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Laying Performance of Japanese Quail (*Coturnix Coturnix Japonica*) Supplemented with Zinc, Vitamin C and E Subjected to Long Term Heat Stress

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Abstract. This study investigated the effect of zinc, Vitamin C and E feed supplementation in the production performance, egg quality characteristics and nutrient digestibility of Japanese quails (*Coturnix japonica*) under heat-stressed environment. Two hundred sixteen 60-day old quails were randomly assigned into 8 treatment combinations with 0 and 60 mg Zn, 0 and 200 mg Vitamin C and E/kg feed under ambient and heat-stressed environment ($\geq 34^{o}$C) for 5 weeks. Zinc, Vit C and E supplementation significantly ($P < 0.05$) improved FCR, egg production, haugh unit score, and shell thickness on heat-stressed Japanese quails. However, feed consumption, body weight gain, mortality rate, and digestibility of nutrients were not significantly ($P > 0.05$) affected by the interaction of heat stress and Zn, Vit C and E supplementation. Under ambient temperature, egg weight and yolk weight were significantly ($P < 0.05$) improved when supplemented with zinc while the supplementation of Zn, Vit C and E have significantly ($P < 0.05$) increased albumen weight and dressing percentage. Therefore, it can be recommended that supplementation of 60 mg zinc/kg feed, 200 mg vitamin C and E/kg feed can be considered as a protective management practice to reduce the deleterious effects of heat stress.

Keywords: heat stress, zinc, vitamin C and E, Japanese quail

1. Introduction

Temperature is just one of the major factors that affect the productivity of farm animals including egg production. Animals exposed to heat stress are prone to thermal imbalance or disrupted homeostasis which may lead to an increase respiration rate, decrease physical activity, feed consumption, feed efficiency, egg production, egg weight and poor egg shell quality. These physiological changes and various effects on production parameters would result to significant economic losses. For example, it was reported in the USA that there are about 8-10% losses on its economy due to poor egg shell quality through breakage [1].

Combating the negative effects of heat stress is one of the primary concerns of poultry producers in the Philippines especially during long summer months. Attempts have been made to reduce effects of heat stress by maintaining a constant temperature within a narrow range through provision of clean and cool drinking water, reducing the number of birds per cage, or feeding during the cooler times of the day [2] as well as the provision of cooling and ventilation system. However, according to Al-Batshan [3], this probably would not result in sufficient improvement in production and egg quality to justify additional cost especially the use of cooling and ventilation system. Similarly, backyard egg producers in the Philippines will not be interested in adding more costs in their production expenses, thus dietary manipulation (*i.e* addition of electrolyte supplements to their drinking water) have gain greater attention which requires cheaper production costs. As such, Vitamin E and Vitamin C are being used in the layer and broiler diets because of their anti-stress effects and their levels in the body are reduced during heat stress [4]-[6]. Furthermore, Vitamin C and

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Vitamin E are considered primary antioxidants in biological systems that break the chain of lipid peroxidation in cell membranes. Generally, vitamin E works synergistically on the immune response. Zinc, on the other hand, is known to prevent growth depression [7] and play an important role in eggshell mineralization that takes place in the shell gland [8].

On the other hand, it has been studied that the addition of Vitamin C or Vitamin E alone into diets appeared to be less beneficial for laying hens during heat stress [9]. Therefore, it is important that the roles of mineral and vitamin supplementation especially during summer months when layer are suffering from heat stress be identified for optimum production and good business venture.

Thus, this study was conducted to evaluate the performance of Japanese laying quails as affected by the supplementation of Zinc, Vitamin C and E subjected to long term heat stress in terms of:

- Production performance (egg production, feed consumption, feed efficiency (FCR), body weight gain, dressing percentage, giblets percentage, mortality);
- Egg qualities (weight, yolk weight, shell thickness, Haugh unit, albumen weight);
- Digestion efficiency (dry matter, crude protein, crude fiber, crude fat, nitrogen free extract, mineral matter and total digestible nutrient).

