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Review article

Heat stress impairs the nutritional metabolism and reduces the productivity of egg-laying ducks

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ABSTRACT

This research was conducted to determine the effect of heat stress on the nutritional metabolism and productivity of egg-laying shelducks. Healthy shelducks ($n = 120$) in the early laying stage (uniform body weights and normal feed intakes) were randomly assigned to two identical climate chambers and exposed to constant high temperature (34 °C) or control temperature (23 °C) for 28 d. The heat-exposed ducks had reduced feed intakes and laying rates ($P < 0.05$), increased frequency of panting and spreading wings and dull featheration; egg weight, eggshell thickness and strength, and Haugh unit also decreased and malondialdehyde (MDA) content of egg yolk increased ($P < 0.05$). Compared with the control ducks, the plasma concentrations of HCO_3^-, phosphorus, glucose, thyroxine and activities of glutamic-pyruvic transaminase and glutamic oxaloacetic transaminase were decreased, while there were increased concentrations of corticosterone ($P < 0.05$). The content of MDA and lactate in plasma and liver was greater in heat-exposed than in control ducks, but superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), total antioxidant enzymes (T-AOC) activities and glutathione (GSH) contents were less. The expression of *HSP70* gene expression in the liver was increased in heat-stressed ducks. The relative weight of oviduct, number of large ovarian follicles, length of the oviduct all decreased ($P < 0.05$) in heat-treated ducks, as did expression of *carbonic anhydrase* and *calcium binding protein* genes in the shell gland as a result of heat stress. In summary, heat stress decreased the productivity of ducks, which related to reduced feed intake, protein synthesis, endocrine dysfunction, less antioxidant capacity, and derangement of calcium and phosphorous balance.

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1. Introduction

Heat stress is of great concern in the poultry industries with egg laying birds. Feed intake, daily egg production, egg quality, body weight, mortality and other important traits are negatively affected by severe heat stress. In southern China and other tropical and warm temperate regions, summer maximal temperatures range between 32 and 40 °C, increasing the likelihood of heat stress in poultry. Laying ducks (optimal ambient temperature is 15 to 25 °C) are particularly sensitive to greater ambient temperatures and the feed intakes decreased when temperatures exceeded 28 °C (Lin et al., 2010). The productivity performance or physiological function of laying ducks also changed under heat stress conditions, including reduced feed intake and acceleration of respiratory rate, which led to fewer eggs of inferior quality, greater death rates and greater culling rates (Zhao et al., 2002). Such impaired productivity causes great financial losses, so avoiding the negative effect of heat stress on laying ducks is important for maintaining good productive performance. Hens are also sensitive to heat stress and the responses to heat stress are similar to laying ducks, such as decreased egg production and egg weight when the environmental temperature increased from 21 to 32 °C (De Andrade et al., 1977). Many studies have characterized the physiological mechanisms of these failures in hens and have attempted to find ways of improving productivity (Odom et al., 1986; Marder and Arad, 1989; Mahmoud et al., 1996; Hansen et al., 2004), but similar investigation has not been done in ducks. The disturbance in physiological function caused by heat stress in laying ducks needs further research. The aim of the present study was to determine the effect of increased temperatures on feed intake and egg production, egg quality, protein and energy metabolism, organs indexes, and plasma variables such as the contents of cortisol, thyroxine, HCO_3^-, calcium *et cetera*. and antioxidant/oxidant indices in plasma.

2. Materials and methods

2.1. Experimental design

Healthy laying Fujian shelducks ducks ($n = 120$) were selected at 60 wk of age and randomly assigned to two treatment groups, each with six replicates, and each replicate consisted of 10 birds in five cages (48.5 × 40 × 52 cm; $L \times W \times H$). The ducks were housed in two identical controlled-environment chambers at the Institute of Animal Science, Guangdong Academy of Agricultural Sciences. Throughout the study, a lighting regimen of 5 W/m^2, 16 h light:8 h dark was used and birds had free access to water. During the adaptation period of 4 weeks (23 °C, 65% relative humidity), ducks and eggs in each cages were weighed and the egg quality traits were tested. After these variables were assessed, careful evaluations were made to ensure there were not differences between the two chambers that might impact treatment differences. Ducks in one chamber were subsequently exposed to heat stress. The temperature was increased from 23 to 34 °C over a period of approximately 2 h and was thereafter maintained at 34 °C for the 28-d experimental period (the average outdoor temperature during most hot summer days in South China area is about 34 °C).The control chamber was maintained at 23 °C. The ducks were all fed the same corn–soybean meal diet with composition included in Table 1.

Because ducks can gorge themselves, weighed feed (140–150 g/duck) was provided twice each day at 08:00 and 17:00 h. Remaining feed in each cage was collected daily, dried and weighed to determine feed intake. The greatest, least, and average room temperature and humidity were recorded daily, as was alertness, activity, and general health of each bird. This study was conducted in accordance with the Chinese guidelines for research (Science and Technology Ministry of China (STMC), 2006) and EU Directive 2010/63/EU (http://ec.europa.eu/environment/chemicals/lab_animals/legislation_en.htm)

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