	2.28±0.014^{b}	4.10±0.065	3.20±0.033
1.45	12.49±0.151	22.66±0.225	17.57±0.180	2.21±0.017^{a}	4.17±0.060	3.17±0.029
Interaction effects						
Protein×Energy	NS	NS	NS	*	NS	NS
22×2900	12.87±0.182	23.33±0.395	18.10±0.287	2.27±0.027^{b}	4.31±0.103	3.26±0.051
22×3000	12.78±0.323	22.62±0.356	17.70±0.323	2.26±0.038^{b}	4.23±0.114	3.22±0.060
23.5×2900	12.77±0.077	23.12±0.228	17.94±0.140	2.24±0.033^{c}	4.24±0.081	3.22±0.024
23.5×3000	12.10±0.104	22.13±0.232	17.12±0.165	2.26±0.025^{b}	3.92±0.075	3.11±0.033
25×2900	12.26±0.190	23.31±0.600	17.98±0.389	2.29±0.035^{a}	4.18±0.117	3.25±0.075
25×3000	11.93±0.038	21.98±0.082	16.95±0.057	2.18±0.007^{d}	3.95±0.076	3.07±0.029
Protein×Lys	NS	NS	NS	*	NS	NS
22×1.30	12.62±0.168	23.00±0.177	17.81±0.169	2.26±0.012^{b}	4.20±0.113	3.22±0.042
22×1.45	13.03±0.306	22.95±0.548	17.99±0.413	2.27±0.045^{b}	4.34±0.099	3.26±0.067
23.5×1.30	12.45±0.187	22.41±0.268	17.43±0.226	2.31±0.011^{a}	3.99±0.088	3.17±0.041
23.5×1.45	12.42±0.160	22.84±0.338	17.63±0.245	2.19±0.012^{c}	4.17±0.107	3.16±0.033
25×1.30	12.17±0.189	23.09±0.657	17.63±0.419	2.27±0.040^{b}	4.12±0.136	3.22±0.087
25×1.45	12.01±0.100	22.20±0.190	17.11±0.145	2.19±0.009^{c}	4.01±0.071	3.10±0.028
Energy×Lys	NS	NS	NS	*	*	*
2900×1.30	12.67±0.128	23.48±0.326	18.08±0.193	2.32±0.014^{a}	4.29±0.085^{a}	3.30±0.040^{a}
2900×1.45	12.59±0.180	23.02±0.346	17.81±0.260	2.21±0.021^{c}	4.20±0.076^{b}	3.18±0.036^{b}
3000×1.30	12.16±0.129	22.18±0.184	17.17±0.153	2.25±0.019^{b}	3.92±0.050^{c}	3.10±0.025^{c}
3000×1.45	12.39±0.250	22.30±0.250	17.34±0.238	2.22±0.029^{c}	4.14±0.097^{b}	3.16±0.048^{b}
Protein×Energy×Lys	NS	NS	NS	NS	NS	NS
22×2900×1.30	12.82±0.122	23.32±0.064	18.07±0.093	2.28±0.012	4.36±0.180	3.29±0.053
22×2900×1.45	12.92±0.386	23.33±0.882	18.13±0.634	2.25±0.058	4.25±0.137	3.23±0.097
22×3000×1.30	12.43±0.297	22.69±0.229	17.56±0.079	2.24±0.016	4.03±0.062	3.14±0.019
22×3000×1.45	13.14±0.553	22.56±0.780	17.85±0.173	2.28±0.081	4.42±0.154	3.29±0.112
23.5×2900×1.30	12.77±0.161	22.82±0.186	17.80±0.215	2.31±0.001	4.14±0.038	3.23±0.012
23.5×2900×1.45	12.76±0.064	23.42±0.367	18.09±0.305	2.16±0.005	4.35±0.146	3.20±0.053
23.5×3000×1.30	12.13±0.212	22.00±0.399	17.07±0.202	2.31±0.025	3.84±0.125	3.11±0.070
23.5×3000×1.45	12.08±0.096	22.25±0.308	17.17±0.573	2.21±0.013	4.00±0.083	3.11±0.025
25×2900×1.30	12.43±0.334	24.31±0.812	18.37±0.293	2.36±0.028	4.36±0.195	3.39±0.101
25×2900×1.45	12.08±0.199	22.32±0.386	17.20±0.022	2.21±0.009	4.01±0.023	3.12±0.015
25×3000×1.30	11.92±0.038	21.86±0.006	16.89±0.109	2.19±0.013	3.89±0.030	3.05±0.023
25×3000×1.45	11.94±0.077	22.09±0.141	17.02±0.126	2.17±0.002	4.01±0.157	3.09±0.058

NS: Not significant, *: $p<0.05$ and **: $p<0.01$, Means bearing different letters in the same column within each factor differ significantly ($p \le 0.05$)

comparable with the results of Abou-Zeid *et al.* (2000), Abdel-Azeem *et al.* (2001) and Aboul-Ela *et al.* (2004) who reported that feeding growing Japanese quail a diet contained high protein level (24%) showed a remarkable improvement in body weight and feed conversion ratio as compared with quail received the lower protein level (21% CP). Also, Barque *et al.* (1994) found that the minimum feed consumption and better feed efficiency was noted in birds fed 26% protein diet.

