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SUPPLEMENTAL THREONINE SUPPORTS PRODUCTIVE AND PHYSIOLOGICAL STATUS OF JAPANESE QUAIL FED PROTEIN-RESTRICTED DIETS

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ABSTRACT: Six-weeks experimental trial was conducted to evaluate the effects of excess dietary threonine [Thr] (150% and 200% of NRC recommendations) with levels of 21% and 22% dietary protein on productive performance, blood biochemical parameters and small intestine histological structure of Japanese quail. Three hundred and fifteen one-day-old unsexed Japanese quail chicks were randomly assigned for seven experimental groups, 45 chicks each. T1- chicks were fed the basal (control) diet contained 24% crude protein; T2 and T3-birds were fed diets contained normal requirement of [Thr] with 22 and 21% crude protein, respectively; T4 and T5-quails received 22% crude protein with 150% or 200% [Thr], respectively; T6 and T7-were given 21% crude protein with 150% or 200% [Thr], respectively. The obtained results showed that [Thr] supplementations particularly 150%, improves quail productive performance and compensates dietary protein restriction. Plasma concentrations of total protein, albumin, high-density lipoprotein (HDL), and glucose were increased significantly (P<0.01), while triglycerides and low-density lipoprotein (LDL) were decreased with [Thr] dietary addition. Kidney and liver functions were not negatively influenced with [Thr] supplementation at any level. The histological observations of intestine showed greater villi height and higher goblet cells number with [Thr] supplementation indicating better digestibility and utilization of feed nutrients. It could be concluded that, supplementary [Thr] at 150% of basal requirement of broiler quails was sufficient to compensate for reduction of dietary crude protein below the NRC recommendations, the therefore, [Thr] supplement had no adverse effect on kidneys and liver functions and improved intestinal status, structure and functions.

Key words: threonine; quail; protein; performance; blood; histology

INTRODUCTION

Poultry farming as one of the vital beneficial sectors of human activity plays an increasing role in bridging the gap between production and consumption by providing considerable quantities of protein, fatty acids, minerals, and vitamins with excellent qualities (FAO, 2013). To increase the benefit of poultry investments from the view of nutrition, feed expenses reduction presents a great challenge, especially with protein costs. Recently, there is eminent interest in the usage of alternative cheap protein sources and/ or maximizing utilization of low dietary protein levels in animal feeds (Olukomaiya *et al*., 2019). Generally, quail performance can be improved by providing a balanced diet along with some supplements (Vargas-Sánchez *et al*., 2019).

Dietary supplements represent a significant tool in modulating performance, immunity, and production of animals, in terms of quality and quantity (Aksu *et al*., 2011; Britanico *et al*., 2012; Fathi *et al*., 2016; El-Senousey *et al*., 2018). Threonine (2-amino-3-hydroxy butanoic acid) is an essential amino acid, which plays a role in several biological processes of livestock animals (Ayasan, 2004; Kidd *et al*., 1999), as it is an essential component of intestinal mucin and plasma g-globulin (Kim *et al*., 2007; Schaart *et al*., 2005). Great portions of threonine (Thr) are utilized in the small intestine, suggesting that Thr is involved in intestinal functionality and maintenance (Van der Schoor *et al*., 2002). Threonine is vital in protein synthesis, stimulating cell growth, cellular signaling mechanisms, and promotes antibody production (Duval *et al*., 1991; Li *et al*., 1999). Besides, it is believed that Thr supplementation boosts feed intake and body weight (Estalkhzir *et al*., 2013; Khan *et al*., 2006).

Few studies have been conducted on quail to evaluate possible influences of dietary Thr supplements with low dietary protein, and controversial results have been reported (Abbasi *et al*., 2014). Thus, this study aimed to investigate effects of extra dietary Thr supplementations (150% and 200% of NRC requirement for quails) in combination with low dietary protein (22% and 21% CP), on growth performance, blood biochemical parameters and intestinal histological status of Japanese quail.

