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Thiamin, Riboflavin, Pyridoxine and Niacin Requirements of Growing Japanese Quail Fed Purified Diets

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Key words: **Japanese quail; thiamin; riboflavin; pyridoxine; niacin.**

RINGKASAN

Burung puyuh yang sedang membesar telah diberi makanan yang mengandungi beberapa peringkat vitamin. Berat badan burung puyuh ini bagi setiap peringkat vitamin dalam makanan pada 35 hari selepas, eksperimen dijalankan adalah seperti berikut: (a) thiamin hydrochloride (mg/kg makanan), 1, 1.5, 2, 2.5, 3, dan 3.5; berat badan (g), 68.5, 94.8, 105.7, 103.3, 99.4 dan 97.4, (b) riboflavin (mg/kg makanan), 0.75, 1, 1.5, 2, 2.5, dan 3; berat badan (g), mati, 45.3, 72.6, 103.0, 100.2 dan 103.9, (c) pyridoxine hydrochloride (mg/kg makanan), 1, 1.5, 2, 2.5, 3, dan 3.5; berat badan (g), 91.9, 101.6, 102.5, 105.9, 105.7, dan 103.2, (d) niacin (mg/kg makanan), 5, 10, 15, 20, 25, dan 30; berat badan (g), 93.8, 100.8, 105.2, 106.8, 101.9, dan 109.4. Daripada data ini serta data kehidupan keperluan setiap vitamin dalam makanan bagi burung puyuh ditaksir seperti berikut (mg/kg makanan): thiamin hydrochloride, 1.5; riboflavin, 2; pyridoxine hydrochloride, 1.5; dan niacin, 15.

SUMMARY

Growing Japanese quail at 35 days of the experiment, weighed respectively, as follows when fed the various levels of a test vitamin in their diet: (a) thiamin hydrochloride (mg/kg diet), 1, 1.5, 2, 2.5, 3, and 3.5; body weight (g), 68.5, 94.8, 105.7, 103.3, 99.4 and 97.4. (b) riboflavin (mg/kg diet), 0.75, 1, 1.5, 2, 2.5, and 3; body weight (g), dead, 45.3, 72.6, 103.0, 100.2 and 103.9. (c) pyridoxine hydrochloride (mg/kg diet), 1, 1.5, 2, 2.5, 3, and 3.5; body weight (g), 91.9, 101.6, 102.5, 105.9, 105.7, and 103.2. (d) niacin (mg/kg diet), 5, 10, 15, 20, 25, and 30; body weight (g), 93.8, 100.8, 105.2, 106.8, 101.9, and 109.4. The dietary supplements for growing Japanese quail are estimated to be as follows (mg/kg diet): thiamin hydrochloride, 1.5; riboflavin, 2; pyridoxine hydrochloride, 1.5; and niacin, 15.

INTRODUCTION

Growing quail, if deficient in thiamin, may exhibit symptoms of weakness, polyneuritis, growth retardation and ruffled plumage leading to high mortality (Alford *et al.*, 1967). Abercrombie (1965) reported that the thiamin requirement of young quail was more than 0.9 mg up to two weeks of age, but not more than 1.8 mg per kg of diet, to prevent the appearance of deficiency symptoms and to promote normal growth. Ramachandran (1974) using purified diets based on glucose and isolated soybean protein, showed that a minimum level of 6.0 mg thiamin hydrochloride per kg of diet was necessary for quail chicks up to 14 days in absence of vitamin B_{12} and vitamin C. However, the requirement decreased to 2 mg per kg in presence of these vitamins (Ramachandran and Arscott, 1974).

A riboflavin deficiency caused retarded growth and high mortality, and a level of 3.0 to 4.0 mg per kg of diet was recommended for quail fed purified diets up to two weeks of age (Abercrombie, 1965). However, Ramachandran (1974) suggested a minimum requirement of 8.0 mg riboflavin per kg of diet in absence of vitamin B_{12} and vitamin C, but it decreased to 4 mg per kg in presence of these vitamins (Ramachandran and Arscott, 1974).

Arscott (1967) reported that 0.5 mg supplementary pyridoxine hydrochloride was needed by Japanese quail per kg purified diets up to two weeks of age to prevent 100% mortality. On the other hand, Ramachandran (1974) estimated the requirement to be 5 to 6 mg/kg. No convulsions, the common symptom of a pyridoxine deficiency of chicks, were observed in coturnix chicks.

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A level of 30 to 40 mg niacin/kg diet was required for normal growth of Japanese quail, and no perosis, dermatitis or inflammation of the mouth cavity were observed (Ramachandran, 1974).

