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Abstract: The interaction between dietary energy and key nutrients, and its impact on broiler performance and mitochondrial function, remains poorly understood. This study aimed to evaluate the effects of energy and nutrient (lysine, calcium, and phosphorus) levels on animal performance and liver expression of genes related to lipid metabolism and electron transport in broilers from 22 to 42 days of age. A total of 432 male Cobb 500 broiler chickens were distributed in a completely randomized design with three treatments, eight replications, and 18 birds per experimental unit. The first treatment (control) consisted of a diet based on corn and soybean meal with a metabolizable energy (ME) content of 12.70 MJ/kg of dry matter. The second treatment was a high-energy (HE) diet (13.33 MJ/kg) formulated by increasing the ME value of the control diet by 0.63 MJ/kg while maintaining the same levels of digestible lysine, calcium (Ca), and available phosphorus (P). The third treatment was a high-energy and high-nutrient (HEHN) diet, providing 13.33 MJ/kg and a 5% increase in digestible lysine, Ca, and P levels compared to the control diet. Animal performance and carcass yield were analyzed at 42 days of age. Expression levels of apolipoprotein B (*APOB*), NADH dehydrogenase subunit I (*ND1*), and cytochrome c oxidase (*COX1*) genes were also determined. The treatments exerted a statistically significant effect on weight gain ($P = 0.0377$). The HE diets resulted in a statistically significant improvement in feed efficiency compared with the control diet ($P = 0.0017$), but no significant effect was observed on carcass yield. Furthermore, the HEHN diet enhanced weight gain compared with the control. *COX1* and *ND1* expression were influenced by dietary energy level. In conclusion, the results indicate that HEHN diets improve performance and alter the expression of genes related to lipid metabolism and electron transport in broiler chickens from 22 to 42 days of age but do not affect carcass yield.
Keywords: amino acids, minerals, mitochondria, gene expression.

1. Introduction

A balanced diet offers significant advantages to animal performance, providing economic and environmental gains. From this perspective, metabolizable energy (ME) is a strategic nutritional factor, as it favors feed intake, improves feed conversion, and reduces body fat in birds. However, when altering the energy level of bird diets, it is essential to proportionally adjust the levels of amino acids and minerals to ensure optimal production efficiency (Jlali et al., 2020).

The minerals calcium and phosphorus and the amino acid lysine are crucial nutrients that need to be obtained in adequate amounts from the diet to support bird growth (Mansilla et al., 2020; Alagawany et al., 2021; Tran et al., 2021). However, more knowledge is needed about the effects of energy and nutrient interactions on the molecular mechanisms of mitochondrial energy production. It is known that nutritional factors are directly associated with the functioning of mitochondria (Jehl et al., 2019; Saheb et al., 2019), suggesting a relationship between energy performance and mitochondrial gene expression in chickens (Li et al., 2021; Poompramun et al., 2021; Dunislawska et al., 2023).

Studies have shown that dietary energy availability affects the expression of mitochondrial genes and that lysine enhances the expression of electron transport chain genes (Désert et al., 2018). These events are only possible because consumed nutrients are exported from the liver to extrahepatic tissues. In birds, the liver is a crucial organ in energy metabolism, as it captures fatty compounds obtained from the diet or through de novo synthesis and transfers them to extrahepatic tissues via very low-density lipoproteins (VLDL) (Hermier, 1997).

The synthesis and release of VLDL depend on numerous factors. Apolipoprotein B (ApoB) plays a vital role in lipid transport and energy metabolism, participating in the regulation of body weight and abdominal fat deposition in animals (Na et al., 2018; Suzuki et al., 2019). APOB gene expression levels vary according to the age and species of the bird. This gene can be easily detected in liver tissues (Li et al., 2018).

Diets containing optimum levels of amino acids, minerals, and energy contribute to enhancing performance and carcass quality (Johnson et al., 2020). Thus, there is likely a correlation between nutritional status and the expression of genes involved in nutrient transport and energy production, as evidenced by ATP synthesis via the electron transport chain. Given the foregoing, this study aimed to assess the effects of dietary energy and nutrient (lysine, Ca, and P) levels on animal performance and expression of genes related to lipid metabolism and electron transport, namely APOB, cytochrome c oxidase (COX1), and NADH dehydrogenase subunit I (ND1), in broilers from 22 to 42 days of age.

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