2. Methodology

2.1. Experimental Animals

The study used 216 Japanese quail (*Coturnix coturnix japonica*) pullets about 25 day-old, obtained from a commercial hatchery in Balagtas, Bulacan. Quails were individually weighed and randomly assigned in 24 battery cages (14 in x 12 in x 12 in) with nine birds in each cage. Quails were then reared and kept under standard husbandry and management procedures. Experimental site and cages were cleaned and disinfected a week before the arrival of the experimental quail pullets.

2.2. Experimental Design and Dietary Treatment

Quail pullets were fed with a commercial quail grower that served as the basal diet with approximately 24% crude protein. At day 36, quail birds were shifted gradually to a basal diet of commercial quail laying mash with approximately 20% crude protein.

At 60% laying efficiency, quails were initially weighed, divided into half and subjected to 2 temperature treatment (room temperature and heat stressed environment with a minimum temperature of 34^{o}C) and zinc, vitamin C and E supplementation.

In the heat-stressed environment, two electric heaters and curtains sacks were used to create the desired temperature but proper ventilation was also maintained. Relative humidity was monitored and recorded using a digital hygrometer and minimum-maximum glass thermometer, respectively. Exposure time to the desired temperature was 6 hours and animals were given 17h light exposure per day.

Dietary treatment combinations were composed of two level of zinc (zinc oxide) at 0 and 60 mg/kg feeds, and vitamin C (ascorbic acid) and vitamin E (DL-α tocopheryl acetate) at 0 and 200 mg/kg feeds (as add-ons). The prepared mixture of feeds and supplements were used for a week feeding scheme. Quails were fed 4 times a day while water was provided *ad libitum.*

Quail layers were equally and randomly distributed to eight (8) treatment combinations following a Factorial design. Each treatment was replicated three (3) times with nine (9) quails per cage as replicate.

2.3. Data Collection and Laboratory Analysis

Production variables, egg characteristics and digestion efficiency were determined following standardized procedures. Furthermore, digestibility test was done every week by collecting fecal materials and subjected to proximate analysis. Data obtained were used to determine the total amount of nutrients digested in heat stressed quail layers.

2.4. Statistical Analysis

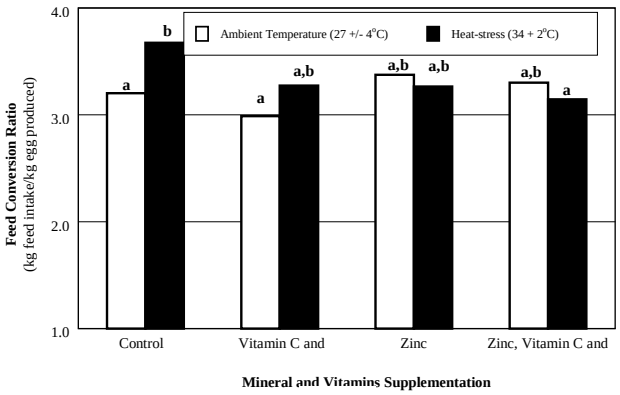
The data were analyzed using the General Linear Model (GLM) procedure of SPSS 11.5 for Windows with the main effects of temperature (T), mineral and vitamin supplement and its interaction. Differences between treatment means were compared using Student-Newman-Keul Test.

