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Growth Performance of Japanese Quail as Affected by Dietary Protein Level and Enzyme Supplementation

M.H. Rabie and Hayam M.A. Abo El-Maaty
Department of Poultry Production, Faculty of Agriculture, Mansoura University, Egypt

Corresponding Author: M.H. Rabie, Department of Poultry Production, Faculty of Agriculture, Mansoura University, Egypt

ABSTRACT

An experiment was carried out to evaluate the effect of different dietary protein (CP) levels (24, 22 and 20%) with or without enzyme addition on growth performance of Japanese Quail. At two weeks old, quail were randomly distributed into six experimental groups, each with three equal replications and fed their respective experimental diets and managed similarly. The criteria of response were growth performance (live body weight, weight gain, feed intake, feed conversion ratio and crude protein intake), nutrient digestibility, some carcass traits and blood parameters (total protein, total lipids and total cholesterol, ALT and AST). Apart from the effect of dietary enzyme supplementation, decreasing dietary CP level from 24-20% caused significant reductions in growth performance (live body weight, weight gain, crude protein intake and feed conversion ratio) of quail. Added exogenous enzyme achieved beneficial effects on quail growth performance but feed intake was unaffected compared with the controls, regardless of the effect of dietary protein level. Nutrient digestibility coefficients were significantly depressed when dietary CP level was decreased from 24-20% but added exogenous enzyme produced positive effects on digestibility of nutrients examined. Neither dietary protein level nor enzyme addition had an effect on carcass traits or blood parameters of quail. It can be concluded that an optimal dietary crude protein level for growing Japanese quail is 24% from 14-42 days of age. Added exogenous enzyme is suggested to have a positive effect on growth performance of quail fed the low protein diets.

Key words: Japanese quail, protein level, exogenous enzyme, performance, nutrient digestibility

INTRODUCTION

Due to genetic selection for high body weight in Japanese quail (*Coturnix coturnix japonica*), practiced during the last few decades, new genetic lines of quail have been evolved with considerably higher growth rate compared with the original quail population (Hussain *et al.*, 2013). Nutrient requirements of these quail lines, particularly energy and protein, might be variable to some extent. To achieve optimal growth performance in Japanese quail, like other poultry species, dietary Crude Protein (CP) must provide sufficient levels of essential amino acids and nonessential amino acids to allow maximum protein synthesis and meet the metabolic demands other than protein synthesis. In addition, the dietary CP should also provide a balanced pattern of amino acids to promote optimal energy and protein intake.

According to the scientific literature, a wide range of dietary CP (16-30%) was used for growing Japanese quail (Kirkpinar and Oguz, 1995; Hyankova *et al.*, 1997; Mosaad and Iben, 2009; Attia *et al.*, 2012; Shayan *et al.*, 2013). In this regard, Marks (1993) concluded that quail populations selected under high protein environments require such environments for maximum growth, whereas populations selected under low protein environments do not require high protein diets for full expression of their genetic potential for growth. Mosaad and Iben (2009) reported a linear increase in body weight gain of Japanese quail with increasing dietary crude protein level from 21-27%. Recently, Shayan *et al.* (2013) suggested that lowering dietary crude protein to 21% had no adverse effect on growth performance of Japanese quail. Accordingly, it seems that protein (amino acids) requirements of growing Japanese quail are not completely established.

Nowadays, the inclusion of commercial enzymes into poultry diets has become a common practice. The target aims of adding exogenous enzymes to poultry diets are: To increase nutrient digestibility, to break down the antinutritional compounds, to achieve the least-cost feed formulations and to reduce the environmental pollution (Bedford and Partridge, 2001).

The aim of the present study was to investigate the effect of decreasing dietary protein level in absence or presence of an addition of exogenous enzyme on growth performance of Japanese quail.

MATERIALS AND METHODS

The present study was carried out at a private farm (Dakahlia Governorate, Egypt) during the period from November to December, 2013. In the starter period, unsexed day-old Japanese quail were kept in floor pens and fed a common starter diet [(containing 2900 kcal of Metabolizable Energy (ME) and 26.06% Crude Protein (CP)]. The chicks were subjected to similar managerial practices until they were 14 days of age.

