Tropical and Subtropical Agroecosystems
E-ISSN: 1870-0462
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Universidad Autónoma de Yucatán
México

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Tropical and Subtropical Agroecosystems, vol. 20, núm. 3, septiembre-diciembre, 2017, pp. 419-427
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Mérida, Yucatán, México

DETERMINATION OF OPTIMUM THREONINE REQUIREMENTS OF JAPANESE QUAIL (*Coturnix coturnix japonica*) CHICKS REARED UNDER TROPICAL ENVIRONMENT[1]

[DETERMINACIÓN DE LOS REQUERIMIENTO ÓPTIMOS DE TREONINA DE LA CODORNIZ JAPONESA (*Coturnix coturnix japonica*) CRIADA EN AMBIENTE TROPICAL]

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SUMMARY

Threonine, like most amino acids, is traditionally noted for its role in protein synthesis. However, dietary threonine concentration required for the maximum performance of Japanese quails is yet to be determined, therefore, a study was conducted to determine the optimum threonine requirement of Japanese quail chicks in the tropical environment. A total of four hundred and fifty, two weeks old quail chicks (mixed sexes) were randomly allocated to five dietary treatments (0.67, 0.81, 0.95, 1.08 and 1.22 % total threonine) and replicated thrice in a completely randomized design (CRD). There were no significant differences (P>0.05) in average weight gain, average feed intake, feed conversion ratio and age at first lay of quails fed the dietary treatments. Weight of first egg laid was significantly (P<0.05) higher for birds fed 1.08% total threonine diets than those fed other dietary treatments. Live weight, dressed weight, dressing percent, thigh, heart and gizzard weights were statistically (P>0.05) similar for all treatments. There were significant differences (P<0.05) in haematological parameters and serum indices studied except white blood cell, total protein, monocyte, eosinophils, mean corpuscular volume, alanine amino transferase, alkaline phosphatase (P>0.05). It was concluded that the performance of birds were not influenced by the dietary treatments up to the highest dietary level of threonine studied (1.22%). Therefore, it is possible that the optimum dietary level of threonine may be above 1.22 %. Further studies will be necessary to establish higher doses of dietary threonine requirement of Japanese quails reared under tropical climatic environment.
Key words: japanese quail; threonine; requirement; tropical environment.

RESUMEN

La treonina, como la mayoría de los aminoácidos, se destaca tradicionalmente por su papel en la síntesis de proteínas. Sin embargo, la concentración de treonina en la dieta requerida para el máximo rendimiento de las codornices japonesas aún no se ha determinado. Por lo tanto, se realizó un estudio para determinar el requerimiento óptimo de treonina de codorniz japonés en ambiente tropical. Se asignaron aleatoriamente 450 codornices (sexo mixto), de dos semanas de edad, a cinco tratamientos dietéticos (0.67, 0.81, 0.95, 1.08 y 1.22% de treonina total) y se replicaron tres veces en un diseño completamente aleatorizado (CRD). No hubo diferencias significativas (P> 0.05) en el aumento de peso promedio, la ingesta promedio de alimento, la tasa de conversión alimenticia y la edad en la primera puesta de codornices alimentadas con los tratamientos dietéticos. El peso del primer huevo puesto fue significativamente (P <0.05) más alto para las aves alimentadas con dietas con treonina al 1.08% que aquellos alimentados con otros tratamientos dietéticos. El peso vivo, peso canal, rendimiento, muslo, corazón y molleja fueron estadísticamente (P> 0.05) similares para todos los tratamientos. Hubo diferencias significativas (P <0.05) en

[1] *Submitted March 30, 2017, – Accepted October 13, 2017.*

los parámetros hematológicos y en los índices séricos estudiados, excepto glóbulos blancos, proteína total, monocitos, eosinófilos, volumen corpuscular medio, alanina amino transferasa, fosfatasa alcalina (P> 0.05). Se concluyó que el desempeño de las aves no fue influenciado por los tratamientos dietéticos hasta el nivel más alto de treonina en la dieta estudiada (1.22%). Por lo tanto, es posible que el nivel dietético óptimo de treonina sea superior al 1.22%. Serán necesarios más estudios para establecer dosis más altas de requerimientos de treonina en la dieta de las codornices japonesas criadas bajo condiciones climáticas tropicales.
Palabras clave: codorniz japonesa; treonina; necesidades; ambiente tropical.

