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Relação entre triptofano e lisina digestivel na dieta de codornas japonesas na fase de crescimento

Digestible trypthophan and digestilbe lysine ratios in diets for growing japanese quails

Ratios digestibles de triptofano y lisina digestible en dietas para crecimiento de cocinos japonês

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Resumo

O objetivo deste estudo foi avaliar os efeitos de diferentes proporções de triptofano e lisina digestível para codornas japonesas em crescimento (1 a 40 dias de idade) com repercussões no estágio inicial de produção (41 a 110 dias de idade). Foram distribuídas aleatoriamente 1000 codornas japonesas com um dia de idade, em cinco proporções de triptofano e lisina digestível, 10 repetições e 20 aves por unidade experimental. Uma dieta basal deficiente em triptofano foi formulada com 1,48 g de triptofano digerível/kg, correspondendo a uma proporção de triptofano e lisina de 0,14. Essa dieta basal foi suplementada com cinco níveis de L-triptofano (98%), substituindo o ácido glutâmico correspondente à proporção de triptofano e lisina de 0,14 (sem suplementação); proporções de 0,16; 0,18; 0,20 e 0,22, sendo as dietas isocalóricas e isonitrógenas. Foi avaliado o desempenho das aves nas fases de crescimento e postura. Embora o peso corporal e o ganho de peso até os 40 dias de idade tenham aumentado (P <0,001) e o consumo de ração na fase de postura tenha diminuído (P =

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0,037) de maneira linear, a PRL foi a que apresentou o melhor ajuste para esses parâmetros. O efeito foi quadrático para consumo de ração (P = 0,0069), conversão alimentar (P = 0,0032) e viabilidade (P <0,001) das aves na fase de crescimento. Um efeito quadrático foi encontrado para a produção de ovos por ave alojada em um dia de idade (P <0,001), ganho de peso aos 110 dias de idade (P = 0,039) e conversão alimentar por massa de ovo (P = 0,046) na fase de postura. A ingestão de triptofano aumentou (P <0,001) e a produção de ovos por ave alojada na fase de postura diminuiu linearmente (P <0,001) com o aumento das proporções entre triptofano e lisina. A proporção de triptofano digestivo e lisina digestível é de 0,18 (1,88 g de triptofano / kg e 10,5 g de lisina / kg de dieta), correspondendo a uma ingestão de 20,63 mg de triptofano por ave por dia, na dieta para crescimento, proporcionando maior viabilidade de aves na fase de crescimento e desempenho satisfatório de codornas japonesas na fase de postura.

Palavras-chave: Aminoácidos essenciais; Desempenho; Produção de ovos; Proteína ideal.

Abstract

The objective of this study was to evaluate the effects of different tryptophan and digestible lysine ratios for growing Japanese quails (1 to 40 days of age) with repercussions on the early stage of production (41 to 110 days of age). A total of 1000 one day old Japanese quails were distributed at random, with five tryptophan and digestible lysine ratios, 10 replicates and 20 birds per experimental unit. A tryptophan- deficient basal diet was formulated with 1.48 g of digestible tryptophan /kg, corresponding to a ratio of tryptophan and lysine of 0.14. This basal diet was supplemented with five levels of L-tryptophan (98%), replacing glutamic acid corresponding to the tryptophan and lysine ratio of 0.14 (no supplementation); ratios of 0.16; 0.18; 0.20 and 0.22, being the diets isocaloric and isonitrogenous. The performance of the birds in the growing and egg laying phases was evaluated. Although body weight and weight gain until 40 days of age had increased (P<0,001) and feed intake in the egg laying phase had decreased (P=0,037) in a linear fashion, LRP was the one with the best adjustment for those parameters. The effect was quadratic for feed intake (P=0,0069), feed conversion (P=0,0032) and viability (P<0,001) of the birds in the growing phase. A quadratic effect was found for egg production per bird housed at one day of age (P<0,001), weight gain at 110 days of age (P=0,039) and feed conversion per egg mass (P=0,046) in the laying phase. Intake of tryptophan increased (P<0,001) and egg production per housed bird in the laying phase linearly decreased (P<0,001) with the increase in the ratios between tryptophan and lysine. The digestible tryptophan and digestible lysine ratio is 0.18 (1.88 g of tryptophan/kg and 10.5

g of lysine/kg of diet), corresponding to an intake of 20.63 mg of tryptophan per bird per day, in the diet for growing, provides greater viability of birds in the growing phase and a satisfactory performance of Japanese quails in the laying phase.