Results in Table 3 showed that, increasing ME level in the quail grower diets from 2900 to 3000 kcal/ME kg^{-1} was associated with a marked significant ($p \le 0.01$) decrease in feed consumption and significant ($p \le 0.01$) improvement in feed conversion ratio during all the experimental periods studied expect feed conversion during 1-3 weeks of age which was not significantly affect. This means that during the starter and finisher periods, the lower energy feed was responsible for any increase in feed consumption. This may be explained on the basis that chicks require more dietary energy values covered by increasing feed consumption. However, birds have the ability to regulate their energy requirements by increasing feed consumption to certain extent. These results are in good agreement with those reported by Gheisari *et al.* (2011) who reported that feed consumption of Japanese quails increased linearly with decreasing dietary energy level from 2900 to 2700 kcal/ME kg^{-1}. Kaur *et al.* (2008) reported that feed consumption of Japanese quail increased and feed conversion improved with decreasing dietary energy from 3100 to 2900 and 2700 kcal ME/kg during 0-3 or 0-5 weeks of age.

Data in Table 3 showed that feed consumption and feed conversion were not significantly affected by Lys level during all the experimental period except feed conversion during 1-3 weeks of age was significantly ($p \le 0.01$) affected by Lys level. Generally, it could be noticed that feed conversion was improved as dietary Lys increased. These results agree with those of Corzo *et al.* (2002) reported that increasing Lys level only improved feed conversion without any effect on feed intake. Yakout *et al.* (2004) indicated that feed conversion ratio was improved significantly ($p<0.05$) as dietary Lys increased up to 1.53%. Also, Shivazad *et al.* (2013) and Attia (2014) found that quails consumed diet containing 1.45% Lys showed the best feed conversion ratio as compared with the other dietary Lys levels.

The interactions between protein and energy levels were significant ($p \le 0.01$) effect on LBW at 3 weeks of age and BWG through 1-3 weeks of age. On the other hand, the interactions between energy and Lys levels were significant ($p \le 0.01$) on LBW at 5 weeks of age and BWG through 1-5 weeks of age. There were no interactions among the different levels of CP, ME and Lys on LBW and BWG of grower quails at all experimental periods ($p<0.05$). The highest values of LBW at 3 and 5 weeks of age and BWG during 1-3 and 1-5 weeks of age were recorded with the quail fed diet containing 22% CP, 2900 kcal kg^{-1} diet and 1.45% Lys when compared with other diets (Table 2).

Results obtained in this study revealed that feed consumption was not significantly affected by the interaction between CP×ME, CP×Lys, ME×Lys and among CP×ME×Lys during all the experimental periods (Table 3). These results agree with Aboul-Ela *et al.* (2004) who revealed that feed consumption was not significantly affected by the interaction between protein×energy levels through all the experimental periods.

In the present study, FCR values were significantly ($p \le 0.05$) affected due to the interaction between CP×ME and CP×Lys during 1-3 weeks of age. The interaction between ME and Lys was significantly ($p \le 0.05$) effected on feed conversion during all the experimental periods studied. While, the interaction among CP×ME×Lys levels was not significantly affect feed conversion (Table 3). According to Aboul-Ela *et al.* (2004) found that feed consumption and feed conversion were not significantly affected by the interaction between protein and energy levels.

Carcass characteristics: Results in Table 4 did not show any significant effect on all carcass characteristics studied of growing Japanese quail due to different dietary CP, ME and Lys levels or their interaction, except carcass percentage was significantly ($p \leq 0.01$) affected by Lys levels whereas, it was higher in chicks fed diets contained 1.3% Lys. Also, giblets were significantly ($p \leq 0.01$) affected by energy levels and the interaction among dietary protein, energy and Lys levels. While, dressing percentage were significantly ($p \leq 0.01$) affected by only different dietary protein and Lys levels.