INTRODUCTION

Recent advances in knowledge of protein metabolism and the emergence of new synthetic amino acids of large-scale production and lower prices have allowed nutritionists to formulate diets closer to the requirement of animals, improving the utilization of dietary protein, reducing costs and harmful waste to the environment. Another advantage of synthetic amino acid use is the possibility to establish an ideal ratio between all amino acids in the diet, the ideal protein concept, which contributes to reduce protein levels in the diet (Brumano, 2009). Marginal dietary deficiency of threonine may result in economic losses from increased feed conversion ratio and reduced breast meat accretion (Kidd *et al*., 1999). It is important, therefore, to meet the minimum dietary threonine requirement in animal diet. Protein and amino acids are some of the most expensive nutrients in feed formulation, thus selecting the correct level of amino acid needed in feed formulation has economical impact. It is well known that imbalance in amino acid profile will result in reduced growth rate and feed utilization efficiency (Dersjant-Li and Peisker, 2011). In quail, as in other species, level of dietary energy is considered as a determinant factor of performance and the bird's daily energy requirement depends on several factors such as growth rate, amino acid balance in the diet, place and circumstances of the bird density (Noblet and Van Milgen, 2004). A dietary protein requirement of quail is influenced by the amount of energy metabolism, and other components used in making the diet, while amino acids requirements are influenced by many factors including dietary, environmental, genetics and productive purposes (Bahare *et al*., 2013). Similarly, Ojewola and Longe (1999) and Babangida and Ubosi, (2006) have reported that nutrient requirements established under temperate conditions may not be entirely satisfactory in the tropical environment characterized by high ambient temperature and low quality feedstuffs. Also, most of the previous studies carried out on amino acid requirement of quails have been conducted under the temperate conditions. Therefore, determining the threonine requirements of Japanese quails under the tropical environment is imperative.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Poultry Unit of Iflosam Integrated Farm, Kilometre 28, Kano-Katsina Road, Bichi, Kano State, Nigeria. Bichi is located on A9 highway on coordinate proximity "69.6105610 – 149.5870380" in North – Western Nigeria. It has an area of 612 Km^2 and a population of 277, 099 at the 2006 Census Kano State (Goggle Map, 2016). Bichi is a Local Government Area in Kano State. The State is located within the Northern Guinea Savannah Zone on the latitude 11^0 14' 44'' N and longitude 7º 38' 65''E, at an altitude of 610 m above sea level. The climate is relatively dry with a mean annual rainfall of 700-1400mm. (Ovimaps, 2014).

Source of experimental birds

A total of five hundred (500), two weeks old un-sexed quail chicks were purchased from the National Veterinary Research Institute, Vom, Plateau State. Four hundred and fifty (450), two weeks old un-sexed quail chicks were however used for the experiment.

Experimental diets

A basal diet (containing 24 %CP and 2800 Kcal/kg ME) was formulated to meet the nutrient requirements for quail chicks as recommended by NRC (1994) except for threonine. The diet was supplemented with five graded levels of threonine (0.00, 0.14, 0.28, 0.42 and 0.56 g/kg) to achieve 0.67, 0.81, 0.95, 1.08 and 1.22 % total threonine levels in the diets used for the experiment. The gross and proximate compositions of experimental diets are presented in Table 1 and 2 respectively.