MATERIALS AND METHODS

Animals and experimental design

The present study was carried out at the experimental quail farm, Poultry Production Department, Faculty of Agriculture, Ain Shams University. Three hundred and fifteen unsexed one-day old chicks with initial live weight of 9.01±0.15 g, were randomly distributed to seven experimental groups, with 45 chicks in each group. Chicks of T1 were fed the basal diet (control), which contained 24% CP; T2 and T3 were fed diets contained 22% and 21% CP, respectively; T4 and T5 received 150% Thr with 21% and 22% CP, respectively; T6 and T7 were given 200% Thr with 21% and 22% CP, respectively. Chicks were raised for 6 weeks in an open house system and were offered both feed and clean drinking water *ad-libitum*. The formulation and proximate composition of the experimental diets were shown in Table 1. During the experimental period, body weight (BW, g) was recorded individually, and weight gain (BWG, g) was calculated weekly to the nearest 0.1 g. Feed intake (FI, g) was calculated by subtracting the amount of feed left from that supplied. Feed conversion ratio (FCR) was calculated as the number of grams of feed required to produce one gram of body weight during the same period.

Samples collection and analytical procedure

Chemical analyses of experimental diets, were performed using standard methods (AOAC, 2010) for dry matter by dehumidification by drying till constant weight at 110 °C, crude protein content by applying the method of Kjeldahl, crude lipid by Soxhlet solvent extraction method and ash by burning samples in Muffle furnace for 4 hr at 550 °C. Amino acid contents of diets, were measured using HPLC (Wincom Co. ltd). At the end of the feeding trial, chicks were fasted for 12 h prior to final sampling. Five quails from each group were randomly selected and slaughtered. Blood samples were collected from each bird in a heparinized 10 ml centrifuge tubes (heparin 20 IU/ ml), and then plasma was obtained by centrifugation at 3000 rpm for 15 min under 4°C. All plasma parameters were determined using commercial kits (Transasia Bio-Medicals, India). Plasma total protein and albumin were determined using colorimetric method according to Gornall *et al.* (1949) and Doumas *et al.* (1971) and globulin was then calculated by subtracting albumin value from corresponding total protein value for the same sample. Triglycerides and cholesterol concentration were determined according to recommended method of Richmond (1973). Aspartic amino transfers (AST) and alanine amino transfers (ALT) were detected according to Reitman and Frankel (1957). Determination of cholesterol, HDL, and LDL were performed according to Watson (1960), Herrmann *et al*. (1983), and Okada and Ishida (2001), respectively. While uric acid was determined according to method described by Caraway (1955). And glucose levels were also determined as described by Trinder (1969).

Histology samples of small intestine were collected after decapitation. According to the standard histological process, samples were fixed in Bouin's solution for 24 hours, then dehydrated in elevated concentrations of alcohol, equilibrated in xylene, embedded in paraffin, and were cut to sections of 5-7 µm thick. Sections were stained with haematoxylin and eosin according to the methods described by Bancroft and Stevens (1990) and then subjected for examination by light microscopy.

Statistical analysis

All data were analyzed by one-way analysis of variance (ANOVA) followed by Duncan’s multiple range tests (Duncan, 1955) to compare the means between individual treatments using statistical analysis system (SAS, 2004) version 9.1 for Windows at $P<0.01$ level, and presented as means with ± standard error of mean (S.E.M, r=3). Data were subjected to statistical analysis according to the following model: $Y_{ij} = \mu + T_i + e_{ij}$ Where; Y_{ij}= the experimental observation, μ= overall mean, T_i= dietary treatment, e_{ij}= experimental error.

RESULTS AND DISCUSSION

Table 2 shows the effect of different dietary protein and Thr levels on the productive performance of Japanese quail. It is clear that, feeding quail chicks on diet contained 3% lesser protein (T3) than the NRC (1994) recommendation (24% protein) reduced the final body weight significantly when compared with those whose diets contained the same protein level in combination with 150% Thr addition of the optimal requirement (T6) and those fed on control diet. While the remaining treatments (T2, T4, T5 and T7) had intermediate values. Similar trend was typically found for the results of body weight gain. The highest and the lowest feed intake were recorded for the chicks fed on control (T1) and 22% protein plus 150% Thr (T4), respectively. Moreover, T6 group had significantly ($P<0.05$) recorded the best FCR followed by T7 and T4 groups, while the worst FCR was obtained for T3. These findings pointed out that, supporting low protein quail diets with amino acid Thr at either 150 or 200% of the optimal level is enough to compensate for the dietary protein restriction, particularly 150%. Thereby, based on our finding herein, there is no need for increasing the Thr level above 150% of the optimal requirements. Moreover, quail broilers have the ability of maintaining body weight and weight gain at constant rate when fed on diet contained 22% protein (T2) as established with the absence of significance when compared with that of control chicks (T1).

