EFFECT OF THREONINE SUPPLEMENTATION ON JAPANESE QUAIL FED VARIOUS LEVELS OF PROTEIN AND SULFUR AMINO ACIDS.
1. GROWING PERIOD

Mohammed, A. A. Abdel-Mageed; Sayed, A. M. Shabaan; and Mohammed, S. Bahnas*

Animal Prod. Res. Inst., Agric. Res. Center, Ministry of Agric, Doki, Giza, Egypt.
*Fac. of Agric., Poultry Production Dept., Fayoum Univ., Fayoum, Egypt.

ABSTRACT:

This study was conducted using 420 unsexed day-old Japanese quail chicks which, equally divided into 7 groups of 3 replicates each, to explore the extent to which dietary crude protein (CP) level can be reduced in corn-soybean meal (C-SBM) starter-grower diets through sulfur amino acids (SAA) and Threonine (Thr) supplementation while maintaining adequate performance. One positive control diet (A) was formulated to cover or exceed NRC (1994) recommendations of CP, SAA and Thr. Two negative control diets (B and C) were formulated to contain lower CP (22 and 20% CP, respectively) than NRC (1994) recommended level but SAA and Thr were held at a constant ratio to CP for obtaining the same ratio in the two diets. Two amino acid-supplemented diets (B_1 and C_1) were formulated to be similar in composition to diets B and C, respectively but still supplying the same SAA and Thr as in diet (A). Two other amino acid-supplemented diets (B_2 and C_2) were formulated in a similar manner as in diets B_1 and C_1, respectively but supplemented with additional Thr at levels of 0.2 and 0.4%, respectively to ensure that it contained higher Thr levels than the NRC (1994) recommended level. Live growth performance, carcass characteristics, some blood serum parameters and economical efficiency were determined. From the nutritional and economical point of view, it could be concluded that the performance of Japanese quail fed low-protein diet (22% CP) supplemented with SAA as NRC (1994) recommendations plus additional Thr at 0.2 over NRC (1994) recommendations was similar to that achieved with the high-protein diet (24% CP) and gave economical efficiency value near to that achieved with the high-protein diet (24% CP).

Key words: Protein, methionine, lysine, threonine, performance, carcass, blood, economic, quails.

INTRODUCTION

Diet formulation for Japanese quail (*Coturnix Coturnix Japonica*) is commonly based on foreign nutrient requirement tables such as **NRC (1994)** from other countries, which are not ideal for Egypt climatic conditions. In addition, no new reports on quail nutrient requirements have been described since 1984 **(NRC, 1994)**, evidencing that new information is needed. Formulating poultry diets based on crude protein (CP) requirements, frequently results in diets containing amino acid (AA) levels above the real bird's requirements. An excess of AA is deaminated and excreted as uric acid. **Firman *et al.*, (1999)** reported that overfeeding CP results in higher feed costs and excess nitrogen levels being excreted into the litter. Moreover, feeding cost still represents around 65-70% of the total poultry production cost and protein cost represents around 15% of the total feeding cost **(Banerjee, 1992 and Singh, 1990)**. Satisfying AA needs while maintaining a minimum CP may decrease diet cost. **Firman *et al.*, (1999)** reported that a 1% decrease in CP level could yield savings of 5 $ per ton of feed. Also, low-protein diets are favored because they reduce the polluting effect on soil and water by reducing nitrogen dropping content **(Holsheimer and Jensen, 1992)**. **Han *et al.* (1992)** indicated that amino nitrogen (needed for dispensable AA synthesis) was a limiting factor in low-protein diets. It has been shown that broilers fed AA-supplemented diets had higher protein utilization and lower nitrogen excretion **(DeSchepper and DeGroote, 1995)**.

On the other hand, the greater commercial availability of the 3 most important limiting AA for birds [methionine (Met), lysine (Lys) and threonine (Thr)] have drawn interest to diet formulation based on reduced CP levels with adequate AA supplementation. The importance of Met is indicated by its 3 major functions in poultry: as a methyl donor, in protein synthesis, and as a precursor to cysteine **(Graber and Baker, 1971)**. The importance of Thr in quail diets has been largely overlooked due to the lack of understanding of Thr nutrition and the high price of the synthetic Thr form. However, Thr has been well recognized for its maintenance characteristics associated with the digestive tract **(Specian and Oliver, 1991; Stoll *et al.*, 1998 and Van Der Schoor *et al.*, 2002)** and virtues towards maximizing productivity **(Kidd and Kerr, 1997; Penz *et al.*, 1997; Kidd *et al.*, 1999; Dozier *et al.*, 2000; Kidd *et al.*, 2003a and Kidd *et al.*, 2003b)**. It also serves as a body protein component, as a feather protein component, a precursor of glycine and serine, involved in immune responses and needed in gastrointestinal mucin production **(Lemme, 2001)**.

This study was designed to explore the extent to which overall dietary CP may be reduced in Japanese quail corn-soybean meal diet by sulfur amino acids (SAA) and Thr supplementation while maintaining adequate performance.

MATERIALS AND METHODS

Experimental Birds and Housing:

Four hundred and twenty unsexed day-old Japanese quail chicks were used in a 35 day growing trial. Chicks were individually wing-banded, weighed, and randomly distributed into 7 experimental groups of similar mean body weight (8.22±0.046 g/bird) of 60 chicks each, which consists of 3 replicates of 20 chicks each.

