World Journal of Agricultural Sciences 4 (5): 605-611, 2008
ISSN 1817-3047

Alleviating the Effect of Some Environmental Stress Factors on Productive Performance in Japanese Quail 1. Growth Performance

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Abstract: The main objective of this study was to elucidate the effect of short-term exposure of Japanese quail eggs to acute high incubation temperature during the incubation period on the ability of post- hatched chicks to cope with the heat stress conditions during growing period. Three dietary treatments were examined in an attempt to alleviate the possible negative effect (s) of heat stress on the subsequent productive performance of quails. A total number of 998 fertile Japanese quail eggs were divided into two groups, the first one (470 eggs) was maintained at the recommended incubation temperature (37.5°C) while the second egg group (528 eggs) was exposed to 39.5°C for two hours at days 3, 7 and 13 of embryogenesis. After hatching, chicks from each incubation temperature were randomly assigned to four dietary treatments, *i. e.* control; high- energy diet (+ 150 Kcal ME/ Kg diet more than the recommended level); high- lysine (10 % more) and vitamin C supplemented diet. During the experimental period all quails were fed *ad libitum* and received similar hygienic and managerial conditions, while the rearing temperature was 32±2°C during the whole experimental period. Data concerning the growth performance (live body weight, body weight gain, feed consumption and feed conversion ratio) were collected during the growing period. Results obtained could be summarized as follows:

- Pre- hatching exposure of eggs to 39.5°C for two hours at days 3, 7 and 13 of embryonic development did not significantly affect the post- hatching body weight and weight gain during the growing period.
- Dietary supplementation with vitamin C or high- energy diet increased body weight and weight gain of growing quails.
- Average feed consumption of growing quails was not significantly changed with pre-hatching incubation temperature or post-hatching dietary treatments.
- A similar trend was also observed for the feed conversion ratio during the whole growing period.
- The relative weights of carcass, gizzard and lungs were insignificantly increased in quails fed the high- energy diet.
- Heat- exposure treatment decreased the relative weights of liver, gizzard, abdominal fat, heart and lungs of growing quails, the changes being insignificant.

Based on the results of the productive performance, it could be concluded that pre- hatching exposure of quail eggs to high temperature and post- hatching feeding of high- energy or vitamin C-supplemented diets could be recommended for alleviating the deleterious effects of heat stress during growing. Therefore, it is suggested that the supplementation of 200 ppm of vitamin C or 150 Kcal ME/ Kg of diet more than the recommended levels of quails may be practically effective in enhancing the general performance of Japanese quails.

Key words: Quail · Heat stress · Growth performance · Feed · Energy · Lysine · Vitamin C

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INTRODUCTION

Japanese quail (*Coturnix japonica*) is becoming more popular as a source of meat and eggs in various parts of the world including Egypt. It has also assumed worldwide importance as a laboratory animal [1] with distinct characteristics such as rapid growth- enabling quail to be marketed for human consumption at 5-6 weeks of age.

Commercial quail production has grown steadily in Egypt utilizing strains of Japanese quail selected for rapid growth and higher body weight. The nutrient requirements of these strains and the optimum housing temperature along with their physiological response(s) to acute heat stress environments are still obscure. It is suggested that acclimatization to heat stress may be induced through pre-hatch and (or) post-hatch short-time exposure to high environmental temperature [2, 3]. The rapid heat stress response can be modulated by early-age thermal conditioning [4] which may affect the integration of thermal information in the hypothalamus, which in turn reduces heat production by reducing the circulating concentration of thyroid hormones [5].

It is well accepted that the main consequence of heat stress is the reduction in feed intake as a trial from the bird to reduce metabolic heat production [6]. This will cause poor growth, reduced feed efficiency and enhanced fat deposition due to hypothyroid activity [7-9].

To reduce the deleterious effect(s) of heat stress, many practical approaches have been developed to facilitate thermo-tolerance of birds, leading to minimize the adverse effects on productivity. These approaches include pre and/or post acclimation of birds [10, 11]; use of some electrolytes and vitamins [12] and dietary energy or lysine levels manipulation [13, 14]. There is, however, a paucity of information on the beneficial effects of such approaches to improve Japanese quail production.

The main objective of the study was to elucidate the effect of short-term exposure of Japanese quail eggs to acute high incubation temperature during the incubation period on the ability of post-hatched chicks to cope with the heat stress condition during growing period. Therefore, three dietary treatments were examined in an attempt to:

- Elucidate the possible effect(s) of increasing dietary energy on alleviating the adverse effects of heat stress.
- Assess the role of higher dietary lysine level in combating distress conditions.
- Evaluate the influence of vitamin C in productive performance of quail.