The present results are coincided with those of Estalkhzir *et al.* (2013) and Rezaeipour *et al.* (2015) who found that dietary Thr supplementation improved productive performance of broiler chicken in terms of

BW, BWG and FCR. In addition, Chen *et al.* (2017) reported that feeding broiler chicks on diet containing 0.81% Thr led to a 5.1% better FCR than chicks given NRC recommended Thr (0.74%). Also, Min *et al.* (2017) found that average daily BWG and FCR were improved by 6 and 4.2%, respectively when broilers were fed on diet containing 0.75% Thr, comparable to chicks of control diet. However, it was shown that dietary supplementation of Thr up to 1.22% of recommended level did not significantly changed daily BWG, FI and FCR of Japanese quail reared under tropical conditions (Samuel *et al.*, 2017). Similarly, increasing supplemental L-Thr did not influence weight gain (Dozier *et al.*, 2001; Kidd and Kerr, 1997), as well as FCR values of broilers during the period from 1-21 day of age (Kidd *et al.*, 1999).

The beneficial effect of dietary supplemental Thr in enhancing the productive performance of quail chicks could be due to the effective role of Thr in stimulating the thyroid gland secretions. Wu (2013) and Azzam and El-Gogary (2015) reported that, increasing the dietary content of broilers with the essential amino acid Thr, resulted in increasing production of triiodothyronine (T_3) and thyroxine (T_4) hormones due to the presence of Thr receptors in thyroid gland. It was established that T_4 hormone is essential for protein and energy metabolism (Johannsen *et al.*, 2012; Mullur *et al.*, 2014) and enhancing the secretion of the IGF-I hormone (Jannini *et al.*, 1995). Moreover, it is needed for protein synthesis and muscular accretion, as well as secretion and function of growth hormone (GH) (Reece, 2015; Hill *et al.*, 2016). Al-Hayani (2017) found an increase in GH level for broiler chickens fed on diets contained Thr at either 600 or 900 mg/ kg. Growth hormone has been reported to stimulate T_3, T_4 and IGF-I secretion, as well its role in protein synthesis and metabolism of amino acid which accelerate protein production (Scanes, 2015). Studies of Kidd and Kerr (1996) and Rao *et al.* (2011) declared that extra dietary Thr addition could improve the productive performance of chickens through its participation in nitrogen metabolism process by reducing expenditure and increasing retention of nitrogen.

Data of blood biochemical analyses of Japanese quail chicks as affected by feeding on different protein and Thr levels are presented in Table 3. It is observed that, feeding broiler quail on low protein diets (T2 or T3), significantly (P<0.01) diminished plasma concentration of total protein and globulin when compared with their counterparts of the other treatment groups, in particular those given 150% Thr with either 21% (T6) or 22% (T4) dietary protein, indicating that chicks fed supplemental Thr had better immune status than those non-supplemented ones.

On the other hand, blood albumin level was not significantly affected by any of the tested diets comparable to the control one. These results are associated with the beneficial effect of Thr in improving quail growth performance. The results of current study are in concomitant with Azzam *et al.* (2011) who observed an increase in the blood globulin level of laying hens fed on diets contained supplemental L-Thr. They attributed this finding to the increase in the lymphocyte ratios. Also, Min *et al.* (2017) found that concentrations of plasma total protein and globulin were increased with increasing Thr level from 85% to 150% of NRC (1994) recommendations. The affirmative effect of increasing supplemental Thr may be associated with the effective immunoglobulins production, accounting for 7-11% of total amino acids (Sandberg *et al.*, 2007)

Wang *et al.* (2006) and Li *et al.* (2007) revealed that dietary Thr addition enhanced immune response by increasing blood immunoglobulin levels particularly, IgG. In addition, Thr is a principal constituent of plasma γ-globulin in poultry, rabbits, pig and humans (Kim *et al.*, 2007). Rezaeipour *et al.* (2012) showed that Thr provision to broiler diets promoted the intestinal digestive enzymes secretion, thus increasing the absorption rate of digested food and the available amino acids for synthesis of protein which is consequently reflected in increasing total blood protein level.