Experimental Diets:

One positive control diet (A) was formulated to cover or exceed NRC (1994) recommendations of CP, SAA and Thr. Two negative control diets (B and C) were formulated to contain lower CP (22 and 20% CP, respectively) than the recommended level but all SAA and Thr were held at a constant ratio to CP for obtaining the same ratio in the two diets. Two AA-supplemented diets (B_1 and C_1) were formulated to be similar in composition to diets B and C, respectively but still supplying the same SAA and Thr as in diet (A). Two other AA-supplemented diets (B_2 and C_2) were formulated in a similar manner as in diets B_1 and C_1, respectively but supplemented with additional Thr at levels of 0.2 and 0.4%, respectively to ensure that it contained higher Thr levels than the NRC (1994) recommended level.

All tested diets were isocaloric (2900 kcal/kg diet). Crystalline Lys (98.5%), Met (99%) and Thr (98%) were supplied as L-isomers with the exception of Met, which was provided in the DL-isomer form. Amino acids were supplied as free base forms, except for lysine (lysine-HCl). The composition and chemical analysis of the experimental diets is shown in Table (1).

Management:

Quail chicks were reared under similar management conditions. Ambient temperature was maintained at 35-36° C during the 1st week and weekly decreased by 5° C for the next 3 weeks. Birds were received continuous artificial lighting at night during the whole experimental period. Mash feed and fresh clean tap water were available *ad liblitum.*

Measurements and Data Collection

Growth Performance:

Individual body weight (BW, g) and feed intake (FI, g/bird) were weekly recorded to determine body weight gain (BWG, g). Feed conversion ratio (FCR, g feed/g gain), protein intake (PI), caloric intake (CI), protein conversion ratio (PCR), caloric conversion ratio (CCR), and mortality rate (MR) % were also calculated on weekly basis.

Carcass Parameters:

At the end of the experimental period (5 wks), 6 birds from each dietary treatment (1 ♂ and & ♀/replicate) with BW similar to the mean were slaughtered to determine carcass characteristics. Obtained criteria were eviscerated carcass, dressing and breast %. Abdominal fat was removed from the gizzard and abdominal region and individually weighed for each carcass. Also, the internal organs (liver, heart, gizzard, thymus, bursa and spleen) were individually separated and weighed.

Blood Serum Parameters:

Forty two blood samples (3 ♂ & 3 ♀/ treatment) were withdrawn from wing vein and serum was separated by centrifugation for 10 minutes (3000 rpm) and stored in vials at –20 °C for later analysis. Frozen serum was thawed and assayed to determine, on individual bases, some biochemical parameters in terms of total protein (TP), albumin (Alb) and triglycerides (TG) by using commercial kits and Atomic Absorption Spectrophotometer, following the same steps as described by manufactures. Values were expressed as mg/100 ml. Serum TP was measured according to **Henry (1974)**. Globulin (Glo) was calculated by the difference between serum TP and Alb, since the fibrinogen usually comprises a negligible fraction **(Sturkie, 1986)**. The Alb/Glo ratio was also calculated.

Chemical and statistical analysis:

Experimental diets were analyzed following procedures detailed by the Association of Official Analytical Chemists **(AOAC 1990)** for CP, CF, DM and EE. The NFE was calculated by difference. Metabolizable energy (ME) of experimental diets was calculated considering the ME values of different feed ingredients **(NRC, 1994)**.

Obtained data were expressed as means ± standard error and statistically analyzed by analysis of variance (ANOVA) according to **Steel and Torrie (1980)**. Also, the General Linear Model (GLM) procedure of **SPSS** computer statistical program for MS Windows release 6.0 June 1993 was used. The significant means were ranked using Duncan's Range Test **(Duncan, 1955)** as outlined by **Obi (1990)**. Statistical significance level was tested at probability of $p \leq 0.05$.

Table (1) Composition and calculated analysis of control and amino acid- supplemented diets.

Item, %	Control diets			Amino acid supplemented-diets			
	A	B	C	B_1	C_1	B_2	C_2
Yellow Corn, ground	**48.94**	55.78	63.25	55.48	61.90	55.00	61.10
Soybean meal (44% CP)	**45.10**	39.30	33.25	39.30	33.50	39.40	33.65
Dicalcium phosphate	**0.72**	0.80	0.84	0.80	0.84	0.80	0.84
Limestone	**1.31**	1.30	1.33	1.30	1.33	1.30	1.33
Common salt	**0.40**	0.40	0.40	0.40	0.40	0.40	0.40
Vegetable oil	**3.00**	2.00	0.50	1.95	0.97	2.13	1.22
Premix*	**0.30**	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	**0.13**	0.12	0.10	0.16	0.18	0.16	0.18
L-Lysine	**0.00**	0.00	0.03	0.13	0.31	0.13	0.31
L-Threonine	**0.10**	0.00	0.00	0.18	0.27	0.38	0.67
Total	**100.00**	100.00	100.00	100.00	100.00	100.00	100.00
Price (L.E./Ton)**	**1614.70**	1506.70	1401.10	1563.00	1518.60	1607.4	1603.60
Calculated analysis***							
ME, kcal/kg	**2900**	2915	2902	2900	2903	2902	2900
CP	**24.01**	22.03	20.01	22.01	20.00	22.01	20.00
Ca %	**0.80**	0.80	0.80	0.80	0.80	0.80	0.80
Avail. P %	**0.30**	0.30	0.30	0.30	0.30	0.30	0.30
Met	**0.50**	0.46	0.42	0.50	0.50	0.50	0.50
Met+Cys	**0.88**	0.82	0.75	0.86	0.83	0.86	0.83
Lys	**1.34**	1.20	1.08	1.30	1.30	1.30	1.30
Arg	**1.60**	1.45	1.28	1.44	1.29	1.45	1.29
His	**0.46**	0.59	0.53	0.59	0.53	0.59	0.53
Ile	**1.03**	0.93	0.84	0.93	0.84	0.93	0.84
Leu	**2.02**	1.89	1.76	1.89	1.75	1.89	1.75
Phe-Ala	**1.16**	1.06	0.96	1.06	0.96	1.06	0.96
Phy-Ala+Tyr	**2.17**	1.98	1.78	1.98	1.78	1.98	1.79
Thr	**1.02**	0.84	0.76	1.02	1.02	1.21	1.42
Tryp	**0.36**	0.32	0.28	0.32	0.29	0.32	0.29
Val	**1.13**	1.04	0.94	1.04	0.94	1.04	0.94
Gly+Ser	**2.23**	2.04	1.84	2.04	1.84	2.04	1.84