The requirement for calcium pantothenate and folic acid suggested by Ramachandran and Arscott (1974) were 15-25 mg and 10 mg per kg diet, respectively. On the other hand, Cutler and Vohra (1977) found a level of 7.5 mg per kg calcium pantothenate was needed for optimal growth, but a level of 10-30 mg per kg was needed for normal feathering. Wong *et al.*, (1977) found that folic acid requirements of Japanese quail depended upon the composition of the diet, and the need for supplementation varied from 0.3 to 0.36 mg per kg diet.

In view of conflicting literature, the purpose of the present study was to reevaluate the thiamin, riboflavin, pyridoxine, and niacin requirements of growing Japanese quail using purified diets based on isolated soybean protein and starch.

MATERIALS AND METHODS

The purified basal diet, as shown in Table 1, was formulated to contain all nutrients except the one under test. The crude protein and the metabolizable energy values of the diets were calculated to be 25.4% and 3400 kcal/kg, respectively. The test diets were supplemented with six different levels of the vitamin under study (mg/kg diet) as follows: –

1. Thiamin hydrochloride: 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5.
2. Riboflavin: .75, 1.0, 1.5, 2.0, 2.5 and 3.0.
3. Pyridoxine hydrochloride: 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5.
4. Niacin: 5, 10, 15, 20, 25, and 30.

Day-old Japanese quail chicks (line 908) were distributed at random among 12 groups with each group being housed in each of the 12 electrically heated stainless steel battery cages. Each cage contained 12 to 14 birds. The stainless steel battery was located in a room at 23°C constant temperature and under a daily lighting regime of 14 hours of light and 10 hours of darkness. The quail chicks were brooded at temperatures of 35.0°, 32.2°, and 29.4°C for the first, second and third week of age, respectively. Thereafter, they were maintained at room temperature. The day-old chicks were fed a commercial starter diet containing about 24 percent protein for the first three days. Thereafter, the 12 groups of birds were wing-banded and fed test diets containing six different levels of the vitamin under study. Each level was fed to two groups at random for a period of 35 days. Each group, which originally contained 12 to 14 birds, was now reduced to 10 birds at this stage which was considered the start of experiment. The birds were weighed twice a week. Mortality was recorded on a daily basis. Feed and water were supplied *ad libitum*. The data on body weights were analyzed statistically according to Steel and Torrie (1960).

TABLE 1

Composition of basal purified diet for determining thiamin, riboflavin, pyridoxine or niacin requirements of Japanese quail[1]

Ingredient	g/kg Diet
Starch[2]	507.5
Isolated soybean protein (87% crude protein)[3]	285.0
Soybean oil	30.0
DL – Methionine	4.5
Cellulose powder[4]	100.0
$CaCO_3$	10.0
$CaHPO_4.2H_2O$	30.0
Mineral mix[5]	23.0
Vitamin mix[6,7]	10.0

[1] Premix (10 grams) supplied in starch one of the following: Thiamin hydrochloride, 1 mg; riboflavin, 1 mg; pyridoxine hydrochloride, 1 mg; or niacin, 20 mg. Premix replaced an equivalent amount of starch.

[2] Pearl starch (A.E. Staley Manufacturing Co., Decatur, Il.)

[3] Assay protein RP-100 (Ralston Purina Co., St. Louis, Mo.)

[4] Solka Floc (Brown Co., New Hampshire)

[5] Mineral mix supplied in starch (g/kg diet): $CuSO_4.5H_2O$, .097; $FeSO_4.7H_2O$, .64; KIO_3, .009; K_2HPO_4, 4.95; KCl, 2.97; $MgCO_3$, 3.97; $MnSO_4.H_2O$, 0.297; NaCl, 9.9; $Na_2MoO_4.2H_2O$, .009; $Na_2SeO_3.5H_2O$, .00066; ZnO, .12.

[6] Vitamin mix in starch supplied the following per kg diet: vitamin A, 5000 I.U.; vitamin D_3, 1500 I.C.U., vitamin E, 20 I.U.; vitamin B_{12}, 4 mcg; calcium pantothenate, 20 mg; folacin, 1 mg; biotin, 0.2 mg; choline chloride, 2 g; menadione, 4 mg; BHT, 100 mg.

[7] The test vitamin was omitted from a combination of the following present in vitamin mix: thiamin HCl, 4 mg; riboflavin, 4 mg; pyridoxine HCl, 3 mg; and niacin, 50 mg.