Experimental diets and management: At 2 weeks of age, 198 quail were randomly distributed into 6 experimental groups, each consisted of three equal replications and kept in open-sided floor pens. Six isocaloric diets (ME of about 2900 kcal kg^{-1}) containing three CP levels (24, 22 and 20%) with or without enzyme (Bio-Feed® Pro) addition were formulated and used. Bio-Feed® Pro was added to the diets at a level of 0.03% at the expense of yellow corn. This enzyme preparation (produced by *Bacillus licheniformis*) contains only protease activity of 3.0 AU g^{-1} of the product, processed in a coated thermo tolerant granulate (Novo Nordisk A/S, Denmark). All quail were given their respective experimental diets from 14 to 42 days of age. Feed and water were provided on an *ad libitum* basis and the birds were subjected to a daily photoperiod of 16 h and managed similarly. Composition and nutrient calculated and determined analyses of the experimental diets are given in Table 1.

Growth performance of Japanese quail: The performance of growing quail was evaluated in terms of Live Body Weight (LBW), Body Weight Gain (BWG), Feed Intake (FI), Feed Conversion Ratio (FCR; g feed; g gain) and CP Intake (CPI). Mortality was monitored and recorded daily throughout the whole experimental period. Live body weights of quail were recorded at the beginning of the experiment and on a weekly basis thereafter. Weekly records on FI and CPI of quail were also maintained on a replication basis; thus, BWG and FCR were calculated.

Digestibility trials: Six digestion trials were undertaken using 5-week-old quail in order to evaluate digestibility of nutrients in the experimental diets. In each trial, a four-bird group from each treatment was placed in a separate battery compartment and fed its respective experimental diet for a 3-day adaptation period, followed by a 3-day test period. During the test period, daily feed intake and excreta voided were quantitatively determined. Just after collection, excreta were

Table 1: Ingredient composition and nutrient analyses of the experimental diets fed to growing Japanese quail in the present study

Ingredients	24% CP[1]	22% CP[2]	20% CP[3]	24% CP+E[4]	22% CP+E[5]	20% CP+E[6]
Yellow corn	49.4	53.95	56.92	49.37	53.97	56.97
Soybean meal (44% CP)	39.7	33.5	29	39.7	33.5	29
Wheat bran	1.6	3.5	5.88	1.6	3.5	5.88
Corn gluten meal (60% CP)	3.5	3.5	2.5	3.5	3.5	2.5
Limestone	1.5	1.6	1.6	1.5	1.6	1.6
Dicalcium phosphate	1.5	1.5	1.5	1.5	1.5	1.5
NaCl	0.3	0.3	0.3	0.3	0.3	0.3
Vit. and Min. Premix*	0.3	0.3	0.3	0.3	0.3	0.3
Sunflower oil	2.2	1.8	1.8	2.2	1.8	1.8
DL-methionine	0	0.05	0.1	0	0	0.1
L-Lysine.HCl	0	0	0.1	0	0	0.02
Bio-Feed Pro®	0	0	0	0.03	0.03	0.03
Total	100	100	100	100	100	100
Calculated analysis (NRC., 1994)						
ME (kcal kg^{-1})	2900	2900	2900	2900	2900	2900
Crude protein (%)	24.09	22.03	20.09	24.09	22.03	20.09
Calorie: CP ratio	120.8	131.8	145	120.8	131.8	145
EE (%)	4.53	4.31	4.44	4.53	4.31	4.44
CF (%)	4.09	3.6	3.96	4.09	3.6	3.96
Methionine (%)	0.39	0.42	0.43	0.39	0.42	0.43
Methionine plus cystine (%)	0.79	0.73	0.77	0.79	0.73	0.77
Lysine (%)	1.2	1.1	1.09	1.2	1.1	1.09
Calcium (%)	1.01	1.04	1.03	1.01	1.04	1.03
Non-phytate phosphorus (%)	0.43	0.43	0.42	0.43	0.43	0.42
Determined analysis (AOAC., 2000)						
Dry matter (%)	89.43	89.57	89.84	89.43	89.57	89.84
Organic matter (%)	83.33	83.24	83.62	83.33	83.24	83.62
Crude protein (%)	26.06	24.12	22.3	26.06	24.12	22.3
Ether extract (%)	5.11	4.25	4.75	5.11	4.25	4.75
Crude fiber (%)	4.57	4.1	4.41	4.57	4.1	4.41
Nitrogen-free extract (%)	64.26	67.53	68.54	64.26	67.53	68.54
Ash (%)	6.1	6.33	6.22	6.1	6.33	6.22