*Vitamins and minerals premix provides per kilogram of diet: 10000 IU vitamin A, 11.0 IU vitamin E, 1.1 mg vitamin K , 1100 ICU vitamin D3, 5 mg riboflavin, 12 mg Ca pantothenate, 12.1 µg vitamin B12, 2.2 mg vitamin B6, 2.2 mg thiamin, 44 mg nicotinic acid, 250 mg choline chloride, 1.55 mg folic acid, 0 .11 mg d-biotin. 60 mg Mn, 50 mg Zn, 0.3mg I, 0. 1 mg Co, 30 mg Fe, 5 mg Cu and 1 mg Se.

** Prices per Egyptian pound (L.E) where 1 US $ = 5.55 L.E

***According to Feed Composition Tables for animal & poultry feedstuffs used in Egypt (2001).

RESULTS AND DISCUSSION

Growth performance:

The results obtained for growth performance are shown in Tables 2 and 3, respectively.

The values of BW, BWG, FI, FCR and MR during the overall starting-growing period are shown in Table 2. The initial BW of day-old Japanese quail chicks was similar for all treatments. With regard to CP levels, it was noticed that 24 % CP-diet gave the best BW, BWG, FCR and the lowest MR % in comparison to the other CP levels. However, it did not cause significant change in FI values. With respect to SAA and Thr supplementation, adding SAA and Thr as % of CP gave the lowest BW, BWG and FI, the worst FCR and the highest MR %. Regarding the interaction between CP levels and AA addition, it was noted that the addition of SAA and Thr as % of CP to 22 or 20% CP-diet showed the least BW, BWG and FI, the worst FCR and the highest MR %. However, supplementing additional Thr to 22% CP-diet (B_2-diet) at 0.2 over NRC (1994) recommendations was the only treatment that showed the best BW, BWG and FC values that similar to those obtained with 24% CP diet (A-diet).

The mean PI, CI, PCR and CCR values of birds during the overall starting-growing period are given in Table 3. Regarding CP levels, it can be seen that 24 % CP-diet gave the highest PI and the best CCR value, but it did not exert any significant effect on CI and PCR.

Concerning SAA and Thr supplementation, adding SAA and Thr as NRC (1994) recommendations or adding Thr over NRC (1994) recommendations exhibited the highest CI and the best PCR values. The best CCR value was obtained from adding Thr over NRC (1994) recommendations followed by those obtained from adding SAA and Thr as NRC (1994) recommendations and then those obtained from adding SAA and Thr as % of CP. Regarding the interaction between CP levels and AA addition, it was noticed that the highest PI values were obtained from feeding the 24% CP-diet followed by those obtained from the 22% CP-diets supplemented with AA and then those obtained from the 20% CP-diet supplemented with AA. Addition of SAA and Thr as % of CP showed the lowest CI and the worst PCR as compared to the other dietary treatments that had similar values in this respect. The best CCR values were obtained from either the 24% CP-diet or the 22% CP-diet supplemented with additional Thr at 0.2 over NRC (1994) recommendations followed by those obtained from either the 22% CP-diet supplemented with AA as NRC (1994) recommendations or those obtained from the 20% CP-diet supplemented with Thr at 0.4 over NRC (1994) recommendations and then those obtained from either diets supplemented with AA as % of CP or the 20% CP-diet supplemented with AA as NRC (1994) recommendations.

The present results are in harmony with those of other investigators who reported that broiler performance was improved by adding nonessential AA (**Parr and Summers, 1991** and **DeSchepper and DeGroote, 1995)** or essential AA **(Han *et al.,* 1992** and **Abd–Elsamee 2001 & 2002)** to low-protein diets. Similarly, **Martinez *et al*. (1999)** and **Barkley and Wallis (2001)** suggested that increasing dietary Thr concentration improved FCR. **Ali, *et al.* (2000)** reported that BW, BWG and FCR of quail fed low-protein diets and supplemented with Met, Lys, and Thr were improved but not significantly different from those fed the high-protein diets.

However, the current results were not coincided with those of **Mendonca and Jensen, (1989), Holsheimer and Janssen, (1991), Jensen, (1991)** and **Surisdiarto and Farrell, 1991)** who found that low-protein AA-fortified diets do not support broilers performance similar to that observed on higher CP-diets from intact protein sources. The same results were obtained by **Baylan *et al.*, (2006)** who found that dietary Thr supplementation did not affect growth performance, assuming that birds can make metabolic adaptation to current dietary Thr supplementations.