Keywords: Egg production; Essential amino acids; Ideal protein; Performance.

Resumen

El objetivo de este estudio fue evaluar los efectos de diferentes proporciones de triptófano y lisina digerible para las codornices japonesas en crecimiento (1 a 40 días de edad) con repercusiones en la etapa temprana de producción (41 a 110 días de edad). Un total de 1000 codornices japonesas de un día de edad se distribuyeron al azar, con cinco proporciones de triptófano y lisina digerible, 10 réplicas y 20 aves por unidad experimental. Se formuló una dieta basal deficiente en triptófano. Contenía 1,48 g de triptófano digerible / kg, correspondiente a una proporción de triptófano y lisina de 0,14. Esta dieta basal se complementó con cinco niveles de L-triptófano (98%), reemplazando el ácido glutámico correspondiente a la proporción de triptófano y lisina de 0.14 (sin suplementación); relaciones de 0,16; 0,18; 0.20 y 0.22, siendo las dietas isocalóricas e isonitrógenas. Se evaluó el desempeño de las aves en las fases de crecimiento y puesta de huevos. Aunque el peso corporal y el aumento de peso hasta los 40 días de edad habían aumentado (P <0,001) y la ingesta de alimento en la fase de puesta de huevos había disminuido (P = 0,037) de forma lineal, LRP fue el que mejor ajuste para esos parámetros. El efecto fue cuadrático para el consumo de alimento (P = 0,0069), la conversión de alimento (P = 0,0032) y la viabilidad (P <0,001) de las aves en la fase de crecimiento. Se encontró un efecto cuadrático para la producción de huevos por ave alojada al día de edad (P <0,001), aumento de peso a los 110 días de edad (P = 0,039) y conversión de alimento por masa de huevo (P = 0,046) en la fase de puesta. La ingesta de triptófano aumentó (P <0,001) y la producción de huevos por ave alojada en la fase de puesta disminuyó linealmente (P <0,001) con el aumento de las relaciones entre triptófano y lisina. La proporción de triptófano digerible y lisina digestible es 0.18 (1.88 g de triptófano / kg y 10.5 g de lisina / kg de dieta), que corresponde a una ingesta de 20.63 mg de triptófano por ave por día, en la dieta para el crecimiento, proporciona una mayor viabilidad de aves en la fase de crecimiento y un desempeño satisfactorio de las codornices japonesas en la fase de puesta.

Palavras clave: Aminoácidos esenciales; Producción de huevo; Proteína ideal; Rendimiento.

1. Introduction

Tryptophan belongs to the class of essential amino acids, that is, it is not produced by the body system of birds in a sufficient rate for their needs for maximum performance. It is involved in several metabolic functions, being a structural component of all proteins in addition of being the precursor of the synthesis of serotonin and melatonin (Corzo et al., 2005). In the immune response, high concentrations of metabolites of tryptophan are present in the blood, organs and sites of inflammation (Moffett & Namboodiri, 2003). This amino acid needs several metabolic steps for biosynthesis, and its absence would prevent the system of the animal to realize protein synthesis, and to grow as a consequence (Bertechini, 2006).

Studies have related the increase in the aggressiveness index of animals in production system, especially cage-housed birds, to the deficiency of tryptophan in the diet. Because quails are birds with an agitated behavior and, by considering the importance of tryptophan in the protein synthesis and animal growth, as well as the need of determining an amino acid pattern, based in the concept of the ideal protein for quails, it is necessary to study the ratio between tryptophan and lysine in the diets of those birds. Nutrition of growing quails have been based in old data and on experiment which did not encompassed all the growing phase of the birds, that is, they did not consider housing of quails since the first day of life.

Requirements of amino acids for growing quails have received little attention (Bennett & Cheng, 2010). Taking into account the precocity and high productivity of quails, to carry out studies for implementation of the correct feeding programs has become important, especially in the initial phase of rearing, which has less volume of works than on the production phase. With the present availability of manufactured amino acids, the gross reduction of protein in the diet based in the ratio of amino acids with lysine may be used.