*: Premix at 0.30% of the diet supplies the following per kg diet, Vit. A: 1000 IU, Vit. D_3: 2000 IU, Vit. E: 10 mg, Vit. K: 1 mg, Vit. B_1: 5 mg, Vit. B_2: 5 mg, Vit. B_6: 1.5 mg, Vit. B_{12}: 0.01 mg, Folic acid: 0.35 mg, Biotin: 0.05 mg, Pantothenic acid: 10 mg, Niacin: 30 mg, Choline chloride: 250 mg, Fe: 30 mg, Zn: 50 mg, Cu: 4 mg and Se: 0.1 mg, CP+E: Diets bearing 4, 5 and 6 superscripts are fortified with the enzyme preparation Bio-Feed Pro®)

sprayed with 1% boric acid to eliminate nitrogen loss due to possible ammonia release. The excreta were then dried in a forced-air oven at 70°C for 48 h. The procedure described by Jakobsen *et al.* (1960) was used for separating the fecal protein fraction in excreta samples. The urinary organic matter was calculated by multiplying the percent of urinary nitrogen by the factor 2.62 (Abou-Raya and Galal, 1971). Chemical analyses of the experimental diets and dried excreta were carried out according to the official methods of analysis (AOAC., 2000). Digestibility of nutrients were calculated for Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE) and Nitrogen-Free Extract (NFE).

Carcass traits of Japanese quail: At the end of the experiment (6 weeks of age), a slaughter test was performed to evaluate carcass characteristics of quail. Six quail were randomly selected of approximately similar body weights and sacrificed 12 h post-fasting. Just after complete bleeding, their carcasses were scalded, feather plucked and immediately processed. Individual weights of eviscerated carcass (i.e., carcass yield) and edible organs (i.e., liver, heart and gizzard) were recorded. Thus, relative weights (% of LBW at slaughter) of carcass yield, liver, heart and gizzard and dressing-out percentage (i.e., carcass yield plus total edible organs) were calculated.

Blood parameters of Japanese quail: During slaughtering, six blood samples per treatment were collected in heparinized tubes. They were immediately centrifuged for 15 min at 4000 r.p.m to obtain blood plasma. The obtained plasma samples were frozen at -20°C until later analysis. Blood plasma levels of total protein (Doumas *et al*., 1981), total lipids (Frings and Dunn, 1970) and total cholesterol (Allain *et al*., 1974) as well as activity of transaminases: alanine aminotransferase and aspartate aminotransferase (ALT and AST; Reitman and Frankel, 1957) were determined by commercial kits.

Experimental design and statistical analysis: A completely randomized design in a 3×2 factorial arrangement of treatments, three dietary CP levels (24, 22 and 20%) and two levels of enzyme addition (0.0 and 0.03% of the diet) was used. The statistical processing of data was performed by using two-way analysis of variance of the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS., 2006). When the main effects of dietary protein level and enzyme addition were significant ($p \leq 0.05$), means were separated by Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance of Japanese quail: Interestingly, there was no deaths in Japanese quail chicks during the course of the present study. The effects of dietary protein level and enzyme supplementation on growth performance of quail from 14-42 days of age are presented in Table 2.