The increase in FI because of SAA addition as NRC (1994) recommendations or Thr addition over NRC (1994) recommendations lend support to the suggestion that TSAA could modify the plasmatic amino acidic profile in animals to activate appetite **(Harper *et al.*, 1970** and **Austic, 1986)**.

Table (2): Live performance of growing Japanese quail fed different dietary treatments from 0 to 35 d of age

Treatments				Live performance parameters					
Diet	CP (%)	SAA	Thr	Initial BW (g/bird)	Final BW (g/bird)	BWG (g/bird)	FI (g/bird)	FCR (feed: gain)	MR (%)
A	24	NRC	NRC	8.17±0.05	223.00±3.12^{a}	214.83±2.10^{a}	506.04±4.50^{a}	2.36±0.10^{c}	1.67±0.01^{c}
B	22	% of	% of	8.21±0.07	163.00±3.22^{d}	154.79±1.30^{d}	487.78±3.40^{b}	3.15±0.08^{a}	5.00±0.03^{a}
C	20	CP	CP	8.15±0.04	160.51±2.79^{d}	152.36±1.22^{d}	480.94±4.12^{b}	3.16±0.12^{a}	5.00±0.02^{a}
B_1	22	NRC	NRC	8.18±0.06	193.26±3.10^{b}	185.08±2.00^{b}	507.64±4.15^{a}	2.74±0.07^{b}	3.33±0.02^{b}
C_1	20			8.20±0.03	179.00±2.88^{c}	170.80±1.55^{c}	505.51±3.70^{a}	2.96±0.13^{b}	3.33±0.04^{b}
B_2	22	NRC	Over	8.23±0.04	209.48±2.91^{a}	201.25±1.25^{a}	511.01±3.22^{a}	2.54±0.10^{c}	1.67±0.02^{c}
C_2	20		NRC	8.19±0.08	189.33±3.00^{b}	181.14±1.40^{b}	509.33±2.97^{a}	2.81±0.14^{b}	3.33±0.03^{b}
CP (24)				8.17±0.05	223.00±3.07^{A}	214.83±1.60^{A}	506.04±3.10	2.63±0.11^{B}	1.67±0.01^{B}
CP (22)				8.21±0.07	188.58±3.00^{B}	180.37±2.12^{B}	502.14±4.00	2.81±0.06^{A}	3.33±0.04^{A}
CP (20)				8.18±0.06	176.28±2.85^{B}	168.10±1.31^{B}	498.59±3.67	2.98±0.09^{A}	3.33±0.01^{A}
SAA + Thr (% of CP)				8.18±0.04	161.76±2.77^{B}	153.58±1.26^{B}	484.36±3.55^{B}	3.16±0.13^{A}	5.00±0.03^{A}
SAA + Thr (NRC)				8.19±0.07	186.13±3.35^{A}	177.94±1.50^{A}	506.58±4.10^{A}	2.85±0.05^{B}	3.33±0.02^{B}
SAA (NRC) +Thr (Over NRC)				8.21±0.03	199.41±2.27^{A}	191.20±1.41^{A}	510.17±3.00^{A}	2.68±0.07^{B}	1.67±0.02^{C}

Means in the same column having different letters are significantly different at p≤0.05.

Table (3): Protein intake, caloric intake, protein conversion and caloric conversion of growing Japanese quail fed different dietary treatments at 35 d of age

Treatments				Live performance parameters			
Diet	CP (%)	SAA	Thr	PI (g/bird/day)	CI (kcal/bird/day)	PCR (Protein: gain)	CCR (Kcal: gain)
A	24	NRC	NRC	3.47±0.04^{a}	41.93±2.00^{a}	0.57±0.02^{b}	6.83±0.10^{c}
B	22	% of	% of	3.07±0.02^{b}	40.42±2.16^{b}	0.69±0.01^{a}	9.14±0.07^{a}
C	20	CP	CP	2.75±0.03^{c}	39.85±2.07^{b}	0.63±0.01^{a}	9.16±0.05^{a}
B_1	22	NRC	NRC	3.19±0.05^{b}	42.06±2.11^{a}	0.60±0.03^{b}	7.95±0.08^{b}
C_1	20			2.89±0.03^{c}	41.89±2.18^{a}	0.59±0.02^{b}	8.58±0.11^{a}
B_2	22	NRC	Over	3.21±0.06^{b}	42.34±2.10^{a}	0.56±0.01^{b}	7.36±0.06^{c}
C_2	20		NRC	2.91±0.05^{c}	42.20±2.14^{a}	0.56±0.03^{b}	8.15±0.09^{b}
CP (24)				3.47±0.03^{A}	41.93±2.06	0.57±0.02	6.83±012^{B}
CP (22)				3.16±0.06^{B}	41.61±2.17	0.62±0.01	8.15±0.11^{A}
CP (20)				2.85±0.04^{C}	41.31±2.21	0.59±0.01	8.63±0.05^{A}
SAA + Thr (% of CP)				2.91±0.05	40.14±2.00^{B}	0.66±0.02^{A}	9.15±0.09^{A}
SAA + Thr (NRC)				3.04±0.03	41.98±2.04^{A}	0.60±0.01^{B}	8.27±0.06^{B}
SAA (NRC) +Thr (Over NRC)				3.06±0.04	42.27±2.20^{A}	0.56±0.02^{B}	7.76±0.11^{C}

Means in the same column having different letters are significantly different at p≤0.05.

Carcass Parameters:

Carcass component values as % of BW in terms of eviscerated carcass, dressing, breast and abdominal fat at 35 d of age are displayed in Table 4.