Concerning plasma lipid profile, the current findings showed that, chicks fed on diet contained the lowest protein percentage (T3) had significantly the highest triglycerides level, while the lowest levels were obtained for chicks of diets contained low crude protein and supported with either 200 or 150% of the recommended Thr requirements. Thus, reduction of triglycerides level was more prominent in T4 and T5.

Converse trend was observed for the plasma concentration of total cholesterol, in which the lowest cholesterol levels (P<0.01) were measured for chicks given lower dietary protein content without excess Thr addition (T2 or T3). Moreover, inclusion of extra supplementation of Thr amino acid over the recommended content by 50 or 100%, raised plasma total cholesterol of quail fed on low crude protein diets (T4, T5, T6 and T7).

It is of interest to note that, the blood HDL content displayed nearly similar trend of cholesterol findings. On the other hand, results of plasma LDL concentration exhibited similar trend to that of triglycerides level. These results may reveal that the achieved higher plasma total cholesterol content, is in close association with the effect of supplemental Thr on increasing the plasma HDL content. In partial agreement with our finding, Debnath *et al.* (2019) reported in blood of broilers fed supplemental Thr that, serum cholesterol and VLDL was significantly (P<0.05) decreased. But linear increase and decrease were obtained in the blood HDL and LDL cholesterol, respectively. Rezaeipour and Gazani (2014) illustrated that serum VLDL was decreased (P<0.05) by dietary L-Thr addition. However, Min *et al.* (2017) showed that serum total cholesterol and triglycerides, were not affected (P>0.05) by dietary Thr supplementation.

With respect to plasma AST and ALT levels that have been used as indication of liver functions, the current results showed insignificant difference among all experimental groups. This reveals that under the circumstances of the present experiment, broiler quail could withstand the dietary protein restriction up to 2% lower than the recommended requirements (NRC, 1994) with no adverse effects on their liver functions. Moreover, Thr treatments showed slightly insignificant increase in the plasma ALT activity comparable to control treatment, that is may be referred to the accelerated growth performance and metabolic rate of Thr fed birds. In agreement with this finding, similar results were reported also in Japanese quail chicks by Samuel *et al.* (2017). Also, Valizade *et al.* (2016) demonstrated that serum level of AST in broiler chicks was not significantly affected with higher Thr level. These findings indicate that dietary Thr supplementation had no deleterious effects on hepatic cells of growing quails.

In an earlier study, Miles and Featherston (1974) explained that plasma uric acid in chickens is a precise indicator for determining their requirement of amino acid. Furthermore, Gong *et al.* (2005) reported that levels of serum uric acid will increase when one or several amino acids are lacking or in excess. Concentration of uric acid and creatinine in quail blood plasma showed that there was a marked increase in both parameters with feeding on diminished dietary protein level whether singly or in combination with extra Thr. In accordance with our results, Min *et al.* (2017) showed that plasma uric acid content in broilers decreased and then increased as dietary level of Thr increased.