Table 2: Growth performance of Japanese quail as affected by dietary protein level and enzyme supplementation from 14-42 days of age

Dietary treatments	Initial LBW (g)	Final LBW (g)	BWG (g)	FI (g)	FCR (g:g)	CPI (g)
CP level (A)						
24% A1	65.68	206.32^{a}	140.64^{a}	458.55^{c}	3.26^{a}	110.05^{a}
22% A2	66.11	201.22^{b}	135.10^{b}	472.35^{b}	3.49^{b}	104.01^{b}
20% A3	65.91	197.81^{c}	131.90^{c}	501.64^{a}	3.81^{c}	100.33^{c}
Pooled SEM	0.251	24.53	25.53	111.18	0.005	5.36
Significance	NS	**	**	**	**	**
Added enzyme (B)						
0.00% B1	65.83	199.41^{b}	133.6^{b}	478.49	3.59^{b}	100.1^{b}
0.03% B2	65.97	204.16^{a}	138.2^{a}	476.53	3.45^{a}	109.5^{a}
Pooled SEM	0.251	24.53	25.53	111.18	0.005	5.36
Significance	NS	**	**	NS	**	**
AB interactions						
A1B1	65.55	204.03	138.47	462.1	3.34	110.9
A1B2	65.80	208.61	142.81	455.0	3.19	109.2
A2B1	65.99	199.88	133.88	474.8	3.55	104.6
A2B2	66.23	202.56	136.33	469.9	3.45	103.5
A3B1	65.95	194.32	128.38	498.6	3.88	99.72
A3B2	65.87	201.29	135.42	504.7	3.72	105.9
Pooled SEM	0.251	24.53	25.53	111.18	0.005	5.36
Significance	NS	*	NS	NS	NS	*

$^{a-c}$: For each of the main effects, means within the same column bearing different superscripts differ significantly ($p \leq 0.05$), SEM: Standard error of the means, *: Significant and NS: Non significant

Irrespective of the effect of enzyme addition, final LBW, total BWG and Crude Protein Intake (CPI) of quail were significantly depressed but total FI was significantly increased with decreasing dietary CP level from 24-20%. Feed Conversion Ratio (FCR) of quail fed the lower dietary CP levels (22 and 20%) were inferior to that of the control birds fed the recommended CP level (24%), regardless of the effect of added enzyme. The decrease in the efficiency of feed utilization for quail fed the lower dietary CP levels is related mainly to the increased FI and the depressed BWG compared with their control counterparts.

Apart from the effect of dietary CP level, dietary supplementation with the exogenous enzyme (Bio-Feed® Pro) achieved beneficial effects on final LBW, total BWG, CPI and FCR of quail but FI was unaffected compared with the control ones. Dietary CP level by added enzyme interactions were insignificant on BWG, FI and FCR but were significant for final LBW and CPI.

In general, the failure of the lower protein diets (22 and 20% CP) in the present study to support optimal performance of quail, despite the observed increase in their FI, may be due to less CPI which is normally coincided with a deficiency in some essential amino acids or perhaps be associated with an amino acid imbalance, thereby reducing the efficiency of protein utilization. Since dietary CPI is determined by the energy: Protein ratio of the diet (Griffiths *et al*., 1977), increasing calorie: Protein ratio by decreasing dietary CP level at constant energy contents, as the case in the present study (Table 1), may also be involved in the poor performance of quail fed the lower CP diets.

In accordance with the present results, Kirkpinar and Oguz (1995) fed day-old Japanese quail chicks on diets varying in crude protein from 160-300 g kg^{-1} for 5 weeks and found that increasing dietary protein concentration caused faster growth rate up to the highest content fed. Similar results were also obtained by Hyankova *et al*. (1997), who evaluated the growth performance of Japanese quail fed two levels of CP in starter diet (26 and 21.6%) and two levels in grower diet (23.8 and 19.5%) and reported that high CP diet exerted a positive effect on body weight of quail only for the first four weeks post-hatching. In addition, Abdel-Azeem *et al*. (2001) evaluated the response of Japanese quail to feeding diets containing three protein levels (20, 22 and 24% CP) during the first 6 weeks of life and found that birds fed the high protein diet (24% CP) exhibited the best growth performance, as measured by live body weight and feed conversion ratio, followed by those of quail fed the medium (22% CP) and the low (20% CP) protein diets.