Regarding CP levels, it was noted that 24% CP-diet significantly caused higher eviscerated carcass, dressing and breast % as well as lower abdominal fat % than 22% CP-diet that did not cause significant differences in these respects as compared to the 20% CP-diet except for breast % that was significantly decreased in case of the latter treatment. Concerning SAA and Thr addition, it was noted that adding SAA and Thr as % of CP significantly exhibited lower eviscerated carcass, dressing and breast % as well as higher abdominal fat % than adding SAA and Thr as NRC (1994) recommendations that did not cause significant differences in these respects as compared to supplementing additional Thr over NRC (1994) recommendations except for eviscerated carcass and breast % that were significantly increased in case of the latter treatment. Regarding the interaction between CP levels and AA addition, it was noticed that the highest eviscerated carcass, dressing, breast and the lowest abdominal fat % were obtained from feeding either the 24% CP-diet or the 22% CP-diet supplemented with Thr at 0.2 over NRC (1994) recommendations followed by those obtained from either the 22 or 20% CP-diets with supplementing AA as NRC (1994) recommendations and the 20% CP-diet supplemented with Thr at 0.4 over NRC (1994) recommendations and then those obtained from the 22 or 20% CP-diets supplemented with AA as % of CP.

Dietary amino acids are major determinants of broiler carcass components, as abdominal fat content and breast meat yield were greatly influenced by their levels **(Moran and Bilgili, 1990; Grisoni *et al.*, 1991; Holsheimer and Veerkamp, 1992; Leclercq, 1995 and Johnson, 1996)**.

Edible giblets and immune organs:

Data of edible giblets as % of BW in terms of liver, heart and gizzard as well as immune organs as % of BW in terms of thymus, bursa and spleen are presented in Table 5.

Table (4): Carcass characteristics of growing Japanese quail fed different dietary treatments at 35 d of age

Treatments				BW (g/bird)	Carcass components (% of BW)			
Diet	CP (%)	SAA	Thr		Eviscerated carcass	Dressing*	Breast	Abdominal fat
A	24	NRC	NRC	219.11±3.12^{a}	65.20±1.85^{a}	70.60±1.14^{a}	34.52±1.00^{a}	0.80±0.03^{c}
B	22	% of CP	% of CP	166.02±3.22^{d}	56.43±1.94^{c}	60.68±1.08^{c}	19.24±1.45^{c}	1.93±0.01^{a}
C	20			161.20±2.79^{d}	57.02±2.10^{c}	61.15±1.12^{c}	18.32±1.60^{c}	2.23±0.02^{a}
B_1	22	NRC	NRC	190.12±3.10^{b}	60.00±2.00^{b}	65.27±1.10^{b}	23.23±1.10^{b}	1.11±0.02^{b}
C_1	20			175.33±2.88^{c}	59.08±1.77^{b}	63.78±1.13^{b}	22.10±1.30^{b}	1.15±0.04^{b}
B_2	22	NRC	Over NRC	205.51±2.91^{a}	64.11±2.11^{a}	69.44±1.05^{a}	33.00±1.41^{a}	0.84±0.01^{c}
C_2	20			185.12±3.00^{b}	59.00±2.06^{b}	63.70±1.01^{b}	22.21±1.33^{b}	1.17±0.01^{b}
CP (24)				219.11±3.00^{A}	65.20±2.13^{A}	70.60±1.06^{A}	34.52±1.13^{A}	0.80±0.03^{B}
CP (22)				187.22±2.12^{B}	60.18±1.79^{B}	65.01±1.11^{B}	25.16±1.06^{B}	1.29±0.02^{A}
CP (20)				173.88±2.00^{B}	58.37±2.09^{B}	62.89±1.00^{B}	20.88±1.15^{C}	1.52±0.02^{A}
SAA + Thr (% of CP)				163.61±3.11^{B}	56.73±2.12^{C}	60.93±1.07^{B}	18.78±1.37^{C}	2.08±0.04^{A}
SAA + Thr (NRC)				182.73±2.02^{A}	58.51±2.10^{B}	63.51±1.00^{A}	22.67±1.22^{B}	1.13±0.02^{B}
SAA (NRC) +Thr (Over NRC)				195.51±2.20^{A}	60.56±2.00^{A}	65.58±1.05^{A}	27.61±1.16^{A}	1.01±0.01^{B}

* Dressing % = [(Carcass weight + Giblets weight) / (Pre-slaughter weight)] x 100.

Means in the same column having different letters are significantly different at p≤0.05.

Table (5): Edible giblets and immune organs of growing Japanese quail fed different dietary treatments at 35 d of age