Table 1. Composition of Experimental Diets Containing Varying Levels of Threonine (2-6 weeks)

	Dietary Levels of Threonine (%)				
Ingredients (%)	0.67	0.81	0.95	1.08	1.22
Maize	44.16	44.16	44.16	44.16	44.16
Groundnut cake	29.00	29.00	29.00	29.00	29.00
Soya cake	6.00	6.00	6.00	6.00	6.00
Maize offal	5.00	5.00	5.00	5.00	5.00
Palm kernel meal	7.50	7.50	7.50	7.50	7.50
Fish meal	4.50	4.50	4.50	4.50	4.50
Bone meal	2.70	2.70	2.70	2.70	2.70
Common salt	0.30	0.30	0.30	0.30	0.30
Chick premix**	0.25	0.25	0.25	0.25	0.25
Lysine	0.38	0.38	0.38	0.38	0.38
Methionine	0.20	0.20	0.20	0.20	0.20
Tryptophan	0.01	0.01	0.01	0.01	0.01
Threonine	0.00	0.14	0.28	0.42	0.56
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME Kcal/kg	2826	2826	2826	2826	2826
Crude protein (%)	24.10	24.10	24.10	24.10	24.10
Ether extract (%)	4.32	4.32	4.32	4.32	4.32
Crude fibre (%)	5.28	5.28	5.28	5.28	5.28
Calcium (%)	1.11	1.11	1.11	1.11	1.11
Lysine (%)	1.30	1.30	1.30	1.30	1.30
Methionine (%)	0.51	0.51	0.51	0.51	0.51
Cysteine (%)	0.28	0.28	0.28	0.28	0.28
Meth + Cyst (%)	0.79	0.79	0.79	0.79	0.79
Available P (%)	0.60	0.60	0.60	0.60	0.60
Tryptophan (%)	0.20	0.20	0.20	0.20	0.20
Threonine (%)	0.67	0.81	0.95	1.08	1.22
Feed cost/kg(₦)	90.25	92.35	94.45	96.55	98.65

SMet = Methionine; P=Phosphorus; ME=Metabolizable Energy; Cys= Cysteine **Biomix premix supplied per kg of diet: Vit. A, 10,000iu; Vit.D_3, 2000 iu; Vit E, 23 mg;Vit. K, 2mg: Vit.B_1,1.8;Vit. B_2, 5.5mg; Niacin, 27.5mg; Pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg: Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1 mg; Iron, 20 mg; Manganese, 40 mg; Selenium, 0.2 mg; Zinc, 30mg; Antioxidant, 1.25mg. Total sulphur amino acid.

Table 2. Proximate Composition of Experimental Diets

	Dietary Levels of Threonine (%)				
Parameters	0.67	0.81	0.95	1.08	1.22
Dry matter (%)	94.13	93.88	94.06	93.36	93.72
Crude protein (%)	25.36	25.51	24.86	25.55	24.98
Crude fibre (%)	5.36	5.22	5.89	5.48	5.67
Ether extract (%)	4.36	4.50	4.39	4.88	4.76
Ash (%)	6.42	7.08	7.77	7.81	7.85
Nitrogen free extract (%)	58.50	57.69	57.09	56.28	56.64

Experimental design and management of birds

A total of four hundred and fifty, two weeks old quail chicks of mixed sexes were used for the experiment. The birds were weighed and randomly assigned into five groups of ninety quail chicks each. Each group were subdivided into 3 replicates of thirty chicks in a completely randomized design (CRD). The birds were housed in 40 x 40 x 20 cm as well as replicated in a 50 x 50 x 10 cm battery cages design with feed and water troughs. The birds received 16 - 18 hours of light per day throughout the growth phase of the experiment. The average temperature and relative humidity were 38^{0}C and 75 %, respectively. All necessary routine management practices were observed throughout the period of the study. Feed and water were provided *ad libitum*. The chicks were fed the experimental diets from 2-6 weeks.