In line with the current results, Soares *et al*. (2003) estimated the protein requirements of Japanese quail during the rearing period using five dietary CP levels (18, 20, 22, 24 and 26%) and found a quadratic effect of protein level on weight gain of quail from 7-35 days but dietary protein level had no effect on feed intake or feed conversion. In addition, Mosaad and Iben (2009) reported a linear increase in body weight gain of Japanese quail with increasing dietary crude protein level from 21-27%. They also found that feed conversion ratio and energy efficiency improved for quail fed the diets with medium and high crude protein levels during the period from 0-3 weeks of age. Moreover, Sharifi *et al*. (2011) fed Japanese quail on high protein diet (24% CP) from 0-42 days old, low protein diet (22.08% CP) from 0-42 days old or medium protein diet (24 and 22% for the periods of 0-21 and 21-42 days old, respectively). They found that live body weight, body weight gain and feed conversion ratio were significantly better in quail fed the medium and high protein diets compared with birds fed the low protein diet. Recently, Shayan *et al*. (2013) suggested that lowering dietary crude protein up to 21% had no adverse effect on growth performance of Japanese quail.

The present results are also in harmony with the findings of Ghazalah *et al.* (2006), who found that broiler chicks fed low protein diets (20% followed by 18% CP, during the starter and grower periods, respectively) consumed significantly more feed and exhibited inferior feed conversion efficiency as compared to those fed the recommended CP diets (22% followed by 20% CP, respectively) but their live body weight was not affected. Similarly, Sherif (2009) evaluated the growth performance of broiler chicks fed isocaloric diets containing 18 or 20% crude protein in absence or presence of enzyme preparations and found that chicks fed the 20% CP diets exhibited superior growth performance (final live body weight, weight gain, feed conversion) as compared to those fed the 18% CP diets.

The beneficial effect of added enzyme (Bio-Feed® Pro), reported herein, on growth performance of Japanese quail may be due to its proteolytic activity on the dietary plant protein components and thus increasing the digestibility of protein and availability of amino acids required for protein biosynthesis and other metabolic demands. Such plant protein sources are known to contain some antinutritional compounds (such as protease inhibitors and lectins) which have a depressive effect on protein digestion and utilization (Thorpe and Beal, 2001). The improved growth performance of quail chicks, observed in the present study, due to dietary enzyme supplementation is mainly attributable to the increased nutrient digestibility (Table 3); the latter may be an indication that the added protease acted synergistically with the endogenous proteases and other digestive enzymes.

In harmony with the present results, Chimote *et al.* (2009) investigated the effect of dietary enzyme supplementation on growth performance of Japanese quail and found that the added multi-enzyme preparation produced a significant improvement in body weight gain and feed conversion efficiency of quail but feed intake was not affected. Results obtained in this study are

Table 3: Nutrient digestibility of 5 week old Japanese quail as affected by dietary protein level and enzyme supplementation

Dietary treatments	DM (%)	OM (%)	CP (%)	EE (%)	CF (%)	NFE (%)
CP level (A)						
24 % A1	81.81^a	70.98^a	83.91^a	66.78^a	25.76^a	86.36^a
22% A2	79.61^b	67.26^b	82.61^b	65.57^b	24.42^b	84.57^b
20% A3	77.91^c	65.01^c	80.81^c	63.86^c	22.61^c	83.64^c
Pooled SEM	0.236	0.281	0.136	0.145	0.132	0.106
Significance	**	**	**	**	**	**
Added enzyme (B)						
0.00% B1	80.93^b	67.16^b	81.90^b	65.00^b	23.85^b	84.49^b
0.03% B2	83.09^a	68.34^a	82.99^a	65.80^a	24.68^a	85.22^a
Pooled SEM	0.236	0.281	0.135	0.145	0.132	0.106
Significance	**	**	**	**	**	**
AB interactions						
A1B1	81.31	70.01	83.54	66.43	25.45	85.83
A1B2	80.31	71.95	84.29	67.13	26.08	86.89
A2B1	76.21	66.99	82.12	65.36	24.05	84.16
A2B2	78.33	67.53	83.11	65.78	24.79	84.98
A3B1	79.93	64.47	80.04	63.22	22.04	83.50
A3B2	82.89	65.54	81.58	64.50	23.18	83.79
Pooled SEM	0.235	0.281	0.135	0.145	0.132	0.105
Significance	NS	NS	NS	NS	NS	NS