MATERIALS AND METHODS

The present experiment was carried out during summer season in Egypt. The experiment lasted for 6 weeks.

1. Experimental Procedures

1.1 Incubation Period: A total number of 998 fertile Japanese quail (*Coturnix japonica*) eggs were obtained from a private quail farm near Cairo, Egypt. Eggs were incubated in a forced draught laboratory incubator at the recommended incubation temperature (37.5°C) and relative humidity between 55 to 66% [15]. Turning of eggs was automatically done every four hours until the day 14^{th} of incubation. From the first day of incubation period, eggs were divided into two groups. The first group (470 eggs) was maintained at the recommended temperature, while the second one (528 eggs) was exposed to 39.5°C for two hours at the 3^{ed}, 7^{th} and 13^{th} days of embryogenesis.

1.2 The Post-Hatching Period: After hatching, the chicks from each incubation temperature group were brooded in electrically heat- controlled batteries at 35°C for one week, and then maintained at 32°C±2°C during the whole experimental period. All chicks were fed *ad libitum* on the basal diet (control) during the first week. The basal diet was formulated to cover the recommended requirements of Japanese quail birds during the growing period according to National Research Council [NRC] [16].

2. Experimental Design: After the first week post-hatching, chicks of each pre-hatch temperature group were sorted by weight and those with extreme weights discarded. The remaining chicks (480 from each of control and heat-exposed eggs) were assigned to four dietary treatments sub-groups in such a manner to achieve equal mean weight per group. The experiment was extended for six weeks.

Birds of each experimental group were randomly distributed into four treatment groups of 60 chicks each as follows:

- The first treatment group (control) received the basal growing diet, which was formulated to cover the recommended requirements of Japanese quail birds according to National Research Council [NRC] [16].
- The second treatment group (high-energy) was fed the basal diet supplemented with 150 Kcal ME/ Kg of diet over the recommended level (2900 *vs.* 3050 Kcal ME/ Kg of diet).

Table 1: Composition and calculated analysis of the experimental diets during the growing period

Ingredients	Control	High energy	High lysine	Vitamin C
Yellow corn	54.65	58. 30	54.70	54.70
Soybean meal 48%	32.00	31. 30	31.70	32.20
Wheat bran	5.10	-	5.20	4.80
Corn gluten meal 62%	4.50	6.00	4.46	4.45
DL-methionine 99%	0.11	0.06	0.112	0.11
L-lysine HCl	0.195	0.15	0.372	0.19
Vegetable oil	0.50	1.20	0.50	0.50
Mono-Ca phosphate	0.825	0.835	0.825	0.82
Premix*	0.30	0.30	0.30	0.30
Limestone	1.49	1.52	1.50	1.50
Salt	0.33	0.34	0.33	0.33
Vitamin C (20%)	-	-	-	0.10
Calculated analysis:				
CP %	24	24	24	24
ME (Kcal/ Kg)	2900	3051	2901	2901
Calcium %	0.81	0.81	0.81	0.81
Av.Phosphorus %	0.32	0.32	0.32	0.32
Methionine %	0.50	0.49	0.50	0.50
Methionine+ Cystine %	0.89	0.89	0.89	0.89
Lysine %	1.32	1.32	1.45	1.32
EE %	3.16	3.85	3.16	3.15
CF %	3.07	2.62	3.07	3.05

* Each 3 Kg contains: vit A 12000000 IU, vit D_3 2500000 IU, vit E 10g, vit K_3 2g, vit B_1 1g, vit B_2 5g, vit B_6 1.5g, vit B_{12} 0.01g, Niacin 30g, Folic 1g, Biotin 0.05g, Pantothenic acid 10g, Copper 10g, Iodine 1g, Selenium 0.1g, Iron 30g, Manganese 60g, Zinc 50g, Cobalt 0.1g

- The third treatment group (high-lysine) was fed the basal diet supplemented with 10% lysine over the recommended level (1.32% *vs*. 1.45%).
- The fourth treatment group (vitamin C) was fed the basal diet supplemented with 0.10% of vitamin C (20%).

The composition and calculated analysis of the experimental diets are shown in Table 1.

Measurements

Growth Performance Parameters: Live body weight (LBW) of hatched chicks and at weekly intervals was measured to the nearest gram. Body weight gain (BWG) was then calculated by subtracting the average LBW of chicks in a previous period from the given period being recorded. Feed consumption was weekly recorded for each group and then the feed conversion ratio was calculated as gram feed to gram body weight gain. Mortality rate during the growing period was also recorded.