Performance data

The amount of feed given and left over was recorded on daily basis and it was used to calculate the feed intake. Before the commencement of the experiment, the initial weight of the birds were taken and the birds were weighed weekly thereafter to obtain weekly weight gain. Feed intake and weight recorded were used to calculate feed conversion ratio (FCR) using the formula below.

Feed conversion ratio (FCR) =feed intake/weight gain
Other growth parameters measured include cost per unit gain, age at first egg and weight of egg at first lay.

Blood analysis

At the end of the study period, three birds from each replicate were randomly selected and 2 ml of blood was collected through the jugular vein into two sets of labeled sample bottles, one set containing Ethylene Di-amine Tetra Acetic Acid (EDTA) for haematological assay and another set of plain sample bottles for serum chemistry evaluation. Packed Cell Volume (PCV) was estimated by spinning blood samples in heparinised capillary tubes in a haematocrit centrifuge for five minutes. The Red Blood Cell (RBC) count was determined using improved Nuebauer haemocytometer (Annon, 2013). The Haemoglobin (Hb) Concentration was estimated using cyanomethaemoglobin method (Coles, 1986). The following parameters were also calculated:

$$MCV = \frac{PCV\ x\ 10}{\text{RBC count (in } 10^6/\text{mm}^3)}$$

$$MCH = \frac{\text{Hb (g/dl) x 10}}{\text{RBC count (in } 10^6/\text{mm}^3)}$$

$$MCHC = \frac{\text{Hb (g/dl) x 100}}{\text{PCV \%}}$$

Total White Blood Cell (WBC) count was carried out by using haemocytometer differential WBC count was done by preparing blood smear stained with Wright stain at the Haematological Laboratory, Veterinary Teaching Hospital, Ahmadu Bello University, Zaria. The blood samples (2mls) collected in the plain bottles were centrifuged at 3000 rpm for 20 minutes. The serum was collected and stored at 20^{o}C until analysed for Alanine amino tranferase (ALT), Aspartate amino tranferase (AST) and Alkaline phosphate (ALP) which were determined using enzyme analytical kits technique (Reitman and Frankel, 1957). Total Serum Protein (TSP) was determined using Biuret method and albumin was determined using Bromcresol green method Doumas *et al*. (1971) at the Chemical Pathology Laboratory, Ahmadu Bello University Teaching Hospital, Shika - Zaria.

Carcass and Organs Weight determination

At the end of the study, three birds per replicate were selected at random and starved for about 12h to empty the crops. They were then slaughtered, scalded, plucked and eviscerated. The carcass and internal organs (liver, heart, spleen, kidney, gizzard and intestines) were removed, weighed and expressed as a percentage of live weight.

Statistical Analysis

Data obtained were subjected to Analysis of Variance using the general linear model procedures for a completely randomized design (SAS, 2008). Significant differences among treatment means was compared using the Tukeys Studentized Test.

RESULTS

Table 3 shows the result of the growth performance of Japanese quails fed diets containing different levels of threonine. The average daily weight gain, average daily feed intake, feed conversion ratio and age at first egg were statistically (P>0.05) similar for all treatments. Weight of first egg at laid were statistically (P<0.05) significant across the dietary treatments. Birds fed 1.08 % threonine diet had significantly (P<0.05) higher egg weight at first lay than those fed other dietary treatments.

Table 3: Growth performance characteristics of Japanese quail growers fed graded levels of threonine (2-6weeks).

	Dietary Levels of Threonine (%)						
Parameters	0.67	0.81	0.95	1.08	1.22	SEM	Pr>F
Initial weight (g/b)	33.33	33.33	33.33	33.33	33.33	0	0.00
Final weight (g/b)	132.07	132.57	131.93	133.31	131.67	0.53	0.06
Total weight gain (g/b)	98.74	99.24	98.60	99.98	98.34	0.00	0.06
Daily weight gain (g/b/d)	3.53	3.54	3.52	3.57	3.51	0.57	1.00
Daily feed intake (g/b/d)	16.20	15.78	16.44	16.70	15.68	0.57	0.69
Feed conversion ratio	4.83	4.65	4.89	4.90	4.67	0.01	0.98
Feed cost/Kg weight gain (₦)	435.91^{b}	429.43^{a}	461.86^{d}	473.10^{e}	460.70^{c}	0.02	0.001
Age at first lay (d)	42.00	42.00	40.00	41.00	41.00	3.53	0.86
Weight of first egg laid (g)	7.90^{b}	8.21^{b}	7.73^{c}	8.46^{a}	7.72^{c}	0.01	0.01

