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Effect of phytase supplementation of diets with different levels of rice bran and non-phytate phosphorus on productive performance, egg quality traits, leukocytes profile and serum lipids of laying hens reared indoor under high environmental temperatures

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ABSTRACT

A total of 288 32-wk-old Lohmann Selected Leghorn (LSL-Lite) laying hens were fed on corn-soyabean meal-based diets containing three concentrations of rice bran (RB; 0, 75 and 150 g/kg; equivalent to 1.8, 2.7 and 3.5 g/kg phytate phosphorus), two of non-phytate phosphorus (NPP; 2.5 and 3.5 g/kg) and two of microbial phytase (Phyzyme® XP 5000G; 0 and 150 FTU/kg) in a 10-wk trial under high temperature condition. The average minimum and maximum room temperatures were 26.0 ± 1.9 and 36.0 ± 1.8 °C, respectively, with relative humidity ranging from 42.3 ± 1.8% to 55.1 ± 2.1%. Each dietary treatment was fed to four cages (six birds/cage) from 32 to 42 wk of age. Egg production, egg weight and feed intake were recorded daily. Egg quality traits were recorded every 5 wk. Leukocyte subset counts and blood lipid profile were evaluated at the end of experiment. The results showed that inclusion of 150 g/kg RB negatively influenced ($P < 0.05$) egg production (EP), feed conversion ratio (FCR), shell weight and shell thickness. Significant reductions ($P < 0.05$) in the blood triglyceride and total cholesterol were observed with increasing dietary inclusion levels of RB. Although, dietary NPP levels did not influence any of the performance traits, the low-NPP diets caused a decrease ($P < 0.05$) in shell weight and shell thickness when compared with normal-NPP diets. The H/L ratio, as a stress indicator, was also increased ($P < 0.05$) by low-NPP diets. These adverse effects were partially overcome by the addition of microbial phytase (PHY). Supplemental PHY improved ($P < 0.05$) EP, FCR and unmarketable eggs but the magnitude of the responses was greater in low-NPP and high-RB treatments, resulting in significant RB × NPP × PHY interactions. Egg mass, shell weight and shell thickness were also improved ($P < 0.05$) by PHY addition but the response was greater at the highest concentration of RB, resulting in a significant RB × PHY interaction. Responses were also greater ($P < 0.05$) in low-NPP diets as indicated by significant NPP × PHY interaction. It can be concluded that the positive effects of PHY supplementation were clearly evident

Abbreviations: RB, rice bran; NPP, non-phytate phosphorus; PHY, phytase; EW, egg weight; EM, egg mass; EP, egg production; FI, feed intake; FCR, feed conversion ratio; H, heterophil to lymphocyte ratio (H/L ratio); HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

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for laying hens reared under the high ambient temperatures pertaining to this study. At high concentration of phytate (high-RB diet) and/or low level of NPP (2.5 g/kg), response to supplemental PHY appears to be increase in terms of performance and egg quality in heat-stressed laying hens.

1. Introduction

Stress is defined as any non-specific biological reaction developed by an animal or bird when its homeostasis is disrupted (Virden and Kidd, 2009). Among the environmental variables, ambient temperature is considered as an important factor in poultry production because of its impacts on welfare and health. High temperature is reported to negatively influence productive performance in laying hens along with physiological changes (Franco-Jimenez et al., 2007; Deng et al., 2012). Stress hormones (adrenocorticotrophic and glucocorticoid hormones) have been reported to change protein, lipid and mineral metabolisms as well as tissue cholesterol concentrations (Moraes et al., 2003; Toghyani et al., 2012). Previous studies have shown reductions in blood triglyceride concentrations (Shim et al., 2006) and decrease in the amounts of hepatic lipid deposition (Takahashi et al., 1983) in heat-stressed broilers. Moreover, the bioavailability of P and trace minerals is reduced due to increased excretion as a result of heat stress (Belay et al., 1992). Broilers raised at high heat stress (cycling 24–35 °C) had also lower rates of phosphorus, magnesium, sulphur, manganese, and zinc retention compared with birds housed at 24 °C (Belay and Teeter, 1996). Moreover, high environmental temperatures have been reported to increase the heterophil to lymphocyte (H/L) ratio as an indicator of stress (Ghasemi et al., 2014).