$^{a-c}$: For each of the main effects, means within the same column bearing different superscripts differ significantly ($p \leq 0.05$), SEM: Standard error of the means also in agreement with those reported by Brenes *et al.* (2005), who evaluated the response of Leghorn chicks to feeding wheat, soybean and lupin-based diets supplemented crude enzyme preparations and found that added enzymes (Energex, Bio-Feed-Pro and Novozyme) positively affected the weight gain, feed consumption and feed conversion efficiency of birds. They also suggested that the enzyme addition can improve the nutritional value of lupin cultivars having low content of alkaloids that can depress chick performance. In addition, Sherif (2009) found that dietary supplementation with Phytase, Natuzyme, Sicozyme or Avizyme to broiler chicks produced significant positive effects on final live body weight of chicks as compared to those fed the non-supplemented diets. In contrast to the present results, Elangovan *et al.* (2004) evaluated the effect of feed-grade enzyme supplementation in diets with varying levels of energy on the performance of growing Japanese quail and found that the added enzyme did not improve growth rate, feed intake or feed efficiency of birds. Generally, inconsistent responses of poultry to dietary enzyme supplementation may be related to a variety of factors such as enzyme type (i.e., singe versus multienzyme preparations), enzyme activity, enzyme specificity to substrate, its inclusion level, diet composition (highly digestible versus low quality feed ingredients), dietary nutrient density, the managerial conditions and avian factors such as species, genotype, age, gender and health status of the bird.

Nutrient digestibility of the experimental diets: The effects of dietary protein level and enzyme supplementation on nutrient digestibility of 5-week-old Japanese quail are introduced in Table 3. Apart from the effect of enzyme addition, digestibility coefficients of DM, OM, CP, EE, CF and NFE of quail were significantly depressed when dietary CP level was decreased from 24-20%. The increase in feed intake of quail coincided with reducing dietary CP level may indicate a faster rate of feed passage within the gastrointestinal tract of birds which might led to a reduction in nutrient digestibility. Apart from the effect of dietary CP level, the added exogenous enzyme (Bio-Feed® Pro) produced a positive effect on digestibility of nutrients (DM, OM, CP, EE, CF and NFE) of quail (Table 3). Such improvement in the nutrient digestibility of the experimental diets, observed in the present study due to enzyme supplementation, was reflected in a superior growth performance (Table 2) compared with the control birds. However, the dietary protein level by enzyme addition interactions were not significant on the digestibility coefficients of all nutrients examined.

In line with the present results, Mosaad and Iben (2009) evaluated the response of Japanese quail to feeding diets containing three protein levels (21, 24 and 27% CP) during the growing period and found that nitrogen retention was significantly higher in quail fed on the high protein diet compared with those fed on the low protein diets. The present findings are also in harmony with the results obtained by Sherif (2009), who evaluated the growth performance of broiler chicks fed isocaloric diets containing 18 or 20% crude protein in absence or presence of enzyme preparations and found that chicks fed the 20% CP diets achieved better nitrogen retention and CP digestibility as compared to those fed the 18% CP diets. However, Ghazalah *et al.* (2006) found no effect of dietary protein level on nutrient digestibility of broiler chicks.