^{abc}Means in the same row with different superscripts are significantly different. SEM=Standard error of means. 1USD=₦ 300.

Table 4 shows the result of the carcass yield of Japanese quails fed diets containing different levels of threonine. The result shows that there were significant (P<0.05) differences in values of some parameters measured except live weight, dressed weight, thigh, heart and gizzard which were not significantly (P>0.05) affected by the levels of threonine in the diets. Live weight, dressed weight, dressing percent, thigh, heart and gizzard weights were statistically (P>0.05) similar for all treatments. The back cut of birds fed control diet, 0.81, 0.95 and 1.08 % threonine diets were statistically (P>0.05) similar and significantly (P<0.05) higher than those fed 1.22% threonine diet. The weight of liver in birds fed control diet, 1.08 and 1.22 % threonine diets were statistically (P>0.05) similar and significantly (P>0.05) higher than those fed 0.81 and 0.95 % total threonine diets. Birds fed control diet, 0.81, 0.95 and 1.22 % threonine based diet had statistically (P>0.05) similar spleen weights, which were significantly (P<0.05) higher than those fed 1.08 % threonine diet. The higher relative weight of organs in this study may probably be due to individual differences since there was no consistent trend. The intestinal weight of birds fed diet with 1.22 % threonine was significantly (P<0.05) higher than those fed other diets. Birds fed control diet, 0.95, 1.08 and 1.22 % had statistically (P>0.05) similar length of intestine which were significantly (P<0.05) higher than those fed 0.81% total threonine diet.

Table 5 shows the result of the blood indices of Japanese quails fed diets containing different levels of threonine. The Packed cell volume (PCV), Haemoglobin, Red blood cell counts, heterophil, lymphocyte, Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), cholesterol, Albumin, and Aspartate amino transferase (AST) differed (P<0.05) significantly across the dietary treatment. The Packed cell volume of birds fed control (0.67), 0.81, 1.08 and 1.22 % total threonine were significantly (P<0.05) higher than those fed 0.95 % threonine diet. Quail chicks fed control (0.67), 0.81 and 1.08 % threonine diets had similar (P>0.05) haemoglobin values which were significantly (P<0.05) higher than those fed 0.95 and 1.22 % threonine diets. White blood cell, total protein, monocytes, eosinophils, Mean corpuscular volume, Albumin, Alanine amino tranferase and Alkaline phosphate values were similar (P>0.05) for all treatments. The Red blood cell observed in birds fed control, 0.81, 1.08 and 1.22 % total threonine diets were similar (P>0.05) and significantly (P<0.05) higher than for quail chicks fed 0.95% dietary level of threonine. Birds fed control, 0.81, 0.95 and 1.08 % had similar (P>0.05) total protein values. Heterophil values of birds fed 0.81, 1.08 and 1.22 % threonine diets were similar and significantly (P<0.05) higher than values of those fed control (0.67) and 0.95 % threonine diets. The heterophils values of birds fed control (0.67 %) and 0.95 % threonine were also similar (P<0.05). Lymphocyte values for birds fed control (0.67), 0.95 and 1.22 % threonine diets were similar (P>0.05) and significantly (P<0.05) higher than those from birds fed 0.81 and 1.08 % dietary threonine, which were also similar (P<0.05). The birds fed control (0.67), 0.81, 0.95 and 1.08 % threonine diets had similar MCH values which were significantly (P<0.05) higher than those from birds on 1.22 % total threonine diet. MCHC for birds fed control (0.67), 0.81, 1.08 and 1.22 % threonine diets were similar (P>0.05) but significantly (P<0.05) higher than values obtained from birds on 0.95 % threonine diet. The cholesterol value of birds fed control (0.67), 0.81 and 1.22 % total threonine diets did not vary (P>0.05) statistically but were significantly (P<0.05) higher than values of birds fed 0.95 and 1.08 % threonine diets and those fed 0.95, 1.08 and