3. Results and Discussion

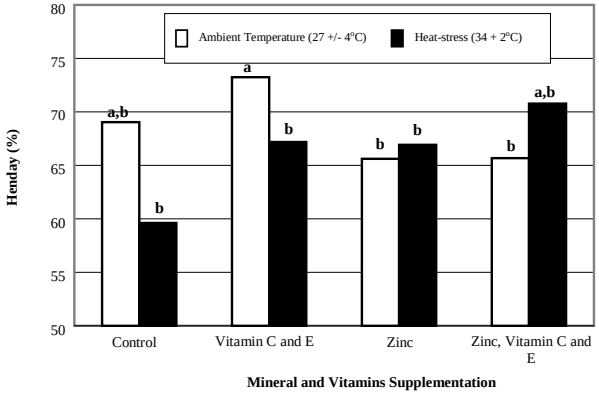
3.1. Production Variables

Feed conversion ratio (FCR) is one of the key performance indicators for livestock production as it was significantly influenced ($P < 0.05$) by the interaction of temperature and mineral-vitamin supplementation in laying Japanese quails (Fig. 1a). Quail layers under heat stress supplemented with zinc, vitamin C and E have comparable FCR with the control group. The synergistic effect of zinc, Vitamin C and E improved the efficiency of the quail birds to convert feed into eggs even under heat stress.

Henday (egg production per day) was significantly influenced ($P < 0.05$) by the interaction of temperature and mineral-vitamin supplementation (Fig. 1b) as manifested by the similar henday of the heat-stressed birds with zinc, vitamin C and E with the control group.



[a]



[b]

Fig. 1: Feed Conversion Ratio (FCR [a] and Henday[b] of laying Japanese quails (n = 216) subjected to ambient and heat-stressed environment and supplemented with Zinc (0 and 60 mg), Vitamin C and E (0 and 200 mg) for five weeks. Means with different superscript differ at $P < 0.05$.

However, the interaction of temperature and mineral-vitamin supplementation did not significantly influenced ($P > 0.05$) the mortality rate of laying Japanese quails (Table 1). Mean mortality rate of heat-stressed quail layers was notably higher but not significantly different ($P > 0.05$) compared to quails under the control group. Heat stress can result in significant losses to producers with all types of poultry enterprise. One obvious loss is due to mortality. Dead birds can be counted and its value can be assessed. Death, on the other hand began to occur on the sixth week after first introduction of the treatment. Apparently, supplemented groups have zero mortality which can be deduced that zinc, vitamin C and E generally improved resistance against the deleterious effect of high temperature.

3.2. Egg Quality

The supplementation of 60 mg/kg feed zinc gave significant beneficial effect ($P < 0.05$) on egg weight of laying Japanese quail under heat stressed environment (Fig. 2).

Likewise, improvements in egg quality (e.g. Haugh units and albumen weight) were found to be significantly influenced by the interaction ($P<0.05$) of temperature and mineral-vitamin supplementations (Fig. 3a and 3b, respectively). In chicken hens, quality of albumen relates to its functionality in foods. Specifically, good quality albumen is desired for its foaming and gelling properties.

Specifically, quails exposed to high temperature with basal diet only had the lowest Haugh unit score compared with those supplemented with zinc, vitamin C and E. Thus, it can be deduced that the addition of 200 mg vitamin C and E, 60 mg zinc into quail's diet under heat-stressed environment were sufficient to

improve the quality of albumen through Haugh units score to a level similar to that of quails reared under ambient temperature.

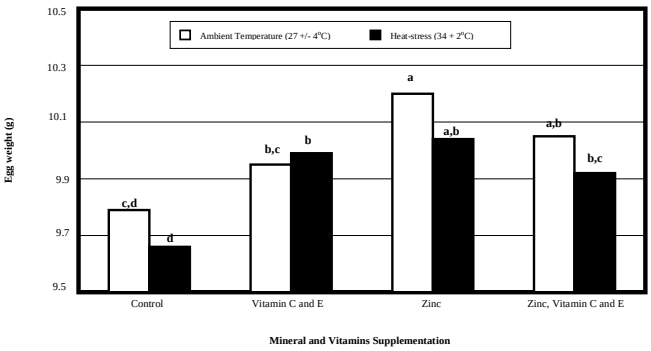


Fig. 2: Egg weight (g) of laying Japanese quails (n = 216) subjected to ambient and heat-stressed environment supplemented with Zinc (0 and 60 mg), Vitamin C and E (0 and 200 mg) for five weeks. Means with different superscript differ at P < 0.05.