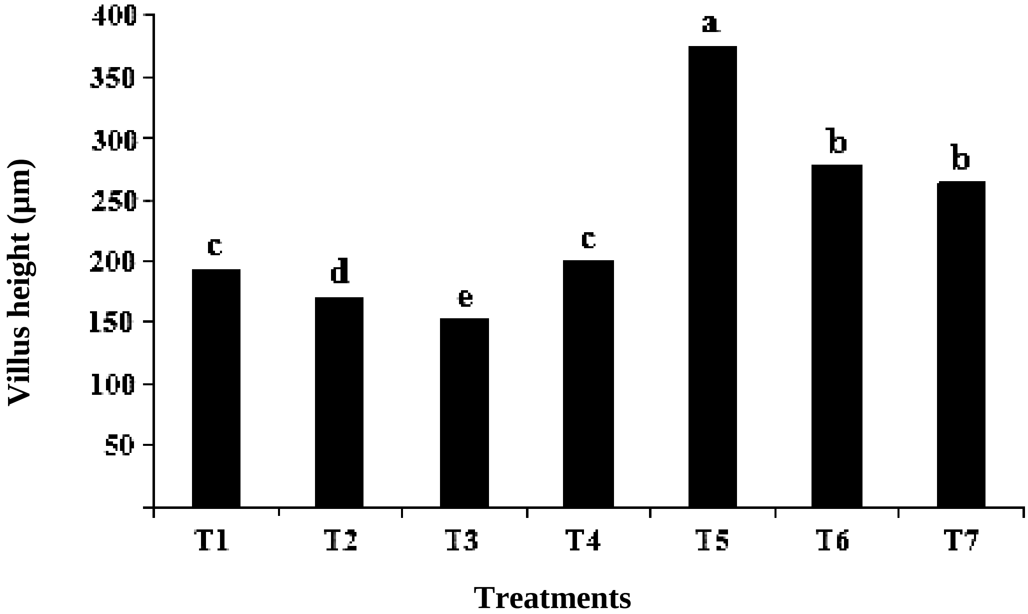
As shown in Table 3, a significant increase was observed in plasma glucose concentration of quail chicks whose diets contained lower crude protein percentages in combination with Thr addition, when compared with chicks of basal diet (control), and those given low protein diets without extra Thr supplementation. Similar results were recently achieved through several authors (Weber *et al.*, 2013; Abdel-Wareth and Esmail, 2014; Debnath *et al.*, 2019) who demonstrated that blood glucose level was significantly increased in broilers with supplemental L- Thr.

Edwards *et al.*, (1997) stated that young chicks catabolize L-Thr producing a number of glucogenic compounds like pyruvate and propionate that are necessary for energy or glucose production. This process might be closely associated with increased blood glucose concentration in the Thr supplemented groups.

The Effect of supplemental Thr on intestinal histomorphometry and histology is presented in Figures 1 and 2 (a-g), respectively. From the histological investigation, it is obvious that chicks of T2 and T3 groups had the lowest villus height (Fig.1) and showed degenerative lining columnar epithelium and goblet cells comparable to that of control and Thr supplemented ones (Fig. 2, b and c). Therefore, quail chicks in T5 group had significantly ($P<0.05$) the highest villus height (VH) followed by those of T6 and T7 ones. Besides, supplemental Thr explained a tendency toward increasing goblet cells number with normal lining epithelium which might be related to increase in the absorptive surface area. In accordance with the current histological findings, Nichols and Bertolo (2008) noticed that dietary Thr supplementation, resulted in greater goblet cell numbers alongside the intestinal villi, consequently higher mucin secretion that protect the intestinal absorptive area from chyme acidity, digestive enzymes activity and pathogenic factors (Horn *et al.*, 2009). The results of Hampson (1986) obtained in piglet showed that; greater villi heights enhanced the activity of enzymes produced from the villi tips, resulting in better digestibility coefficients. On the other hand, Tanure *et al.* (2015) observed no effect of extra dietary addition of Thr on VH in broiler chicks at 14 and 21 day of age.

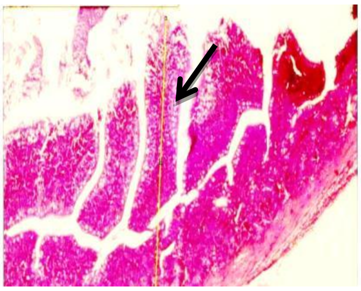
CONCLUSIONS

It could be concluded that, supplemental Thr with 150% of basal requirement was enough to compensate reduction of dietary crude protein below the NRC recommendations in broiler quail. Moreover, Thr supplementation had no adverse effect on kidneys and liver functions and could improve the intestinal status, structures and functions through increasing villi height, goblet cells number and subsequently the absorptive surface area that enhanced the growth performance of supplemented birds.