1.22 % threonine were also similar (P>0.05).The glucose levels in birds fed control (0.67) and 0.95 % threonine diets were similar and significantly (P<0.05) higher than those on 1.08%, which was higher than those on 0.81 and 1.22% threonine diet. Albumin values for birds fed control (0.67), 0.81, 0.95, and 1.08 % total threonine were significantly (P<0.05) higher than those of chicks fed 1.22 % threonine diet. The AST values recorded for birds fed control (0.67) and 1.08 % threonine diet were similar but higher (P<0.05) than values from those fed other threonine diets and those fed 0.95, 1.08 and 1.22 % threonine were also similar (P>0.05).

Table 4: Carcass performance and organ characteristics of Japanese quail growers fed graded levels of threonine (2-6weeks).

Parameters	0.67	0.81	0.95	1.08	1.22	SEM	Pr>F
Live Weight (g)	133.33	135.55	131.11	130.00	127.78	5.31	0.85
Dressed Weight (g)	123.33	125.55	118.33	117.78	116.67	4.46	0.58
Dressing (%)	90.50[d]	92.62[a]	90.25[e]	90.60[c]	91.31[b]	0.03	0.01
Prime cuts							
Breast (% of DW)	27.34[b]	27.57[a]	27.93[a]	28.90[a]	28.18[a]	0.33	0.04
Thigh (% of DW)	6.59	6.62	6.71	6.67	6.71	0.16	0.97
Back (% of DW)	17.69[a]	18.49[a]	17.68[a]	17.91[a]	17.21[b]	0.46	0.04
Organs							
Heart (% of LW)	1.01	0.95	1.02	1.01	1.01	0.04	0.77
Liver (% of LW)	1.68[a]	1.39[c]	1.51[b]	1.68[a]	1.61[a]	0.11	0.02
Spleen (% of LW)	0.06[a]	0.06[a]	0.06[a]	0.05[b]	0.07[a]	0.01	0.05
Gizzard (% of LW)	58.31	56.89	57.44	58.84	59.90	3.06	0.96
Empty Intestinal weight (% of LW)	2.64[c]	2.98[c]	2.79[c]	3.63[b]	4.07[a]	0.20	0.02
Length of Intestine (cm)	30.07[a]	26.67[b]	29.96[a]	31.58[a]	30.40[a]	0.98	0.05

[abc]Means in the same row with different superscript are significantly different. SEM =standard error of means.

Table 5: Effects of threonine levels on blood indices of Japanese quail growers (2-6weeks).

