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The optimal digestible valine, isoleucine and tryptophan intakes of broiler breeder hens for rate of lay

M.B. Lima[a,*], N.K. Sakomura[a], E.P. Silva[a], J.C.P. Dorigam[a], N.T. Ferreira[a], E.B. Malheiros[b], J.B.K. Fernandes[c]

[a] Department of Animal Science, College of Agrarian and Veterinary Sciences, University Estadual Paulista, 14884-900, Jaboticabal, São Paulo, Brazil
[b] Department of Exact Science, College of Agrarian and Veterinary Sciences, University Estadual Paulista, 14884-900, Jaboticabal, São Paulo, Brazil
[c] Aquaculture Center of University Estadual Paulista, 14884-900, Jaboticabal, São Paulo, Brazil

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ABSTRACT

Three concurrent assays were conducted with objective of to evaluate the response of broiler breeder hens to valine (Val), isoleucine (Ile), and tryptophan (Trp) intake, determine amino acid utilization efficiency (k), and develop a factorial model. One hundred ninety-two hens were used in each amino acid (AA) assay. A completely random design was used, which consisted of eight treatments, eight replicates, and one hen per cage. The diets were formulated by dilution technique using one summit diet and one nitrogen (N)-free diet, resulting in AA levels that ranged from 1.90 to 9.52, 1.75 to 8.75, and 0.52 to 2.59 g/kg of Val, Ile, and Trp, respectively. A validating diet was included for each amino acid studied to confirm that the response of the birds was a function of the limiting amino acid. Each experiment lasted nine weeks (five weeks of adaptation and four weeks for data collection). The data obtained were AA intake (AAI), body weight (BW), and egg output (EO). Broken line model was used to evaluate the responses. The model design used was $AAI = [AA_m \times (BW \times 0.196)^{0.73}] + [(N_{egg} \times EO \times AA_{egg})/k]$, where AA_m is AA for maintenance (247, 134, or 37 mg/$BP_m^{0.73}$ for Val, Ile, and Trp respectively); $BP_m^{0.73}$ is mature body protein or $(BW \times 0.196)^{0.73}$; k is 0.70 for Val, 0.66 for Ile, or 0.55 for Trp; N_{egg} is the N content in the egg (1.89 g/100 g); and AA_{egg} is the AA content in the egg (413, 338, or 108 mg/g for Val, Ile, and Trp respectively). The additional response seen with the supplementation of the crystalline amino acid confirmed that Val, Ile, and Trp were the first limiting amino acid. The values estimated by the model for utilization efficiency were: 70, 66, and 55% for Val, Ile, and Trp, respectively. The AAI estimated by the model at 30 weeks was 803, 708, and 232 mg/day for Val, Ile, and Trp, respectively. The prediction of the model was improved using the coefficients estimated here with physiologically relevant units.

1. Introduction

Constant genetic improvements have enhanced poultry industry productivity in recent decades. In parallel with these advances, feed producers must frequently redefine nutritional plans considering new breed requirements, scientific developments, and local or global economic situation of the productive chain. Despite existing recommendations (NRC, 1994; Rostagno et al., 2011), industry

Abbreviations: AA, amino acids; AAI, amino acid intake; BW, body weight; BWG, body weight gain; E, efficiency; EO, egg output; Ile, Isoleucine; RL, rate of lay; Trp, Triptofano; Val, valine

* Corresponding author.
E-mail address: michele_bernardino@yahoo.com.br (M.B. Lima).

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professionals often attempt to improve rate of lay, egg weight, and hatchling weight by manipulating protein daily intake with no attention to specific amino acid requirements. Nevertheless, a number of reports suggest that high protein intake negatively affects fertility and hatchability (Pearson and Herron, 1982; Shafey, 2002; Ekmay et al., 2013). In addition, increasing the intake of amino acids such as lysine and isoleucine adversely affects hen fertility and egg hatchability (Ekmay et al., 2013).

Mathematical models represent an important tool that incorporates productivity variables to update nutritional requirements. These models also allow for greater flexibility than experimental methods in determining what variables might be more relevant to specific regions or even individual producers (Gous, 2014). However, to have good predictive value models must incorporate the correct factors and coefficients. Furthermore, these factors and coefficients must often be adjusted to new breeds and conditions.

Specifically regarding broiler breeder hens, existing factorial models mostly rely on coefficients and data from commercial laying hens. This is clearly not an optimal situation. For example, laying hens have an amino acid utilization efficiency of 85% whereas for broiler breeders this number is closer to 49% (Bowmaker and Gous, 1991; Silva et al., 2015a). These differences arise from the egg-laying potential of the two types of hens, and demonstrate how poorly data from one breed, inserted into a model, would predict nutritional needs of the other.

Therefore, more studies are necessary to define the relevant variables and correct coefficients to be used in mathematical models for the nutrition of broiler breeders. Thus, in this study we evaluated the response of broiler breeder hens to different concentrations of valine, isoleucine, and tryptophan, three amino acids that are rarely studied in this context. We determined amino acid utilization efficiency and adapted the mathematical model originally developed by Bornstein et al. (1979).

2. Materials and methods

2.1. Birds and experimental design

Three dose response studies were performed using broiler breeder hens. The Animal Ethics and Welfare Committee of Universidade Estadual Paulista approved all experimental procedures used in this study under the Protocol number 9999/14.

One hundred ninety-two broiler breeder hens of Cobb 500® genotype with 48 weeks of age were used, with sixty-four birds per trial housed individually in metabolic cages. The cages were equipped with individual feeders and nipple drinkers. The experimental design was a completely randomized design with eight treatments (seven increasing levels of the amino acid and a control diet) and eight replicates.

2.2. Bird management

Two weeks before the beginning of the experiment, all birds were fed 150 g per day of a diet designed to meet their nutritional requirements during this period, according to recommendation of Rostagno et al. (2011). The rate of lay was monitored to provide a baseline for the experimental period. The experiment lasted nine weeks, with the first five weeks of adaptation and the last four weeks for data collection.

The lighting program adopted during the experiment was 17 hours of light. The hens were raised in a poultry house with a negative-pressure system with controlled temperature of 21 °C. The daily management was performed according to the Cobb 500 guidelines.

2.3. Experimental diets

For each amino acid assay a high protein summit diet, based on corn and soybean meal, was formulated, containing 9.52 g/kg of Val, 8.75 g/kg of Ile, and 2.59 g/kg of Trp (Table 1). The total amino acid content in experimental diets were analysed by Ajinomoto using high-performance liquid chromatography (HPLC), and values obtained were corrected for digestible amino acids using the tabulated coefficients of digestibility (Rostagno et al., 2011).

For each trial a nitrogen-free diet was formulated to meet the same nutritional levels as the summit diets, except for protein and amino acids. The nitrogen-free diets were used to dilute the summit diets, in appropriate proportions, to obtain the range of Val, Ile, and Trp (Table 2) contents required for each dilution series (Fisher and Morris, 1970).

To confirm that the response of the birds to each dilution series was in function of the respective limiting amino acid, a control diet was included for each amino acid assay. A small quantity of the respective crystalline amino acid was added to the diet with the lowest level of the amino acid tested sufficient to meet the level of the amino acid in the second-lowest level in the dilution series (Table 2).

2.4. Allocation of diets and measurements

The birds were fed 150 g per day of feed, at the same time each morning, and at the end of the week the leftovers were weighed to quantify the weekly consumption of the feed. The body weight of the hens was measured on the first, sixth, and tenth weeks of the assay. Egg production was recorded daily and egg weight was measured on three consecutive days each week.