Carcass Characteristics and Some Organs Weight: At the end of the growing period, eight birds from each treatment group were randomly taken, weighed and slaughtered. Feathers were manually removed and birds were reweighed and eviscerated. Carcass weight and weights of head, liver, heart, lungs, gizzard and abdominal fat were also recorded to the nearest 0.01 gram.

Analytical Methods: The analysis of feed was done for moisture, ash, nitrogen (N), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE) according to AOAC [17]

Statistical analysis: Data were subjected to the analysis of variance by using the General Linear Models procedure (GLM) of the Statistical Analysis System [18] according to the following model:

$$Y_{ijk} = M + G_i + D_j + GD_{ij} + £_{ijk}$$

Where:

Y_{ijk} = an observation
M = an effect of overall mean
G_i = a fixed effect of feeding treatment
D_j = a fixed effect of heat treatment
Gd_{ij} = the interaction of G and D
$£_{ijk}$ = experimental error

Differences among treatment means were detected by using Ducan's multiple range test [19].

RESULTS AND DISCUSSION

Productive Performance of Quails: Results in which periodic heat exposure of eggs was applied during days 3, 7 and 13 of embryogenesis are listed in Table 2.

Live Body Weight (Lbw) and Weight Gain: It is clear that live body weight (LBW) of Japanese quail chicks was significantly changed with both heat exposure of eggs and dietary treatments. The lowest body weight values were recorded for quails being hatched from the control (221.65) and lysine (229.59) of non heat treatment supplemented diets followed by the high-energy fed diet quails (228.55) in heat-exposed experiment.

Regardless of heat exposure of eggs, the overall means of quails fed on vitamin C (vit. C) -supplemented diet and high-energy diets were significantly (P<0.01) higher than the control quails which have the lowest LBW

Table 2: Effect of different treatments on productive performance of quail (6 weeks of age)

	Traits				
	Body weight (g)				
Treatment	Initial (7 days)	Final (42 days)	Feed Intake (g)	Body weight gain (g)	Feed conversion ratio
Feeding treatment					
A-Non heat treatment					
Control	22.76b	221.65c	797.00	197.50b	4.04
Energy	22.83ab	240.42a	847.00	222.00a	3.82
Lysine	22.92ab	229.59bc	792.50	214.50a	3.70
Vitamin C	22.91ab	236.91ab	849.50	217.50a	3.91
B-Heat treatment					
Control	22.92ab	232.80ab	796.50	213.00a	3.74
Energy	23.02a	228.55bc	801.00	208.00ab	3.85
Lysine	22.86ab	232.65ab	816.50	213.00a	3.83
Vitamin C	22.74b	237.12ab	841.50	216.50a	3.89
Overall of feeding					
Control	22.84	226.81b	796.75	205.25b	3.89
Energy	22.92	234.66a	824.00	215.00a	3.83
Lysine	22.89	231.07ab	804.50	213.75ab	3.76
Vitamin C	22.82	237.02a	845.50	217.00a	3.90
Overall of heat					
Non heat	22.86	232.03	821.50	212.88	3.87
Heat	22.88	232.83	813.88	212.63	3.83
SEM	0.23	45.74	75. 91	31.00	0.03
Source of variation					
Feed	NS	0.01	NS	0.07	NS
Heat	NS	NS	NS	NS	NS
Feed* Heat	0.01	0.003	NS	0.04	NS

Table 3: Relative weights (%) of carcass and some organs of growing quails at 6 weeks of age

	Traits							
Treatment	Live body weight (g)	Carcass (%)	Head (%)	Liver (%)	Gizzard (%)	Abdominal Fat (%)	Heart (%)	Lung (%)
Feeding treatment								
A-Non heat treatment								
Control	221.50	72.02	3.86	1.96	1.93	1.51	1.02	0.81
Energy	247.75	71.65	3.86	1.80	2.13	1.39	1.01	0.91
Lysine	230.00	70.15	3.92	2.11	1.44	2.79	1.05	0.71
Vitamin C	226.50	72.03	3.64	1.88	1.88	1.45	1.01	0.92
B-Heat treatment								
Control	231.25	71.43	3.73	1.97	1.56	1.52	0.95	0.60
Energy	228.50	72.50	3.90	1.50	1.62	1.72	0.90	1.03
Lysine	227.25	70.51	4.11	1.78	2.05	1.50	1.07	0.74
Vitamin C	254.25	70.92	3.54	1.62	1.90	1.95	0.82	0.62
Overall of feeding								
Control	226.38	71.73	3.78	1.96	1.75	1.52	0.99	0.71
Energy	238.13	72.08	3.88	1.65	1.88	1.56	0.96	0.97
Lysine	228.63	70.33	4.02	1.95	1.75	2.15	1.06	0.73
Vitamin C	240.38	71.48	3.59	1.75	1.89	1.70	0.92	0.77
Overall of heat								
Non heat	231.44	71.46	3.82	1.94	1.85	1.79	1.02	0.84
Heat	235.31	71.34	3.82	1.72	1.78	1.67	0.94	0.75
SEM	95.92	2.40	0.29	0.09	0.13	0.59	0.03	0.06
Source of variation								
Feed	NS	NS	NS	NS	NS	NS	NS	NS
Heat	NS	NS	NS	NS	NS	NS	NS	NS
Feed* Heat	NS	NS	NS	NS	NS	NS	NS	NS