Treatments				Edible giblets (% of BW)			Immune organs (% of BW)		
Diet	CP (%)	SAA	Thr	Liver	Heart	Gizzard	Thymus	Bursa	Spleen
A	24	NRC	NRC	2.02 ± 0.10^{a}	1.04 ± 0.04^{a}	2.34±0.11	0.38 ± 0.03^{a}	0.20 ± 0.02^{a}	0.14 ± 0.02^{a}
B	22	% of CP	% of CP	1.44 ± 0.13^{c}	0.54 ± 0.02^{c}	2.27±0.10	0.08 ± 0.01^{c}	0.07 ± 0.01^{b}	0.05 ± 0.01^{b}
C	20			1.37 ± 0.11^{c}	0.50 ± 0.03^{c}	2.26±0.12	0.06 ± 0.02^{c}	0.05 ± 0.01^{b}	0.04 ± 0.01^{b}
B_1	22	NRC	NRC	1.96 ± 0.14^{a}	1.00 ± 0.05^{a}	2.31±0.14	0.36 ± 0.02^{a}	0.18 ± 0.02^{a}	0.12 ± 0.02^{a}
C_1	20			1.63 ± 0.12^{b}	0.77 ± 0.07^{b}	2.30±0.13	0.20 ± 0.01^{b}	0.12 ± 0.01^{b}	0.08 ± 0.01^{b}
B_2	22	NRC	Over NRC	1.98 ± 1.10^{a}	1.02 ± 0.03^{a}	2.33±0.08	0.37 ± 0.03^{a}	0.19 ± 0.02^{a}	0.13 ± 0.02^{a}
C_2	20			1.70 ± 1.08^{b}	0.70 ± 0.01^{b}	2.30±0.06	0.21 ± 0.01^{b}	0.13 ± 0.01^{b}	0.09 ± 0.01^{b}
CP (24)				2.02 ± 1.15^{A}	1.04 ± 0.02^{A}	2.34±0.10	0.38 ± 0.02^{A}	0.20 ± 0.02^{A}	0.14 ± 0.02^{A}
CP (22)				1.68 ± 1.00^{B}	0.85 ± 0.01^{B}	2.30±0.09	0.27 ± 0.01^{AB}	0.15 ± 0.01^{AB}	0.10 ± 0.01^{AB}
CP (20)				1.57 ± 1.08^{B}	0.66 ± 0.03^{B}	2.29±0.12	0.16 ± 0.03^{B}	0.10 ± 0.01^{B}	0.07 ± 0.02^{B}
SAA + Thr (% of CP)				1.41 ± 1.12^{B}	0.52 ± 0.02^{B}	2.27±0.07	0.07 ± 0.01^{B}	0.06 ± 0.01^{B}	0.06±0.02
SAA + Thr (NRC)				1.80 ± 1.05^{A}	0.89 ± 0.04^{A}	2.31±0.09	0.28 ± 0.01^{A}	0.15 ± 0.01^{A}	0.10±0.02
SAA(NRC)+Thr(Over NRC)				1.84 ± 1.11^{A}	0.86 ± 0.03^{A}	2.32±0.10	0.29 ± 0.02^{A}	0.16 ± 0.01^{A}	0.11±0.01

Means in the same column having different letters are significantly different at $p\leq0.05$.

Regarding CP levels, it was noted that 24% CP-diet significantly caused higher liver, heart, thymus, bursa and spleen % than 20% CP-diet that did not cause significant differences in these respects as compared to the 22% CP-diet. Gizzard was not affected by CP levels. Concerning SAA and Thr supplementation, adding SAA and Thr as % of CP significantly exhibited lower liver, heart, thymus and bursa % than adding SAA and Thr as NRC (1994) recommendations that did not cause significant differences in these respects as compared to supplementing Thr over NRC (1994) recommendations. Neither gizzard nor spleen % was affected by SAA and Thr supplementation. Regarding the interaction between CP levels and AA addition, it was noticed that the highest liver, heart, thymus, bursa and spleen % were obtained from feeding 24% CP-diet, 22% CP-diet supplemented with AA as NRC (1994) recommendations or 22% CP-diet containing Thr at 0.2 over NRC (1994) recommendations followed by those obtained from 20% CP-diets supplemented with AA as NRC (1994) recommendations or 20% CP-diet containing Thr at 0.4 over NRC (1994) recommendations and then those obtained from diets supplemented with AA as % of CP. Gizzard was not affected by the interaction between CP levels and AA addition.

Dietary Thr supplementation did not affect edible carcass parts **(Baylan *et al.*, 2006)**.

Blood Serum Parameters:

The results of blood serum parameters in terms of TP, Alb, Glo, Alb/ Glo and TG at 35 d of age are given in Table 6.

Regarding CP levels, it was noted that 24% CP-diet significantly caused higher TP, Alb, Alb/Glo and TG values than 22% CP-diet that significantly showed higher values in these respects as compared to 20% CP-diet. The only exception was Alb/Glo ratio that was not affected by reducing CP levels from 22 to 20%. Also, Glo values were not affected by CP levels. Concerning SAA and Thr supplementation, adding SAA and Thr as NRC (1994) recommendations or supplementing Thr over NRC (1994) recommendations showed significantly higher TP than adding SAA and Thr as % of CP. The highest Alb value was obtained from supplementing Thr over NRC (1994) recommendations followed by those obtained from adding SAA and Thr as NRC (1994) recommendations or those obtained from adding SAA and Thr as % of CP. Supplementing Thr over NRC (1994) recommendations significantly showed lower Glo as well as higher Alb/Glo ratio and TG than adding SAA and Thr either as NRC (1994) recommendations or as % of CP. Regarding the interaction between CP levels and AA addition, it was noticed that the highest TP and Alb values were obtained from feeding the 24% CP-diet followed by those obtained from the 22% CP-diet supplemented with Thr at 0.2 over NRC (1994) recommendations and then those obtained from the 22% CP-diets supplemented with AA as NRC (1994) recommendations or the 20% CP-diets supplemented with Thr at 0.4 over NRC (1994) recommendations. The lowest TP and Alb values were obtained from the 22 or 20% CP-diets supplemented with AA as % of CP. The highest Alb/Glo ratio and TG values were obtained from feeding either the 24% CP-diet or the 22% CP-diet supplemented with Thr at 0.2 over NRC (1994) recommendations followed by those obtained from both 22% CP-diet supplemented with AA as NRC (1994) recommendations or 20% CP-diet supplemented with Thr at 0.4 over NRC (1994) recommendations and then those obtained from the 22 or 20% CP-diets supplemented with AA as % of CP or 20% CP-diet supplemented with AA as NRC (1994) recommendations. Globulin values were not affected by the interaction between CP levels and AA addition.