Table 1. Production variables of Japanese quails (n = 216) supplemented with zinc (60 mg), Vitamin C and E (200 mg) subjected to ambient (27+/- 4oC) and heat-stressed (34 + 2oC) environment for five weeks.

SUPPLEMENT	TEMPERATURE		
	Ambient	Heat Stress	Mean
Feed Consumption (g/day)			
Control	19.82[a]	19.49[a]	19.65[a]
Vitamin C and E	19.42[a]	20.14[a]	19.74[a]
Zinc	19.57[a]	19.92[a]	19.78[a]
Zinc, Vitamin C and E	19.69[a]	20.15[a]	19.92[a]
Mean	19.62[a]	19.92[a]	
Body Weight Gain (g)			
Control	5.2[a]	8.1[a]	6.7[a]
Vitamin C and E	8.7[a]	10.6[a]	9.6[a]
Zinc	7.6[a]	8.7[a]	8.1[a]
Zinc, Vitamin C and E	9.4[a]	10.0[a]	9.7[a]
Mean	7.7[a]	9.4[a]	
Giblets (%)			
Control	6.4[a]	6.1[a]	6.2[a]
Vitamin C and E	7.2[a]	7.1[a]	7.2[a]
Zinc	7.1[a]	7.0[a]	7.0[a]
Zinc, Vitamin C and E	6.6[a]	6.7[a]	6.6[a]
Mean	6.8[a]	6.7[a]	
Mortality (%)			
Control	3.7[a]	7.4[a]	5.6[a]
Vitamin C and E	0.0[a]	0.0[a]	0.0[a]
Zinc	0.0[a]	0.0[a]	0.0[a]
Zinc, Vitamin C and E	0.0[a]	0.0[a]	0.0[a]
Mean	0.9[a]	1.9[a]	

* Means with different superscript differs (P < 0.05)

Furthermore, highest albumen weight (P<0.05) was documented with eggs supplemented with 60 mg zinc and the combinations of zinc, vitamin C and E both reared under ambient temperature. Likewise, quails reared in ambient temperature supplemented with vitamin C and E and quails under heat-stressed conditions with zinc have similar mean albumen weight. Conversely, eggs from quails exposed to high temperature for five weeks with no supplements produced eggs with the lowest albumen weights.

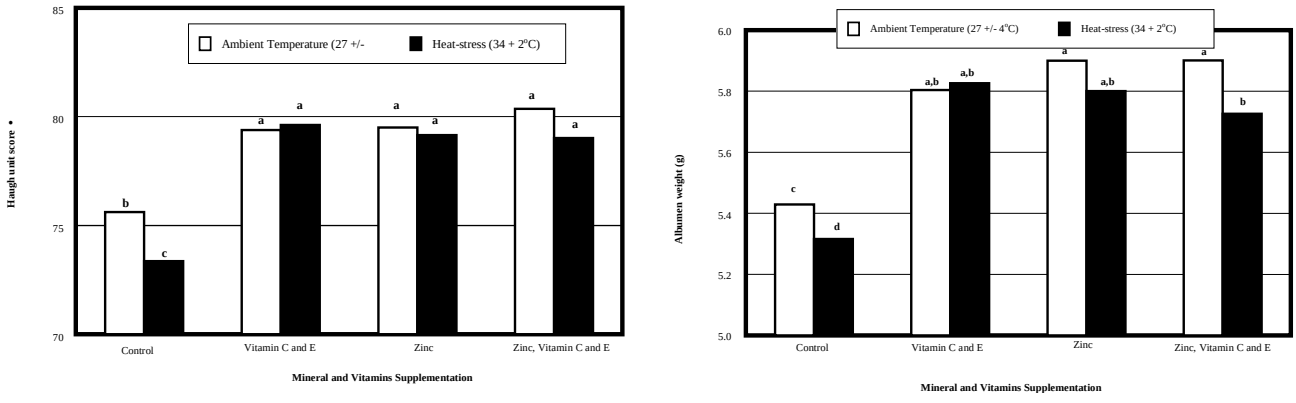


Fig. 3: Haugh unit score [a] and albumen weight [b] of laying Japanese quails (n = 216) subjected to ambient and heat-stressed environment supplemented with Zinc (0 and 60 mg), Vitamin C and E (0 and 200 mg) for five weeks. Means with different superscript differ at P < 0.05.