Results of the present work are in agreement with those of Shivazad *et al.* (2013) and Attia (2014) who revealed that dietary Lys significantly ($p<0.05$) affect carcass weight and carcass weight increase up to 103.13 g with 14.5 g kg^{-1} dietary Lys although this Lys level has no significant difference with 13 g kg^{-1} Lys. Alagawany *et al.* (2014b) found that carcass traits (carcass, giblets, dressing and feather percentages) were not affected due to either the different dietary protein and

Table 4: Carcass traits of quails as affected by dietary CP, ME and Lys levels and their interactions

Treatments	Pre-slaughter weight (g)	Carcass (%)	Giblets (%)	Dressing (%)
Protein levels (%)	NS	NS	NS	**
22	186.81±2.044	71.88±0.502	5.74±0.351	77.62±0.351^{b}
23.5	186.77±2.851	71.49±0.482	5.73±0.165	77.22±0.151^{b}
25	186.23±1.040	72.13±0.581	6.11±0.155	78.25±0.051^{a}
Energy levels (kcal kg^{-1})	NS	NS	**	NS
2900	186.62±1.840	71.64±0.601	6.13±0.154^{a}	77.78±0.356
3000	186.58±1.041	72.02±0.780	5.58±0.161^{b}	77.61±0.334
Lys Levels (%)	NS	**	NS	**
1.30	186.50±1.044	72.23±0.134^{a}	5.92±0.165	78.16±0.350^{a}
1.45	186.70±1.845	71.43±0.151^{b}	5.79±0.169	77.23±0.051^{b}
Interaction effects				
Protein×Energy	NS	NS	NS	NS
22×2900	187.00±1.044	71.72±0.690	5.81±0.111	77.53±0.355
22×3000	186.63±2.048	72.04±0.601	5.66±0.165	77.70±0.401
23.5×2900	186.60±1.049	71.02±0.702	6.16±0.155	77.18±0.352
23.5×3000	186.94±0.987	71.96±0.663	5.29±0.036	77.25±0.251
25× 2900	186.24±0.998	72.20±0.691	6.42±0.231	78.62±0.452
25× 3000	186.19±1.654	72.07±0.653	5.80±0.025	77.87±0.350
Protein×Lys	NS	NS	NS	NS
22×1.30	186.50±1.445	72.22±0.712	5.81±0.156	78.04±0.254
22×1.45	187.13±2.049	71.54±0.654	5.66±0.165	77.20±0.271
23.5×1.30	186.69±1.523	72.21±0.692	5.59±0.169	77.81±0.352
23.5×1.45	186.84±0.089	70.76±0.445	5.86±0.055	76.63±0.410
25× 1.30	186.33±0.698	72.26±0.654	6.37±0.222	78.63±0.341
25× 1.45	186.13±0683	72.01±0.523	5.85±0.142	77.86±0.301
Energy×Lys	NS	NS	NS	NS
2900×1.30	186.59±0.987	72.01±0.362	6.32±0.15	78.33±0.225
2900×1.45	186.59±0.658	71.28±0.654	5.94±0.15	77.23±0.271
3000×1.30	186.41±2.045	72.45±0.251	5.53±0.15	77.98±0.256
3000×1.45	186.75±0.895	71.59±0.653	5.64±0.15	77.23±0.234
Protein×Energy× Lys	NS	NS	**	NS
22× 2900× 1.30	186.83±2.365	71.67±0.624	6.07±0.155^{bc}	77.75±0.381
22×2900×1.45	187.16±1.454	71.76±0.691	5.55±0.159^{d}	77.32±0.231
22× 3000 ×1.30	186.16±0.698	72.76±0.656	5.55±0.160^{d}	78.32±0.353
22×3000×1.45	187.10±2.048	71.31±0.564	5.77±0.170^{c}	77.09±0.122
23.5× 2900×1.30	186.67±0.478	72.03±0.725	5.83±0.152^{c}	77.87±0.135
23.5× 2900×1.45	186.53±0.784	70.01±0.213	6.48±0.132^{b}	76.50±0.355
23.5×3000× 1.30	186.71±2.023	72.40±0.124	5.35±0.123^{e}	77.76±0.263
23.5×3000×1.45	187.16±1.325	71.51±0.365	5.23±0.159^{e}	76.75±0.651
25×2900×1.30	186.29±2.045	72.33±0.256	7.05±0.035^{a}	79.39±0.451
25×2900×1.45	186.25±0.369	72.06±0.213	5.79±0.125^{c}	77.86±0.425
25× 3000 ×1.30	186.37±0.225	72.18±0.698	5.68±0.158^{d}	77.87±0.355
25× 3000×1.45	186.01±2.046	71.95±0.656	5.91±0.169^{c}	77.86±0.306

NS: Not significant and **: $p>0.01$, Means bearing different letters in the same column within each factor differ significantly ($p \leq 0.05$)

Lys levels or their interactions. Aboul-Ela *et al.* (2004) reported that carcass traits (carcass, giblets and dressing percentages) were not affected due to either the different dietary energy and protein levels or their interactions.

CONCLUSION

From our results we can conclude that, using 22% crude protein was enough to get the best growth performance of growing Japanese quails. While, chick quails during the starter period (1-3 weeks of age) need to increase Lys level in their diets to 1.45% to meet nutrient requirement. On the other hand, dietary level of 1.3% Lys is recommended for feeding quails during the finisher period (3-5 weeks of age). Moreover, the level of 2900 kcal ME kg^{-1} quail diet would be suitable from 1-5 weeks of age.

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