Studies based on the ratios between amino acids and lysine for quails will be able to make it feasible the protein content of the diets with the supplementation of essential amino acids. Thus, aiming at the reducing of the level of crude protein in the diet by using the concept of ideal protein, the objective of this study was to evaluate the ratio between digestible tryptophan and digestible lysine in the diet for Japanese quails in the growing phase (from 1 to 40 days of age) with repercussion in the initial laying phase (41 to 110 days of age).

2. Material and Methods

Growing phase (from 1 to 40 days of age)

The experiment was carried out in the Poultry Section (Setor de Avicultura) in the Animal Science Department (Departamento de Zootecnia) at the Federal University of Viçosa. This study was carried out in strict accordance with the recommendations in the Guide for the Care of Brazilian Council of Experiments using Animals. The protocol was approved by the Committee on the Ethics of Animal Experiments of the Departament of Animal Science, Universidade Federal de Viçosa (Permit Number: 13/2011).

A total of 1000 one day old, female, Japanese quail species (*Coturnix japonica*), body weight of 8.37 $\pm$ 0.27 g, were distributed into a complete random design with five dietary treatments (ratios between digestible tryptophan and digestible lysine), 10 replicates and 20 birds per cage (experimental unit). Each cage had 50 cm of width and 50 cm of length, providing a space of 125 cm^2/bird, with masonry floor covered with 4 cm of shavings. Light bulbs of 60w were used for heating until birds were 15 days of age in each cage. Bulbs were turned on two hours before arrival of the flock to adjust installation temperature and to provide the needed heat for the birds.

The cages, which were installed inside a shelter, were made of galvanized wire, covered and managed by raffia curtain in the first 15 days of age to keep the heating, which was also achieved by installing curtains in the sides of the shelter.

The drinkers used in the experiment were the pressure glasses at the proportion of one drinker per cage. After being housed, the birds were directed for the presence of water. From the age of 12 days, the pressure glass drinkers were replaced by nipple type drinkers with a glass at the proportion of one drinker per cage.

Tray type feeders were used. They had a diameter of 18 cm, at a proportion of one feeder per cage until 12 days of age, when they were replaced by gutter type feeder, placed in the front part of the cages.

Light program was the 24 hours of artificial light (the same light bulbs used for heating source) until day 15, and after until birds were 40 days of age, when natural light was used to avoid early sexual maturity of the quails.

Temperature was controlled by sensors set in the cages and based in the behavior of the quails as well. Room temperature of the cages was automatically checked every second by temperature sensors and air relative humidity was checked by dry bulb and wet bulb thermometers both set close to the cages. Data of wet and dry bulb thermometers were collected twice a day at 9:00 a.m. and at 3:00 p.m.

Birds were submitted to basal diets, deficient in digestible tryptophan based on corn and soybean with 174.0 g CP/kg, 12.14 MJ/kg, 10.5 g digestible lysine /kg (sub-optimal level) and 1.48 g of digestible tryptophan/kg, corresponding to a tryptophan and lysine ratio of 0.14 (Table 1). This basal diet was supplemented with five levels of L-tryptophan (98%), replacing glutamic acid, corresponding to the following tryptophan and lysine ratios: 0.14 (no supplementation, 1.48 of digestible tryptophan/kg); 0.16 (1.68 g of digestible tryptophan/kg); 0.18 (1.88 g of digestible tryptophan/kg); 0.20 (2.08 g of digestible tryptophan/kg) and 0.22 (2.36 g of digestible tryptophan/kg), being the diets isoprotein, isocaloric and isonitrogen.

It was maintained the amino acid ratios with lysine, proposed by NRC (1994), except the one between methionine + cystine and lysine which was in function of Lima et al. (2015) and the one between threonine and lysine which was in agreement with Lima et al. (2016). To guarantee the lack of deficiencies, 3% were added into the the requirements of each amino acid, except digestible lysine and digestible tryptophan.

Before being moved into laying cages, quails at 40 days of age had their beaks trimmed to prevent cannibalism according to the orientations of Conselho Nacional de Controle de Experimentação Animal – CONCEA (Brazilian Council of Experiments using Animals) and approved by the Ethics Committee of the Animal Science Department of the Federal University of Viçosa.