RESULTS AND DISCUSSION

Thiamin experiment

The data on body weight and percentage of chicks survived, for the thiamin experiment are given in Table 2. Birds fed 1.0 mg thiamin hydrochloride per kg of diet showed the lowest body weights throughout the experimental period. Their survival of 35, 10, and 10% at 21, 28 and 35 days, respectively, were markedly lower than those from the other groups during the same period. At 14 and 21 days, body weights of birds fed thiamin hydrochloride ranging from 1.5 to 3.5 mg per kg of diet showed no significant differences ($P<0.05$). However, the body weights of 41.4 and 58.1 g for birds fed 1.0 mg thiamin hydrochloride per kg at 14 and 21 days, respectively, were significantly lower when compared to birds of other groups during the same period. At 35 days of the experiment, the body weights of 68.5, 94.8, 105.7, 103.3, 99.4 and 97.4 g for birds fed 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 mg thiamin hydrochloride per kg of diet, respectively, suggested that a supplementation with 1.5 mg thiamin hydrochloride per kg was needed for optimum growth of the birds. This finding is in agreement with that of Abercrombie (1965), and Ramachandran and Arscott (1974) who reported a dietary requirement of between 0.9 to 2.0 mg thiamin hydrochloride per kg of diet. The characteristic nervous symptoms were only observed in birds receiving 1.0 mg thiamin hydrochloride per kg of diet between seven and fifteen days of the experiment.

In a preliminary thiamin experiment, all birds receiving 0.25, 0.50, 0.75, and 1.0 mg thiamin hydrochloride per kg of diet at one day of age, died by or before 11 days after the start of experiment. In the present study, higher thiamin hydrochloride levels were, therefore, used.

Riboflavin experiment

In the riboflavin experiment, birds fed 0.75, 1.0, and 1.5 mg supplementary riboflavin per kg of diet had significantly lower body weights when compared to those receiving 2.0, 2.5, and 3.0 mg riboflavin from 14 days of the experiment onwards (Table 3). No significant differences in body weights were observed among birds that received 2.0, 2.5, and 3.0 mg riboflavin per kg of diet. At 35 days of the experiment, the survival figures of 0, 15, and 55% in birds from the first

TABLE 2

Effect of different thiamin levels on the mean body weight of growing quail at different days on experimental diets. Percentage survival is given in parenthesis over the experimental period.

Thiamin HCL levels, mg/kg	Body Weight g, (mean ± S.E.) Days on experimental diets: 0	7	14	21	28	35
1.0	11.3 ± 0.4[a] (100)	27.5 ± 0.9[b] (100)	41.4 ± 1.9[b] (70)	58.1 ± 2.7[b] (35)	63.0 ± 16.0* (10)	68.5 ± 1.5* (10)
1.5	11.7 ± 0.4[a] (100)	28.8 ± 1.1[ab] (85)	48.5 ± 2.2[a] (85)	70.1 ± 3.2[a] (80)	85.5 ± 2.5[a] (80)	94.8 ± 2.3[a] (80)
2.0	11.0 ± 0.3[a] (100)	28.2 ± 0.7[b] (95)	49.5 ± 1.6[a] (85)	73.8 ± 2.2[a] (85)	92.8 ± 2.3[ab] (85)	105.7 ± 2.5[b] (80)
2.5	11.6 ± 0.2[a] (100)	30.9 ± 0.6[a] (85)	49.1 ± 1.7[a] (85)	72.3 ± 3.1[a] (80)	94.4 ± 1.3[b] (75)	103.3 ± 2.6[ab] (75)
3.0	11.3 ± 0.3[a] (100)	28.3 ± 0.6[b] (95)	46.6 ± 1.4[a] (95)	69.2 ± 2.0[a] (85)	86.6 ± 2.9[a] (80)	99.4 ± 3.0[ab] (75)
3.5	11.9 ± 0.3[a] (100)	30.4 ± 0.7[a] (100)	47.1 ± 1.8[a] (85)	69.6 ± 2.9[a] (85)	85.5 ± 3.5[a] (85)	97.4 ± 4.4[ab] (85)

[a, b]Statistical significance at P<0.05 is denoted by different letters in a column.

*Not included in statistical analysis; only 2 birds survived.

TABLE 3

Effect of different riboflavin levels on the mean body weight of growing quail at different days on experimental diets. Percentage survival is given in parenthesis over the experimental period.