	Dietary Levels of Threonine (%)						
Parameters	0.67	0.81	0.95	1.08	1.22	SEM	Pr>F
Packed cell volume (%)	41.00[a]	41.00[a]	32.00[b]	42.50[a]	35.33[a]	4.47	0.04
Haemoglobin (g/dl)	13.63[a]	13.63[a]	10.53[ab]	14.10[a]	11.67[b]	1.46	0.02
White blood cell (x10^9/L)	11.47	10.97	11.40	12.35	9.73	2.21	0.94
Red blood cell (x10^{12}/L)	6.87[a]	6.97[a]	5.37[b]	7.00[a]	6.03[a]	0.71	0.04
Total protein (g/L)	40.00	38.00	42.00	37.67	35.67	17.82	0.48
Heterophil (%)	9.67[b]	15.33[a]	11.33[b]	16.00[a]	13.33[a]	1.96	0.04
Lymphocyte (%)	89.00[a]	81.33[b]	88.67[a]	83.00[b]	86.33[a]	1.98	0.05
Monocyte (%)	0.00	1.00	0.00	0.67	0.00	0.54	0.07
Eosinophills (%)	1.00	1.67	0.00	0.00	0.00	0.87	0.56
MCV (fl)	59.44	59.05	59.68	60.70	58.20	1.22	0.69
MCH (pg)	19.70[a]	19.63[a]	19.68[a]	20.14[a]	19.23[b]	0.38	0.01
MCHC (g/L)	33.26[a]	33.24[a]	32.98[b]	33.18[a]	33.05[a]	0.02	0.03
Cholesterol (mmol/L)	5.53[a]	5.57[a]	4.03[b]	4.60b[b]	5.30[ab]	0.66	0.01
Glucose (mmol/L)	14.13[a]	12.67[c]	13.97[a]	13.50[b]	10.37[d]	0.13	0.01
Albumin (g/dl)	4.27[a]	4.40[a]	3.93[a]	4.30[a]	2.73[b]	0.48	0.02
AST (IU/l)	25.33[a]	13.33[c]	21.67[b]	18.67[ab]	21.00[b]	0.02	0.05
ALT (IU/l)	18.00	21.00	21.67	18.33	18.67	3.54	0.89
ALP (IU/l)	126.00	157.33	116.00	131.33	136.67	21.06	0.73

[abc]Means in the same row with different superscript are significantly ($p<0.05$) different. SEM= Standard error of the means. MCV-Mean corpuscular volume, MCH-Mean corpuscular haemoglobin, MCHC-Mean corpuscular haemoglobin concentration, AST-Aspartate amino transferase, ALT-Alanine amino tranferase, ALP-Alkaline phosphate.

DISCUSSION

The similarities in final weight of birds fed control diet, 0.81, 0.95 and 1.08 % total threonine diets suggest that the amino acid profile of these diets were adequate enough to sustain body weight that will enhance efficiency of egg production. This corroborates the report of Odunsi *et al*. (2007) and Bawa *et al*. (2011) that quails are capable of maintaining their body at constant rate. The result of carcass analysis revealed that birds fed diets containing 0.81, 0.95, 1.08 and 1.22% total threonine had statistically (P>0.05) similar breast weights which was significantly (P<0.05) higher than those fed the control diet. This finding is in contrast with the report of Ojano-Dirain and Waldroup (2002) who reported that feeding diets with threonine levels of 0.78 and 0.87 % had no significant effect on breast meat yield. The responses of birds used for this study is in line with the findings from the studies of Kerr *et al.* (1999) and Dozier *et al*. (2000) who reported that carcass yield (%) was not affected by threonine supplementation of the diet. In this study, increasing dietary threonine increased breast yield and corroborates the study by Ciftci and Ceylan (2004) which established that increasing threonine levels improves breast meat yield. Aggoor *et al*. (2000) also found that increasing threonine content of the control diet produced carcasses of higher dressing %, while it had no significant (P>0.05) effect on gizzard, liver, giblets, heart and testis.

The higher packed cell volume values (35.33 - 42.50 %) obtained were within the normal range (37 – 69 %) reported by Campbell (1988) but higher than the values of (22.33-26.67 %) reported by Makinde *et al.,* (2015). The haemoglobin values (13.63 – 14.10 g/dl) obtained in this study also fell within the normal range (12.0 – 15.2 g/dl) for quails as reported by (Campbell, 1988). The values obtained for packed cell volume and haemoglobin showed that the nutrients were adequate to meet nutritional requirements and the treatment diets did not portend any danger to the animals. The observed increase in Red blood cells (RBC) for birds fed control (0.67), 0.81, 1.08 and 1.22 % threonine diet in this study could be an indication that the birds were not suffering from any form of anaemia and there was the ability to withstand stress and an efficient transportation of oxygen and carbon (IV) oxide which is a major function of (RBC). The higher total protein in birds fed control (0.67), 0.81, 0.95 and 1.08 % was an indication that total protein intake of the birds was greatly influenced. This was because total proteins, albumin and globulin were generally influenced by total protein intake (Njidda and Isidohomen, 2010) and high concentrations of total protein were associated with significant increases in levels of serum albumin and globulin (Azzam *et al*., 2011). The Heterophil values of birds fed 0.81, 1.08 and 1.22 % threonine diets were higher than those fed the control (0.67) and 0.95 % threonine diets, an indication of inflammation. Though, the level (13.33 – 16.00 %) does not portend any danger since it could also result due to the influence of season or age. Chicken heterophils as reported by Bennoune *et al*., (2009) were polymorphonuclear leukocytes that constitute the first line of defense against invading microorganisms.