Laying phase (41 to 110 days of age)

To evaluate the repercussion of the growing and development of quails in the laying phase, birds at 41 days of age were moved into laying cages where the remaining birds of each experimental unit of the growing phase were kept.

Birds were housed in galvanized wire cages (experimental unit), arranged in ladders, with dimensions of 50 x 34 cm, equipped with gutter type feeders, placed in the front part of each cage and nipple type drinkers.

Each experimental unit provided 106.2 cm^2 /bird, when there was no mortality in the respective experimental unit in the growing phase. Light program was of 16 daily hours, remaining the same until the end of the experimental period. Light supply was controlled by a timer, which allowed to turn on and to turn off lights at night as the procedure adopted in the commercial poultry farms. Room temperature was checked automatically at every second.

In the laying phase, quails were fed a single diet based on corn and soybean (Table 2), formulated to meet the presented nutritional requirements as well as the chemical composition and nutritional value of the ingredients used in the diet formulation in Rostagno et al. (2011).

Assessed parameters

Feed intake was measured weekly. For the dead birds, their average intake was subtracted and corrected, resulting in the real average intake for experimental unit.

Feed conversion in the growing phase was calculated by dividing feed intake by the body weight gain accumulated in the period (kg of diet /kg of weight gain).

All birds were weighed at the beginning and in the end of the growing phase and the laying phase for weight determination at 40 and 110 days and weight gain of animals in each phase.

To determine viability of the birds in the growing and laying phases, the number of dead quails was written down daily. Mortality of the birds was subtracted from the total number of live birds in both laying and growing phases, by converting the numbers obtained in the end of the period into percentage.

All birds were individually weighed for determination of uniformity in each experimental unit in both growing and laying phases, expressed as percentage of the weights with a variation of an average $\pm$ 10% obtained in the respective unit.

Two quails were killed at 40 days of age within the average weight of each experimental unit. Birds were slaughtered according to the Conselho Nacional de Controle de Experimentação Animal – CONCEA and approved by the ethic committee of the Animal Science Department of the Federal University of Viçosa. Birds were dry plucked and the feathers were weighed for calculation of feathering. Then, they were eviscerated, cooled, frozen and ground for determination of contents of dry matter, ether extract and crude protein according to Silva and Queiroz (2002).

Deposition of body fat and protein was calculated by means of the slaughter carried out in another group of 50 quails at one day of age. They were compared to those birds slaughtered in the end of the growing phase. The value found in the sample for average weight of the live animal in each experimental unit was used for the final calculation of deposition of body fat and protein, according to Pinto et al. (2003).

Average egg production in the period was obtained by daily computing of the number of produced eggs, including broken, cracked and abnormal eggs, being expressed on the number of birds in the period (produced egg/bird/day) and on the number of the birds housed in the beginning of the experiment (produced egg/housed bird).

Feed conversion per dozen eggs expressed by total feed intake in kilograms divided by produced dozen eggs (kg/dz) was evaluated as well as egg mass conversion, which was obtained by feed intake in kilogram divided by egg mass produced in kilograms (kg/kg).

All intact eggs produced in the last three days of each week during the whole experiment period, in each replicate, were weighed and the total weight obtained was divided by the number of eggs used in the weighing.

Average weight of the eggs was multiplied by the total number of eggs produced in the period, this total mass was divided by the total number of birds in the period and by the number of days in the period as well, expressed in egg gram per bird per day (egg g/bird/Day).

Statistical analyses

The cages were the experimental units used for statistical evaluation. The effects of the treatments were estimated by analyses of the variables by the models of linear and quadratic regression and by the *Linear Response Plateau* (*LRP*), according to the best adjustment obtained for each variable and by considering the biological behavior of the birds. The parameters were submitted to the statistical analyses according to the software SAS (2004).

3. Results

In the growing phase, quails need an ideal thermo-hygrometric environment of 35 to 37°C and air relative humidity of 65% in the first week of life; in the second week of life these values change to 32°C and 60% of relative humidity and from 15 days of life those birds do not require artificial heating no longer because they present good feathering at maximum and minimum temperatures of 31°C and 19°C and 60 and 65% of relative humidity (Vohra Pran, 1971; Reis, 1980; Singh & Narayam, 2002; Pinto et al., 2003; Oliveira, 2004). In the adult phase, the thermal comfort range of quails is between 18 and 22°C and the relative humidity of air is 65 to 70% (Oliveira, 2004).