Eggshells from quails under heat-stressed condition supplemented with vitamin C and E and with zinc, vitamin C and E; and zinc supplemented quails reared under ambient temperature have similar (P > 0.05)

mean eggshell thickness (Fig. 4). Eggshell thickness is of vital importance in ensuring shell quality in layers. Apparently, the present study was able to prove the deleterious effects of heat stress on egg shell quality. The present study on the supplementation of zinc, vitamin C and E and its combinations on quails under long term heat stress proved to have a positive effect on egg shell thickness.

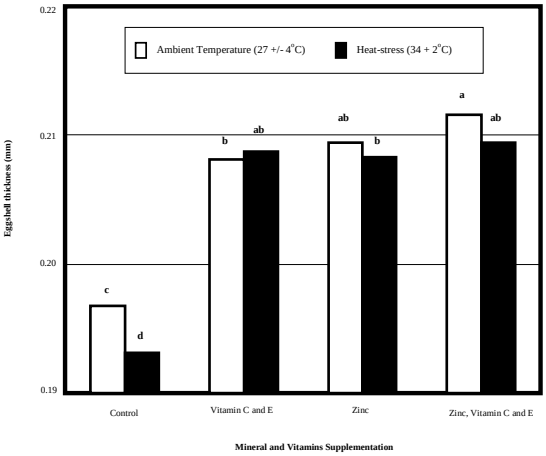


Fig. 4: Egg Shell thickness of laying Japanese quails (n = 216) subjected to ambient and heat-stressed environment supplemented with Zinc (60 mg), Vitamin C and E (200 mg) for five weeks. Means with different superscript differ at $P < 0.05$).

3.3. Apparent Digestibility

Although, dry matter, crude fat, crude fiber, and nitrogen-free extract digestibility and percentage total digestible nutrients did not significantly ($P>0.05$) improved by the mineral-vitamin supplementations, protein digestibility of laying Japanese quails was significantly ($P < 0.05$) affected by the interaction of temperature and mineral-vitamin supplementation. Specifically, the combination of zinc, vitamin C and E significantly increased ($P < 0.05$) protein digestibility of laying Japanese quails under ambient temperature.

The digestibility tests did not provide well conclusive positive results however, based on the total production performance of the birds, it can be considered that mineral and vitamin supplementation improved the absorption and utilization of nutrients under long term heat stress.

4. Conclusion and Recommendations

The supplementation of (separately and/or combination) of 60 mg zinc/kg feed, 200 mg vitamin C and E/kg feed to laying Japanese quails subjected to long-term heat stress provided better feed efficiency, higher egg production, and better dressing percentage compared to the control groups. Furthermore, the supplementation of zinc, vitamin C and E (separately or in combination) have zero mortality compared to the control group.

Egg qualities, on the other hand, such as egg weight, yolk weight, shell thickness, Haugh unit, and albumen weight were significantly improved by the supplementations (separately or in combination) of zinc, vitamin C and E.

However, in spite of the fact that most production performance and egg qualities were improved by the supplementation (separately or in combination) of zinc, vitamin C and E, yet beneficial effects were not define on the digestibility of nutrients (*e.g.* dry matter, crude fat, crude fiber, NFE) especially those on heat-stressed condition.

Hence, this finding leads to the assumption that supplementation of 60 mg zinc, 200 mg vitamin C and E (separately or in combination) may help in combating deleterious effects of heat stress during hot season in the Philippines. Specifically, it is suggested that the complete supplementation of zinc, vitamin C and E would give a significant improvement to production performance and egg qualities under long term heat stress condition. Furthermore, it is recommended that further research could be done to validate some important observations and the beneficial effects of zinc, vitamin C and E on animals under various stressors.

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