A, b and c Means within columns with no common superscripts differ significantly ($P<0.05$) NS= Non-significant. SEM=Standard error of means

(226.81) followed by the lysine supplemented ones (231.07). In this concern, it appears that pre-hatching heat exposure of eggs has insignificant effects on post-hatching LBW of quails at 6 weeks of age.

Statistical analysis of data reflects the highly significant (P<0.01) effects of dietary treatments and their interaction with heat exposure (P<0.003) on LBW of quails.

It is likely that pre-hatch temperature treatment did not affect the post-hatching body weight of quails during the whole experimental period (6 weeks). Similar results were reported by Abd El-Azim [11] and Yalcin and Siegel [20] who reported that the changes in body weight of broiler chicks as a result of pre-hatch temperature have disappeared with age. Results showed also that body weight gain of quails, which fed on high energy and vit. C-supplemented diets, was higher than the other treatments (control and lysine). This trend may be due to the enhancement of feed intake (Table 2) as a result of good palatability and more utilization of nutrients. In this respect, results of the present study showed that there are considerable increases in feed consumption in quail that gained more. The growth stimulation, which was recorded for vit. C-supplemented quail may reflect the beneficial effect of this vitamin on growth performance. It is suggested that supplemental vit. C could improve heat tolerance and body weight reduction associated with stress conditions. It is worse to note that the experimental quails were housed at 32°C, which may induce corticosterone synthesis. This hormone was reported by many investigators to reduce growth rate of chickens [21-26].

Feed Intake and Feed Conversion Ratio: As shown in Table 2 the average feed intake of growing quails was not significantly changed with neither pre-hatch temperature nor feeding treatments. However, non-significant increases in feed intake were detected in quails, which fed on high energy and vit. C-supplemented diets. These increases were coincident with the highest values of LBW and weight gain of these groups. A similar trend was also observed for the values of feed conversion ratio, which showed insignificant differences between all treatment groups. It is clear that the post-hatching temperature which used in the present experiment (32°C) was insufficient to induce a hyperthermia status of quails, with its first consequence being the reduction of feed intake. The present results failed to support the previous findings that heat stress reduced feed intake and feed to gain ratio [7, 27, 28], however, they used different avian species and temperatures.

Relative Weights of Carcass and Some Important Organs: The overall means of carcass weight (%) and the proportional weights of some body organs are presented in Table 3.Japanese quail chicks receiving different dietary treatments had insignificant effects on all the studied traits. However, a slight increase in the relative weights of carcass, gizzard and lungs were recorded in quails fed on high-energy diets. Also, there were slight increases in the relative weights of head, liver, abdominal fat and heart in the high-lysine-fed quails. Moreover, there were no significant effects of heat exposure treatments on all traits, although an obvious decreases was observed in the relative weights of liver, gizzard, abdominal fat, heart and lungs for the heat treatment group.

These results may reflect the interrelationships between the dietary supplements and some endocrine functions, which include stimulatory effects of vit. C, energy level and lysine on thyroid gland activity under heat stress conditions. It is well known that the normal growth of all body organs needs an euthyroid status [29] which adversely affected by increasing ambient air temperature [7]. Since, the supplemental lysine, energy and vit. C is of great importance to compensate or modulating the growth depression that could be expected under hot conditions. Similar results were reported by Puvadolpirod and Thaxton [8] , Yalcin *et al.* [30] and Puvadolpirod and Thaxton [31, 32] who reported a decrease in carcass weight as the ambient temperature increased. Also, Oliveira *et al*. [33] reported a significant effect of dietary energy (under stress conditions) on decreasing heart, liver and gizzard weights (%) and increasing abdominal fat (%). The same was observed in lysine-supplemented group [34] and vit. C-fed group as reported by Sahin *et al.* [23-25] and El-Komy [35].

Similar results dealing with the important role of vit. C, high-energy and high-lysine in the diets for better performance of different avian species under stress conditions [34, 36-39]. These studies are in accordance with the results of the present study.

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