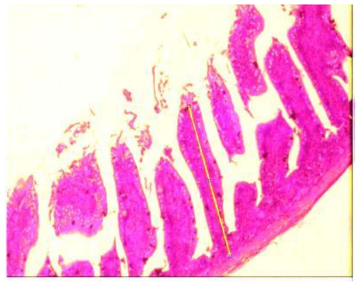
a, b, c, d, e different letters on columns represent significant difference

Fig. (1): Effects of supplemental threonine on intestinal histomorphometry

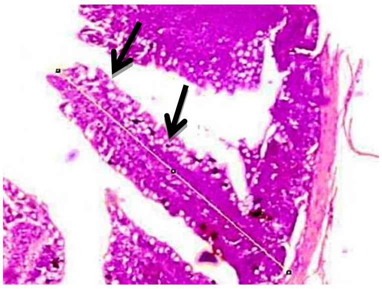


a-T1: 24% CP + 100% Thr (Control)

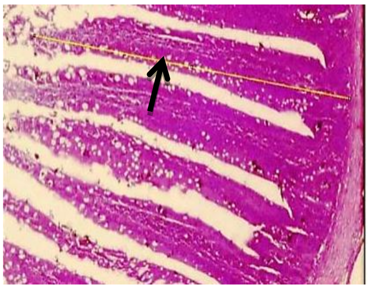
b-T2: 22% CP



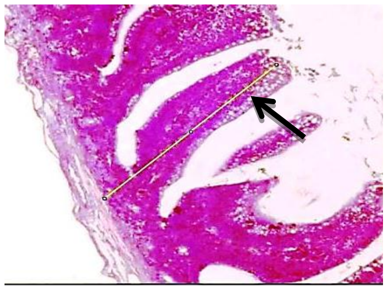
c-T3: 21% CP



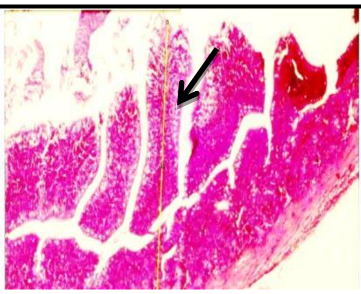
d-T4: 22% CP + 150% Thr



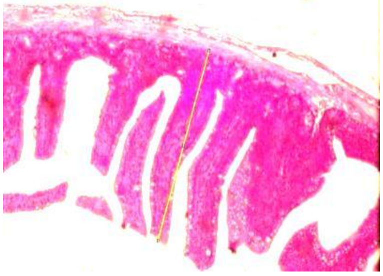
e-T5: 22% CP + 200% Thr



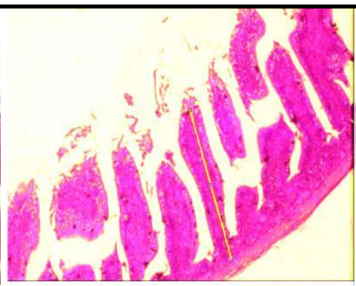
f-T6: 21% CP + 150% Thr



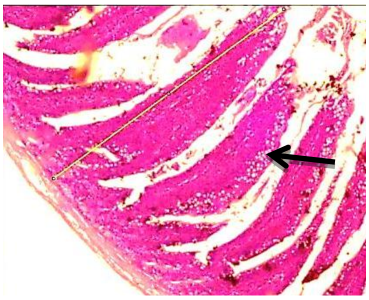
a-T1: 24% CP + 100% Thr (Control)



b-T2: 22% CP



c-T3: 21% CP



g-T7: 21% CP + 200% Thr

Arrows points to columnar epithelium with goblet cells.
Haematoxylin and eosin stain using 10x magnification powers.

Fig. (2): Effect of supplemental threonine of the intestinal histological status.

Table (1): Feed ingredients and proximate composition of experimental diets.

Ingredients	**Dietary Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Yellow Corn	53.79	56.97	58.97	56.96	56.86	58.49	58.35
Soybean meal 44%	37.23	37.30	36.46	35.76	34.20	35.76	34.34
Corn Gluten 60%	5.00	1.30	0.05	2.40	3.50	0.60	1.60
Vegetable Oil	0.90	1.20	1.20	1.10	1.10	1.30	1.30
Ca Carbonate	1.23	1.22	1.22	1.22	1.24	1.22	1.23
Mono Calcium Phosphate	0.91	0.93	0.94	0.94	0.94	0.94	0.95
Lysine	0.11	0.14	0.17	0.17	0.20	0.18	0.21
DL-Methionine	0.10	0.15	0.17	0.14	0.13	0.17	0.16
Threonine	0.13	0.19	0.22	0.71	1.23	0.74	1.26
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix#	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Proximate composition							
Crude Protein %	24.05	22.06	21.09	22.06	22.05	21.08	21.06
Metabolizable Energy Kcal/ Kg	2907	2907	2909	2903	2906	2907	2908
Calcium %	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Available Phosphorus %	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine %	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Methionine %	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Cysteine %	0.40	0.36	0.35	0.36	0.37	0.35	0.35
Threonine %	1.03	1.02	1.02	1.53	2.04	1.53	2.04
Methionine + Cysteine %	0.90	0.86	0.85	0.86	0.86	0.85	0.85
C/P Ratio	121	132	138	132	132	138	138