Riboflavin levels, mg/kg	Body Weight g, (mean ± S.E.) Days on experimental diets 0	7	14	21	28	35
0.75	10.9 ± 0.3[a] (100)	21.6 ± 1.0[d] (100)	29.4 ± 1.6[c] (85)	34.0 ± 2.3[c] (30)	35.3 ± 2.7* (15)	– (0)
1.00	11.0 ± 0.4[a] (100)	23.4 ± 1.1[cd] (100)	33.2 ± 1.7[c] (85)	39.2 ± 2.4[c] (70)	36.7 ± 4.0[d] (30)	45.3 ± 8.2* (15)
1.50	10.5 ± 0.3[a] (100)	24.7 ± 0.8[ce] (100)	39.4 ± 1.3[b] (95)	53.4 ± 2.2[b] (85)	62.6 ± 3.2[c] (70)	72.6 ± 4.5[b] (55)
2.00	11.8 ± 0.3[a] (100)	27.3 ± 0.9[be] (95)	45.8 ± 1.9[a] (95)	65.6 ± 2.4[a] (95)	83.0 ± 2.6[b] (95)	103.0 ± 2.2[a] (95)
2.50	11.7 ± 0.3[a] (100)	28.6 ± 1.0[ab] (100)	47.8 ± 1.0[a] (100)	65.7 ± 2.9[a] (100)	85.1 ± 3.0[ab] (100	100.2 ± 4.0[a] (95)
3.00	11.4 ± 0.4[a] (100)	30.9 ± 0.9[a] (100)	50.0 ± 1.1[a] (100)	68.2 ± 2.0[a] (100)	90.8 ± 1.7[a] (100)	103.9 ± 1.5[a] (100)

[a, b, c, d, e]Statistical significance at P<0.05 is denoted by different letters in a column.
*Not included in statistical analysis; only 3 birds survived.

three lower riboflavin levels were extremely poor in comparison to the values of 95, 95, and 100% for birds from the other three higher riboflavin levels. The final body weights of 45.3, 72.6, 103.0, 100.2, and 103.9 g for birds fed 1.0, 1.5, 2.0, 2.5, and 3.0 mg riboflavin per kg of diet suggested a supplementary requirement of 2.0 mg riboflavin per kg of diet. Ramachandran and Arscott (1974) and Abercrombie (1965) suggested the minimum requirement to be 4.0 mg per kg of diet. It is interesting to note that birds from the 0.75 and 1.0 mg riboflavin levels were observed to huddle together from 16 days of the experiment onwards. At 28 days of the experiment, the mean body temperature readings of three birds from each riboflavin level were 39.7°, 40.7°, 40.8°, 42.2°, 42.2°, 42.2°C from the lower to the higher riboflavin levels, respectively. Dermatitis were seen at the foot pad, as follows: one bird fed 1.0 mg riboflavin at 33 days, died next day; and one bird fed 1.5 mg riboflavin at 35th day.

Pyridoxine experiment

At 14 days of the pyridoxine experiment, birds receiving 1.0 mg pyridoxine hydrochloride per kg of diet were significantly lower (P ⟨ 0.05) in body weight when compared to those receiving 1.5, 2.0, 2.5, 3.0, and 3.5 mg (Table 4). No significant differences in body weights were observed among birds receiving 1.5 mg or higher pyridoxine hydrochloride per kg of diet at 21, 28, and 35 days of the experiment. The survival of 80% at 28 days in birds receiving 1.0 mg pyridoxine hydrochloride per kg of diet was lower than of those receiving higher pyridoxine levels. At 35 days, the final body weights of 91.9, 101.6, 102.5, 105.9, 105.7 and 103.2 g for birds fed 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 mg pyridoxine hydrochloride per kg of diet indicate that a supplementary requirement of 1.5 mg for growing quail. This level (1.5 mg per kg) is higher than that (0.5 mg per kg) suggested by Arscott (1967) but lower than the one (5-6 mg per kg) observed by Ramachandran (1974).

Niacin experiment

In the niacin experiment, birds fed 5 and 10 mg supplementary niacin had generally lower body weights than those fed the higher levels of 15, 20, 25, and 30 mg niacin per kg of diet at 7, 14, 21, 28, and 35 days of the experiment (Table 5). At 21 days of the experiment, the body weights of birds fed the higher levels were significantly higher than of those fed 5 or 10 mg

TABLE 4

Effect of different pyridoxine hydrochloride levels on the mean body weights of growing quail at different days on experimental purified diets. Percentage survival is given in parenthesis over the experimental period.