Phosphorus (P) is an essential and critical mineral for poultry to aid several functions in metabolism. During earlier decades, insufficient utilization of phytate P by monogastric animals, especially poultry species, necessitated addition of inorganic P in the diet to meet their nutritional needs (Panda et al., 2007). Supplementation of poultry diet with phytase (PHY) can reduce P excretion up to 50% which will not only reduce environmental pollution but also lead to a decreased need for inorganic P supplementation by improving phytate P utilization. Beneficial effects of dietary PHY supplementation on feed intake, egg production, egg weight, eggshell quality and P utilization of laying hens fed diets based on corn or a combination of wheat and corn have been frequently published (Wu et al., 2006; Yao et al., 2007; Lei et al., 2011; Gao et al., 2013). In these studies, levels of dietary non-phytate phosphorus (NPP) ranged from 0.10% to 0.50% and PHY supplementation was also used at dietary inclusion levels ranging between 100 and 600 units (U)/kg feed. The results of a long-term study (Meyer and Parsons, 2011) also confirmed that a corn-based diet containing 1.05 g/kg NPP and supplemental PHY at 150 U/kg supported optimal egg laying performance from 32 to 62 wk of age. In another study from 22 to 46 wk of age, a diet containing 1.1 and 1.3 g/kg NPP and as little as 150 FTU/kg of the supplemental PHY enzyme was as efficacious as a diet containing 3.2 g/kg NPP for laying hen performance (Francesch et al., 2005). Englmaierová et al. (2014) also found that 2.1 g of NPP with 150 FTU was sufficient in the diet for optimal laying performance in the laying hens from 37 and 49 wk of age.

Rice bran (RB), a by-product of rice milling, is one of the main feed ingredients used in rice-producing countries, which has the highest content of phytate P among feed ingredients of plant origin. Paik (2003) reported that RB contains as high as 1.89% P but the availability of P in RB is greatly reduced due to its high phytate level. Although RB is relatively less expensive than corn, its use is limited in poultry diets due to high crude fiber, unsaturated fatty acid and phytate contents. Ersin Samli et al. (2006) showed that dietary inclusion of RB at more than 10% had adverse effects on laying performance and egg quality of laying hens. Improving methods for the feeding value of RB, including supplementation of non-starch polysaccharide-degrading enzymes and microbial PHY, have also been evaluated. In this case, Leske and Coon (1999) found that the addition of PHY significantly increased phytate hydrolysis and P retention from RB in broiler and laying hen rations. In another study, microbial PHY was effective in improving P utilization in brown-egg layers fed corn-soybean meal-based diets containing 22% RB and at its recommended level could replace at least 0.12% total P from dicalcium phosphate (Tangendjaja et al., 2002). However, most of these studies were performed in environmentally controlled houses at a thermo-neutral zone. Since many regions of world are located in the tropical and subtropical zones, heat stress is mostly a problem when layers are kept in naturally ventilated houses during hot summer months. Although the use of PHY in laying hen diets to improve P utilization has received the majority of the focus in research, to our knowledge, there is no published data evaluating the value of PHY supplementation in laying hens' receiving diets low in NPP level and/or high in RB content (phytate concentration) while exposed to high ambient temperatures. Therefore, the objective of this study was to investigate the effects of PHY supplementation of diets with different levels of RB and NPP on performance, egg quality traits, blood lipids profile and leukocyte subset response in laying hens reared indoors under high environmental temperatures.

2. Materials and methods

2.1. Meteorological data

The experiment was conducted at the farming and animal husbandry station, Razi University, Kermanshah city, Kermanshah province, Iran. Kermanshah is located in western region of Iran positioned between 34°18′ N and 47°03′ E at height of