#Each 3 Kg of premix contains: Vitamins: A: 12000000 IU; Vitamins; D_3 2000000 IU; E: 10000 mg; K_3: 2000 mg; B_1:1000 mg; B_2: 5000 mg; B_6:1500 mg; B_{12}: 10 mg; Biotin: 50 mg; Choline chloride: 250000 mg; Pantothenic acid: 10000 mg; Nicotinic acid: 30000 mg; Folic acid: 1000 mg; Minerals: Mn: 60000 mg; Zn: 50000 mg; Fe: 30000 mg; Cu: 10000 mg; I: 1000 mg; Se: 100 mg and Co: 100 mg.

Table (2): Effect of dietary treatments on productive performance.

Items	Dietary Treatment							
	1	2	3	4	5	6	7	Sig.
Initial body weight (IBW) (one-day of age)	9.01 ±0.15	9.02 ±0.16	9.03 ±0.15	9.03 ±0.17	9.01 ±0.13	9.02 ±0.15	9.01 ±0.14	NS
Final body weight (FBW) (40 days of age)	189.23[a] ±8.56	175.01[ab] ±7.09	154.44[b] ±6.28	163.68[ab] ±11.81	163.29[ab] ±11.73	189.31[a] ±4.40	179.51[ab] ±6.16	*
Body weight gain (BWG) (0-40 days)	180.21[a] ±8.68	165.97[ab] ±7.24	145.41[b] ±6.13	154.65[ab] ±11.94	154.30[ab] ±11.80	180.32[a] ±4.56	170.50[ab] ±6.25	*
Total feed intake (TFI) (0-40 days)	665.87[a] ±42.73	606.41[ab] ±34.13	580.46[b] ±44.05	542.65[c] ±33.60	569.10[bc] ±35.69	589.21[b] ±21.53	590.01[b] ±42.53	*
Feed conversion ratio (FCR) (0-40 days)	3.71[b] ±0.42	3.67[b] ±0.31	3.97[a] ±0.31	3.51[bc] ±0.36	3.69[b] ±0.51	3.27[d] ±0.19	3.46[c] ±0.31	*

[a, b, c, d] Means within the same row with different superscripts are significantly different. Sig.= Significance, * (P≤0.05). NS= Non-Significant.

Table (3): Effect of dietary treatments on blood biochemical parameters.