The positive effect of the added enzyme (Bio-Feed® Pro), reported herein, concurs with the findings of Khan *et al.* (2006), who found that broiler chicks fed enzyme-supplemented diets exhibited higher means of apparent digestibility of DM, OM, CP and EE as compared to their control counterparts. Similarly, Pourreza *et al.* (2007) reported that dietary enzyme supplementation had positive effects on protein and energy digestibility in broiler chicks. In addition, Sherif (2009), found that dietary supplementation with Phytase, Natuzyme, Sicozyme or Avizyme to broiler chicks produced significant improvements in CP and EE digestibility and rate of nitrogen retention as compared to their the control ones. However, Elangovan *et al.* (2004) found that enzyme addition did not influence nitrogen retention or DM digestibility of Japanese quail.

Carcass traits of Japanese quail: The effects of dietary protein level and enzyme supplementation on carcass traits of 6-week-old quail are given in Table 4. It was observed that neither dietary protein level nor enzyme addition had an effect on carcass traits of quail, measured in this study. The effect of interaction between dietary protein level and enzyme addition on carcass traits was also insignificant.

The present results are in accordance with the findings of Abdel-Azeem *et al.* (2001), who evaluated the response of Japanese quail to feeding diets containing three protein levels (20, 22 and 24% CP) during the first 6 weeks of life and found that carcass traits were not affected by dietary protein level. Similarly, Sharifi *et al.* (2011) fed Japanese quail on high protein diet (24% CP) from 0-42 days old, low protein diet (22.08% CP) from 0-42 days old or medium protein diet (24 and 22% from 0-21 and 21-42 days old, respectively) and found that carcass yields (relative weights of carcass, breast and thighs) were not affected by dietary protein level. In addition, Attia *et al.* (2012) observed that carcass characteristics of growing Japanese quail were not affected by dietary protein level (22 versus 24% CP). Recently, Shayan *et al.* (2013) investigated the effect of reducing dietary protein level (from 24-21% CP) to growing Japanese quail and found that dietary protein level had no effect on their carcass traits. More recently,

Table 4: Carcass traits of 6 week old Japanese quail as affected by dietary protein level and enzyme supplementation

Treatments	LBW (g)	Carcass yield (%)	Gizzard weight (%)	Liver weight (%)	Heart weight (%)	Dressing out (%)
CP level (A)						
24% A1	202	71.27	1.74	1.95	1.07	75.88
22% A2	200	71.09	1.77	1.95	1.08	75.83
20% A3	198	70.81	1.74	1.96	1.08	75.65
Pooled SEM	20.3	0.768	0.007	0.006	0.003	0.06
Significance	NS	NS	NS	NS	NS	NS
Added enzyme (B)						
0.00% B1	198	70.95	1.76	1.96	1.07	75.78
0.03% B2	201	71.17	1.75	1.95	1.09	75.80
Pooled SEM	19.1	0.768	0.007	0.006	0.003	0.05
Significance	NS	NS	NS	NS	NS	NS
AB interactions						
A1B1	200	71.10	1.76	1.94	1.08	75.97
A1B2	204	71.43	1.73	1.96	1.06	75.80
A2B1	198	71.05	1.78	1.97	1.07	75.81
A2B2	200	71.14	1.77	1.94	1.09	75.86
A3B1	196	70.69	1.75	1.98	1.06	75.55
A3B2	200	70.94	1.74	1.95	1.10	75.75
Pooled SEM	19.8	0.768	0.001	0.006	0.003	0.08
Significance	NS	NS	NS	NS	NS	NS

[a-c]: For each of the main effects, means within the same column bearing different superscripts differ significantly ($p \leq 0.05$), SEM: Standard error of the means, NS: Non Significant

Alagawany *et al*. (2014) fed Japanese quail on diets having two protein levels (20 and 22% CP) and found no effect of dietary protein on their carcass characteristics (percentages of carcass yield, giblets and dressing). However, Kirkpinar and Oguz (1995) fed day-old Japanese quail on diets varying in crude protein from 160-300 g kg^{-1} and containing ME of about 11.72 MJ kg^{-1} for five weeks and found that slaughter and carcase weights showed a quadratic response to increasing dietary protein contents. In addition, Mosaad and Iben (2009) found a linear increase of dressing percentage of quail fed increasing levels of protein but edible organs (gizzard, liver and heart) were not affected by the dietary protein level.