Pyridoxine hydrochloride levels, mg/kg	Body Weights g, (mean ± S.E.) Days on experimental purified diets 0	7	14	21	28	35
1.0	10.9 ± 0.3^{a} (100)	24.2 ± 0.8^{c} (100)	39.1 ± 1.7^{b} (95)	58.3 ± 1.8^{b} (90)	76.2 ± 2.9^{b} (80)	91.9 ± 3.0^{b} (80)
1.5	10.8 ± 0.4^{a} (100)	26.4 ± 1.0^{bc} (100)	47.3 ± 1.5^{a} (95)	70.8 ± 1.9^{a} (95)	89.2 ± 2.1^{a} (95)	101.6 ± 2.6^{a} (95)
2.0	10.2 ± 0.4^{a} (100)	27.5 ± 1.0^{ab} (100)	46.9 ± 1.6^{a} (95)	70.2 ± 1.9^{a} (95)	87.2 ± 2.5^{a} (90)	102.5 ± 2.6^{a} (85)
2.5	11.0 ± 0.3^{a} (100)	27.7 ± 0.6^{ab} (100)	51.3 ± 1.1^{a} (95)	75.5 ± 1.5^{a} (95)	93.9 ± 1.8^{a} (95)	105.9 ± 2.3^{a} (95)
3.0	10.5 ± 0.3^{a} (100)	28.8 ± 0.7^{ab} (100)	49.5 ± 1.4^{a} (100)	74.2 ± 2.0^{a} (100)	92.4 ± 2.2^{a} (95)	105.7 ± 3.0^{a} (95)
3.5	11.2 ± 0.3^{a} (100)	29.2 ± 0.8^{a} (100)	49.2 ± 1.3^{a} (95)	73.3 ± 2.0^{a} (90)	91.1 ± 1.9^{a} (90)	103.2 ± 2.3^{a} (90)

[a, b, c]Statistical significance at $P < 0.05$ is denoted by different letters in a column.

TABLE 5

Effect of different niacin levels on the mean body weights of growing quail at different days on experimental purified diets. Percentage survival is given in parenthesis over the experimental period.

Niacin levels (mg/kg)	Body Weights g, (mean ± S.E.) Days on experimental purified diets 0	7	14	21	28	35
5.0	10.4 ± 0.3^{a} (100)	24.9 ± 1.2^{b} (80)	41.0 ± 1.8^{b} (65)	62.3 ± 2.5^{b} (65)	80.2 ± 2.6^{b} (65)	93.8 ± 2.2^{b} (65)
10.0	9.9 ± 0.2^{a} (100)	25.0 ± 1.0^{b} (75)	40.0 ± 2.6^{b} (60)	62.4 ± 3.5^{b} (60)	83.6 ∓ 3.6^{ab} (60)	100.8 ± 3.1^{ab} (60)
15.0	9.7 ± 0.2^{a} (100)	26.3 ± 0.5^{ab} (85)	45.0 ± 1.3^{ab} (85)	69.9 ± 1.4^{a} (85)	88.5 ± 1.4^{ab} (85)	105.2 ± 2.0^{a} (85)
20.0	9.9 ± 0.4^{a} (100)	26.7 ± 0.9^{ab} (75)	47.4 ± 1.3^{a} (75)	70.3 ± 1.7^{a} (70)	88.5 ± 2.0^{ab} (70)	106.8 ± 2.7^{a} (65)
25.0	10.4 ± 0.3^{a} (100)	28.2 ± 0.9^{a} (85)	46.4 ± 1.8^{a} (80)	69.1 ± 2.8^{a} (80)	86.9 ± 3.7^{ab} (75)	101.9 ± 2.9^{a} (75)
30.0	10.2 ± 0.2^{a} (100)	28.7 ± 0.5^{a} (80)	47.4 ± 2.2^{a} (75)	75.1 ± 1.7^{a} (70)	92.4 ± 3.3^{a} (70)	109.4 ± 3.3^{a} (70)

[a,b]Statistical significance at $P < 0.05$ is denoted by different letters in a column.

niacin per kg of diet. However, at 28 days of the experiment, a significant difference in body weights was detected only in birds fed the lowest (5 mg) and the highest (30 mg) niacin per kg of diet. At 35 days of the experiment, body weights of 105.2, 106.8, 101.9, and 109.4 g for birds fed 15, 20, 25 and 30 mg niacin were significantly higher than 93.8 g for birds fed 5 mg niacin per kg of diet. Though the body weight of 100.8 g for birds fed 10 mg niacin per kg of diet was not significantly lower than that of birds fed the higher niacin levels, their survival of 60% was comparatively lower than of ones fed higher levels. The survival in birds fed 5 and 10 mg niacin per kg of diet from 14 days of the experiment onwards was consistently lower than of those fed the higher niacin levels. A dietary requirement of 15 mg of supplementary niacin per kg of diet is suggested for normal development of growing quail and differs from 30 to 40 mg suggested by Ramachandran (1974).

The supplementary need in growing Japanese quail diets appears to be as follows (in mg/kg): thiamin hydrochloride, 1.5; riboflavin, 2; pyridoxine hydrochloride, 1.5; and niacin, 15.

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