Items	Dietary Treatment							Sig.
	1	2	3	4	5	6	7	
Total protein (g/dl)	4.54[bc] ±0.61	4.25[c] ±0.11	4.20[c] ±0.10	4.90[ab] ±0.17	4.58[bc] ±0.18	5.17[a] ±0.07	4.58[bc] ±0.43	**
Albumin (g/dl)	2.09 ±0.04	1.95 ±0.06	2.09 ±0.11	2.07 ±0.07	1.84 ±0.07	2.20 ±0.09	2.11 ±0.11	NS
Globulin (g/dl)	2.45[bc] ±0.05	2.30[c] ± 0.07	2.11[d] ±0.04	2.83[a] ±0.14	2.74[ab] ±0.14	2.97[a] ±0.12	2.46[bc] ±0.14	**
Triglycerides (mg/dl)	237.61[bc] ±7.70	241.33[b] ±5.23	258.77[a] ±5.23	225.43[d] ±5.07	228.73[cd] ±12.46	234.39[c] ±5.29	231.70[c] ±5.32	**
Cholesterol (mg/dl)	190.33[cd] ±1.21	183.67[d] ±1.76	188.66[d] 1.76±	198.33[b] ±3.81	202.33[ab] ±4.09	196.67[bc] ±1.76	209.00[a] ±1.15	**
HDL (mg/dl)	35.67[b] ±1.07	35.40[b] ±0.56	35.83[b] ±1.25	45.52[a] ±1.27	45.70[a] ±0.98	46.00[a] ±0.72	44.67[a] ±0.90	**
LDL (mg/dl)	83.43[b] ±1.60	94.53[a] ±1.36	93.60[a] ±1.18	80.00[b] ±1.53	72.33[c] ±2.03	83.00[b] ±2.65	77.67[cb] ±2.60	**
ALT (U/L)	21.30 ±0.59	20.97 ±1.05	21.39 ±0.57	21.95 ±0.52	21.92 ±1.02	21.50 ±1.04	21.46 ±0.42	NS
AST (U/L)	82.86 ±1.66	85.27 ±1.07	82.68 ±0.99	79.85 ±1.90	81.18 ±2.51	75.69 ±1.99	77.79 ±2.70	NS
Uric acid (mg/dl)	5.75[b] ±0.21	6.40[ab] ±0.33	6.56[a] ±0.07	5.84[b] ±0.18	5.73[b] ±0.15	5.91[b] ±0.20	6.59[a] ±0.17	*
Creatinine (mg/dl)	0.68[b] ±0.02	0.77[a] ±0.02	0.79[a] ±0.02	0.69[b] ±0.03	0.77[a] ±0.02	0.64[bc] ±0.02	0.71[ab] ±0.03	*
Glucose (mg/dl)	240.67[bc] ±3.38	239.33[cd] ±3.52	231.33[d] ±2.03	246.33[bc] ±2.72	249.00[ab] ±2.89	256.67[a] ±2.33	255.33[a] ±1.28	**

[a, b, c, d] Means within the same row with different superscripts are significantly different. Sig. = Significance ** (P≤0.01), * (P≤0.05). NS = Non-Significant.

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threonine; quail; protein; performance; blood; histology

الملخص العربي

إضافة الثريونين لدعم الأداء الإنتاجي والحالة الفسيولوجية للسمان الياباني المغذى على علائق محددة البروتين

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أجريت تجربة مزرعية مدتها ستة أسابيع لتقييم تأثير إضافة غذائية زائدة من الحمض الأميني ثريونين [Thr] بما يعادل 150% أو 200% من الإحتياجات الموصى بها، مع مستويات بروتين خام 21 أو 22٪، على الأداء الإنتاجي، وبعض مقاييس الدم والتركيب النسيجي للأمعاء الدقيقة في طيور السمان الياباني. تم توزيع ثلاثمائة وخمسة عشر كتكوت غير مجنس عمرها يوم واحد على سبع مجموعات تجريبية، بواقع 45 كتكوت لكل منها. تم تغذية الطيور في (T1) على العليقة القاعدية (Control) والتي تحتوي 24% بروتين خام بما يناسب الإحتياجات الموصى بها للطيور. وكذلك فإن الطيور في المجموعات (T2) و(T3)، فقد غذيت على علائق تحتوي الإحتياجات الطبيعية من [Thr] مع معدل 22% و21% بروتين خام، على التوالي. أما الطيور في المجموعات (T4) و(T5)، فإنها قد غذيت على علائق بها 22% بروتين خام مع 150% و200% من [Thr]، على التوالي. أيضاً تم تقديم علائق للطيور في مجموعات (T6) و(T7) تحتوي 21% بروتين خام مع 150% و200% من [Thr]، على التوالي. أظهرت النتائج أنه مع إضافة [Thr] خاصة بمعدل 150%، تحسن الأداء الإنتاجي للسمان وتم تعويض التحديد الغذائي للبروتين. كذلك إزدادت تركيزات بلازما الدم من البروتين الكلي والألبومين وHDL والجلوكوز بشكل معنوي (P<0.01)، بينما إنخفضت مستويات الدهون الثلاثية وLDL مع إضافة [Thr]. كذلك فإن مؤشرات وظائف الكلى ووظائف الكبد، لم تتأثر سلباً بأي مستوى من الإضافة الزائدة من [Thr]. على الجانب الآخر، أظهرت ملاحظات التركيب النسيجي للأمعاء للطيور المغذاة علائق مضاف إليها [Thr]، إزدياد طول الخملات وعدداً أكبر من الخلايا الكأسية، مما يشير إلى تحسن عمليات هضم واستفادة أفضل من العناصر الغذائية بالعليقة.