The lack of significant differences in carcass traits in response to dietary enzyme supplementation, reported in the present study, agrees with the findings of Elangovan *et al*. (2004), who found that enzyme addition did not significantly affect carcass traits of Japanese quail. The present results are also in accordance with the findings of Sherif (2009), who found that dietary enzyme supplementation had no significant effect on carcass traits, including relative weights of dressed carcass, liver, giblets, breast, legs, total edible parts and abdominal fat pad.

In disagreement to the present results, Chimote *et al*. (2009) reported that dietary enzyme supplementation had a positive effect on carcass traits of Japanese quail. In addition, Khan *et al*. (2006) indicated that dietary enzyme supplementation to broiler chicks improved dressing percentage but reduced the relative weights of gizzard.

Blood parameters of Japanese quail: The effects of dietary protein level and enzyme supplementation on blood plasma parameters of 6 week old quail are given in Table 5. The present results indicated that the examined blood parameters (total protein, total lipids and total cholesterol

Table 5: Blood plasma parameters of 6-week-old Japanese quail as affected by dietary protein level and enzyme supplementation

Dietary treatments	Total protein (g dL^{-1})	Total lipids (g L^{-1})	Total cholesterol (mg dL^{-1})	AST activity (U L^{-1})	ALT activity (U L^{-1})
Protein level (A)					
24% A1	4.06	6.64	111.98	11.89	23.46
22% A2	4.04	6.62	110.32	11.98	23.38
20% A3	4.02	6.59	112.04	12.08	23.41
Pooled SEM	0.012	0.025	24.75	0.566	0.495
Significance	NS	NS	NS	NS	NS
Added enzyme (B)					
0.00% B1	4.02	6.59	110.92	11.99	23.46
0.03% B2	4.05	6.64	111.97	11.98	23.37
Pooled SEM	0.012	0.025	24.75	0.566	0.495
Significance	NS	NS	NS	NS	NS
AB interactions					
A1B1	4.05	6.61	111.15	11.89	23.49
A1B2	4.08	6.66	112.81	11.91	23.43
A2B1	4.02	6.59	110.20	12.03	23.41
A2B2	4.07	6.64	110.43	11.92	23.36
A3B1	4.00	6.56	111.42	12.06	23.49
A3B2	4.03	6.63	112.66	12.11	23.33
Pooled SEM	0.012	0.025	24.75	0.566	0.495
Significance	NS	NS	NS	NS	NS

NS: Not significant, SEM: Standard error of the means and activity of the transaminases: ALT and AST) were not affected by either dietary protein level or enzyme addition. Dietary protein level by enzyme addition interactions had also no effect on blood parameters estimated in this study.

The absence of significant differences in blood parameters of Japanese quail, reported herein, is in agreement with the findings of Abdel-Azeem *et al.* (2001), who reported that blood plasma total protein, total lipid and total cholesterol of 6-week-old Japanese quail were not affected by dietary protein level. Similar results were also obtained by Mosaad and Iben (2009), who found no significant effect of dietary protein level on serum levels of total lipids, cholesterol and glucose of Japanese quail but levels of total protein, calcium and phosphorus were significantly increased as dietary level of protein increased. In addition, Sharifi *et al.* (2011) found that dietary CP level did not significantly affect blood parameters (total protein, uric acid, triglycerides, cholesterol, low-density lipoprotein and high-density lipoprotein) of Japanese quail. Moreover, Shehab *et al.* (2012) found that single and combined addition of Kemzyme-plus dry® and phytase to growing Japanese quail diets did not alter any of blood serum parameters measured. In line also with the present results, Sherif (2009) found that neither dietary crude protein level nor enzyme supplementation affected the blood parameters of broiler chicks.

In conclusion, it can be concluded that the optimal dietary crude protein level for growing Japanese quail is 24 % during the period from 14 to 42 days of age. Dietary supplementation with the exogenous enzyme (Bio-Feed® Pro) proved to be effective to improve the growth performance of quail fed the low protein diets under the condition of this study.

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