Economical efficiency:

Economical evaluation parameters for Thr supplementation in Japanese quail diets containing various levels of CP and SAA in terms of feeding cost of the experimental diets, net revenue, economical efficiency (EE_f) and relative economical efficiency (REE_f %) of meat production are listed in Table 7.

Regarding CP levels, it was noted that feeding 24% CP-diet showed higher REE_f % than 22% CP-diet that caused higher values in these respect as compared to the 20% CP-diet. Concerning SAA and Thr supplementation, adding Thr over NRC (1994) recommendations gave the highest REE_f %, followed by those obtained from adding SAA and Thr as NRC (1994) recommendations and then those obtained from adding SAA and Thr as % of CP. Regarding the interaction between CP levels and AA addition, it was noticed that the highest REE_f % was obtained from feeding 24% CP-diet followed by diets containing Thr at 0.2 over NRC (1994) recommendations.

The present results are in disagreement with those of **Ali, *et al.*, (2000)** who found that the EE_f of quail chicks fed diets containing 22 or 20% CP supplemented with Met and Lys were increased by 4 and 6%, respectively. They also added that adding AA (Met, Lys, Thr and Iso-Leu) to diets containing 20% CP gave the best EE_f and the reverse was noticed with diets containing either 22 or 20% CP without Iso-Leu supplementation.

From the nutritional and economical point of view, it could be concluded that the performance of Japanese quail fed low-protein diet (22% CP) supplemented with SAA as NRC (1994) recommendations plus additional Thr at 0.2 over NRC (1994) recommendations was similar to that achieved with the high-protein diet (24% CP) and gave REE_f % near to that achieved with the high-protein diet (24% CP).

Table (6): Some blood constituents of growing Japanese quail fed different dietary treatments at 35 d of age

Treatments				TP (g/100 ml)	Alb (g/100 ml)	Glo (g/100 ml)	Alb/Glo ratio	TG (mg/dl)
Diet	CP (%)	SAA	Thr					
A	24	NRC	NRC	4.60±0.03^{a}	2.03±0.11^{a}	2.57±0.10	0.79±0.02^{a}	60.31±2.10^{a}
B	22	% of CP	% of CP	3.03±0.02^{d}	0.45±0.08^{d}	2.58±0.13	0.17±0.01^{c}	51.01±2.05^{c}
C	20			3.00±0.02^{d}	0.40±0.13^{d}	2.60±0.06	0.15±0.01^{c}	50.23±2.13^{c}
B_1	22	NRC	NRC	3.50±0.04^{c}	1.00±0.12^{c}	2.50±0.12	0.40±0.03^{b}	54.20±2.00^{b}
C_1	20			3.04±0.07^{d}	0.57±0.09^{d}	2.47±0.05	0.23±0.02^{c}	51.00±2.11^{c}
B_2	22	NRC	Over NRC	4.04±0.06^{b}	1.61±0.05^{b}	2.43±0.11	0.66±0.03^{a}	59.08±2.08^{a}
C_2	20			3.55±0.09^{c}	1.08±0.07^{c}	2.47±0.04	0.44±0.02^{b}	54.10±2.14^{b}
CP (24)				4.60±0.05^{A}	2.03±0.10^{A}	2.57±0.07	0.79±0.02^{A}	60.31±2.12^{A}
CP (22)				3.52±0.10^{B}	1.02±0.02^{B}	2.50±0.10	0.41±0.03^{B}	54.76±1.07^{B}
CP (20)				3.20±0.08^{C}	0.68±0.03^{C}	2.52±0.08	0.27±0.01^{B}	50.44±1.10^{C}
SAA + Thr (% of CP)				3.02±0.11^{B}	0.43±0.03^{C}	2.59±0.05^{A}	0.17±0.03^{B}	50.62±1.09^{B}
SAA + Thr (NRC)				3.27±0.13^{A}	0.79±0.04^{B}	2.48±0.13^{A}	0.32±0.04^{B}	52.60±1.13^{B}
SAA (NRC) +Thr (Over NRC)				3.40±0.12^{A}	1.35±0.10^{A}	2.05±0.10^{B}	0.66±0.02^{A}	56.59±1.00^{A}

Means in the same column having different letters are significantly different at $p \leq 0.05$.

Table (7): Input-output analysis and economical efficiency ratio of experimental treatments during the whole period.