Lymphocyte of birds fed control (0.67), 0.95 and 1.22 % threonine diets were higher than those fed threonine diet at 0.81 and 1.08 % suggesting that the birds fed those dietary treatments were immunologically challenged. This was because lymphocytes are the main constituent of immune system defense against viruses, bacteria and fungi and adequate number of lymphocytes showed direct fights with antigens within the body (Kabir, 2013). The observed increased Mean corpuscular haemoglobin (MCH) value (19.63 - 20.14) range for birds fed control and threonine diet at 0.85, 0.95 and 1.08 % was probably due to increased haemoglobin synthesis (Daudu *et al*., 2014) at these dietary levels. Mean corpuscular haemoglobin concentration (MCHC) for quails fed control (0.67), 0.81, 1.08 and 1.22 % threonine diets were higher than birds fed 0.95 % threonine based diet suggesting that the birds had no possible deficiency of iron and other elements. All MCHC values obtained in this study were similar to the value (31.35 g/dl) reported by Campbell (1988). The similar cholesterol value of birds fed control (0.67), 0.81 and 1.22 % threonine diets were higher than those recorded for quails fed 0.95 and 1.08% threonine diets. The observed decreased cholesterol values (4.03 – 4.60 mm/L) for birds on 0.95 and 1.08 % threonine diets was similar to the value (4.8 – 7.4 mmol/L) which were within the normal range for growing quail reported by Scholtz *et al.* (2009). The decreased glucose levels observed in this study is an indication that threonine had positive effect on gut microflora which able to enhance glucose absorption, particularly in the caeca. The differences in albumin content reported in this study reflected the beneficial effect of threonine in protein metabolism in quails. This agreed with the report of Braun (2003) who asserted that nitrogenous compounds which persist in the caeca are broken down by bacteria into ammonia, which are then absorbed. Significant decrease in AST concentrations in bird fed 0.81% threonine diet could be a reflection of the absence of degenerative changes in their muscles and livers (Ayo-Ajasa *et al*, 2015). The AST values (13.33 – 25.33 IU/l) recorded in this study were lower than the normal AST range (64.67 – 140.50 IU/l) proposed by Sokol *et al*. (2015). The results from this study disagrees with Azzam *et al*. (2011) who reported that supplementation with L-threonine had no effect on haematological parameters and serum biochemistry of Japanese quail at early ages (0 – 3 weeks and 3 – 6 weeks). However, the values obtained in this present study for haematological parameters and serum biochemistry were within the normal range for healthy birds as reported by (Ali *et al.,* 2012). This was also in consonance with the works of Bawa *et al.* (2012) and Ojebiyi *et al.* (2009) on serum variables. These results suggest that the birds were in good health throughout the period of the experiment hence threonine levels had no detrimental effect.

CONCLUSION

It was concluded that the performance of birds were not influenced by the dietary treatments up to the highest dietary level of threonine studied (1.22%). Therefore, it is possible that the optimum dietary level of threonine may be above 1.22 %. Further studies will be necessary to establish higher doses of dietary threonine requirement of Japanese quails reared under tropical climatic environment.

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