Treatments				Total FI/ bird (kg)	Price/kg feed (PT)	Total feed cost /bird (PT)*	Total gain (kg/bird)	Total price /bird (PT)**	Net revenue /bird (PT)	EE_f***	REE_f%****
Diet	CP (%)	SAA	Thr								
A	24	NRC	NRC	0.51	161.47	82.35	0.21	315.00	232.65	2.83	100.00
B	22	% of CP	% of CP	0.49	150.67	73.83	0.15	225.00	151.17	2.05	72.44
C	20			0.48	140.11	67.25	0.15	225.00	157.75	2.35	83.04
B_1	22	NRC	NRC	0.51	156.30	79.71	0.19	285.00	205.29	2.58	91.17
C_1	20			0.51	151.86	77.45	0.17	255.00	177.55	2.29	80.92
B_2	22	NRC	Over NRC	0.51	160.74	81.98	0.20	300.00	218.02	2.66	93.99
C_2	20			0.51	160.30	81.75	0.18	270.00	188.25	2.30	81.27
CP (24)				0.51	161.47	82.35	0.21	315.00	232.65	2.83	100.00
CP (22)				0.50	155.90	77.95	0.18	270.00	192.05	2.46	86.93
CP (20)				0.50	150.76	75.38	0.17	250.00	174.62	2.32	81.98
SAA + Thr (% of CP)				0.48	145.39	69.79	0.15	225.00	155.21	2.22	78.45
SAA + Thr (NRC)				0.51	154.08	78.58	0.18	270.00	191.42	2.44	86.22
SAA (NRC) +Thr (Over NRC)				0.51	160.52	81.87	0.19	285.00	203.13	2.48	87.63

*According to the local market price of feed ingredients at the experimental time.

**According to the local market price of one kg live body weight which was 1500 PT at the experimental time.

***EE_f: Economical efficiency, net revenue per unit of total feed cost.

****Relative economical efficiency, assuming that the control treatment = 100 %.

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تأثير إضافة الثريونين على السمان اليابانى المغذى على مستويات مختلفة من البروتين والأحماض الأمينية الكبريتية ١- فترة النمو

محمد أحمد على عبد المجيد - سيد أحمد محمد شعبان - محمد سعد بهنس*

قسم بحوث تغذية الدواجن- معهد بحوث الإنتاج الحيواني – الدقي - جيزة - مصر.

* قسم الدواجن - كلية الزراعة - جامعة الفيوم – الفيوم - مصر

أجريت هذه الدراسة باستخدام ٤٢٠ كتكوت سمان يابانى غير مجنس عمر يوم – بعد تقسيمها إلى ٧ مجاميع متساوية العدد والوزن وبكل منها ٣ مكررات- لتحديد إلى أى مدى يمكن تقليل مستوى بروتين العليقة فى فترة النمو وذلك من خلال إضافة الأحماض الأمينية الكبريتية والحمض الأمينى "ثريونين" شريطة الحفاظ على آداء الطيور.

تم تكوين عليقة كنترول إيجابية (أ) لتغطى احتياجات كتاكيت السمان اليابانى من البروتين (٢٤٪) والطاقة الممثلة والأحماض الأمينية الكبريتية والحمض الأمينى "ثريونين" خلال فترة النمو وذلك طبقاً لتوصيات المجلس القومى الأمريكى للبحوث (NRC) سنة ١٩٩٤. كما تم تكوين عليقتين كنترول سلبية (ب ، ج) لتحتوى على ٢٢ ، ٢٠٪ بروتين خام على الترتيب ولكنهما يحتويان على الأحماض الأمينية الكبريتية والحمض الأمينى "ثريونين" كنسبة مئوية من البروتين. أيضاً تم تكوين عليقتين (ب١، ج١) مماثلتين فى التركيب للعليقتين (ب ، ج) على الترتيب ولكنهما يحتويان على الأحماض الأمينية الكبريتية والحمض الأمينى "ثريونين" بنسبة وجودهما فى العليقة (أ). كما تم تكوين عليقتين (ب٢ ، ج٢) مماثلتين فى التركيب للعليقتين (ب١ ، ج١) على الترتيب ولكن أضيف لهما الحمض الأمينى "ثريونين" بمعدل ٠.٢، ٠.٤٪ على الترتيب.

تم تقدير صفات النمو وخصائص الذبيحة وبعض مكونات سيرم الدم والكفاءة الأقتصادية.

بشكل عام كانت أهم النتائج المتحصل عليها هى تماثل نتائج التغذية على العليقة المحتوية على ٢٢٪ بروتين + أحماض أمينية كبريتية طبقاً للـ NRC (١٩٩٤) + ثريونين أعلى بمقدار ٠.٢ من الموصى به فى الـ NRC (١٩٩٤) مع نتائج التغذية على العليقة المحتوية على ٢٤٪ بروتين (عليقة الكنترول) فيما يتعلق بما يلى:

١- وزن الجسم الحى، معدل الزيادة فى وزن الجسم، العلف مأكول، معامل التحويل الغذائى، معامل تحويل البروتين، معامل تحويل الطاقة، معدل النفوق.

٢- النسبة المئوية لكل من الذبيحة، التصافى، وزن الصدر، وزن دهن البطن، ٣- الكبد، القلب، الغدة الثيموسية، غدة البيرسا، الطحال.

٤- نسبة الألبيومين إلى الجلوبيولين، الجليسريدات الثلاثية فى سيرم الدم.

من وجهة النظر الغذائية والأقتصادية يمكن أن يستنتج من هذه الدراسة – تحت ظروف التجربة الحالية- بأن آداء السمان اليابانى المغذى على العلائق المنخفضة البروتين (٢٢٪) والمضاف لها الأحماض الأمينية الكبريتية طبقاً لتوصيات المجلس القومى الأمريكى للبحوث (NRC) سنة ١٩٩٤ وكذا الحمض الأمينى "ثريونين" بمستوى أعلى بمقدار ٠.٢ من الموصى به من قبل المجلس القومى الأمريكى للبحوث (NRC) سنة ١٩٩٤ كان مشابهاً لتلك المغذى على العليقة المرتفعة البروتين (٢٤٪) كما أعطت عائداً إقتصادياً يلى تلك التى أعطته العليقة المرتفعة البروتين (٢٤٪).