The air temperature inside the experimental shelter for the period 1 to 7, 8 to 14, 15 to 40 and 41 to 100 days of age of the birds was 31.64±2.13, 29.10±2.03, 25.12±2.54 and

24.38±2.17 respectively. The relative humidity for the period 1 to 7, 8 to 14, 15 to 40 and 41 to 100 days of age of the birds was 88.14±3.88, 87.43±6.16, 87.77±4.91 and 87.33±5.12 to 9:00 a.m. and was of 85.57±5.19, 79.57±5.50, 72.40±11.84 and 70.45±10.32 to 3:00 p.m. respectively.

By considering the information in the literature, temperature measurements and humidity as well as the behavior of the quails, it was found that birds were in an adequate thermo-hygrometric environment; however, they were exposed to stress conditions during some periods during the day.

Even if the higher critical temperature of the thermoneutrality zone for Japanese quails of 27°C (Vercese, 2010), had not been exceeded most of the time in the experimental units, after birds had presented complete feathering, quails were exposed to periods of temperature and humidity higher than the thermal comfort range. On the other hand, this fact showed that it affected quail productions since performance of the birds was within the range considered normal for the species.

Although body weight and weight gain of birds until 40 days of age had increased (P<0,001) and feed intake had linearly decreased (P=0,037) in the laying phase (table 3), LRP was the one with the best adjustment, estimating at 0.20; 0.20 and 0.17 the ratios in which a plateau occurred for the greatest weights at 40 days of age, with gains until 40 days of age and a lower feed intake for laying phase, respectively, according to the following equations: weight at 40 days of age: $\hat{Y}$= 106.0790 + 139.050X; Y= 133.68; R^2= 0.99; weight gain until 40 days of age: $\hat{Y}$= 97.6180 + 139.350X; Y=125.33; R^2=0.99 and feed intake in the laying phase: $\hat{Y}$= 27.3100 – 26.500X; Y= 22.7250; R^2=0.99.

A quadratic effect was found for feed intake (P=0,0069), feed conversion (P=0,0032) and viability of the birds in the growing phase (P<0,001) according to the following equations: Feed intake: $\hat{Y}$= -5.29453 + 166.957X – 424.831X^2, R^2=0.85; Feed conversion: $\hat{Y}$= 0.0651752 + 36.4400X – 97.0582X^2, R^2=0.62 and viability of the birds: $\hat{Y}$= -85.7857 + 1978.57X – 5357.14X^2, R^2=0.62, estimating the ratios of 0.196, 0.19 and 0.18, in which the greater feed intake, the worst feed conversion and the highest viability of birds occurred, respectively.

It was found, in the laying phase, a quadratic effect (P<0,001) for egg production per housed bird at 1 day of age, egg weight (P=0,0014), weight gain until 110 days of age (P=0,039) and feed conversion per egg mass (P=0,046). The following values of ratios was found: 0.18 for the greatest egg production per housed bird at 1 day of age; 0.18 for the lowest egg weight; 0.19 for the smallest weight gain at 110 days of age and 0.19 for the worst (0.14 provided a better result) feed conversion per egg mass (equations: eggs per housed bird at one day of age: $\hat{Y}$= 128.540 + 1998.49X – 5474.80X^2, R^2=0.87; egg weight: $\hat{Y}$= 15.6769 – 58.5357X + 166.071X^2, R^2=0.80; weight gain at 110 days of age: $\hat{Y}$= 137.563 – 1011.74X + 2589.29X^2, R^2=0.84; Feed conversion per egg mass: $\hat{Y}$= 7.54225 + 115.507X – 298.214X^2, R^2=0.61).

Consumption of tryptophan increased (P<0,001) and egg production per housed bird in the laying phase linearly decreased (P<0,001) as the ratios between tryptophan and lysine increased (equations: tryptophan intake: $\hat{Y}$ = -4.85900 + 139.850 X, R^2 = 0.98; production of eggs per housed bird in the laying phase: $\hat{Y}$ = 71.0810 – 72.1500 X, R^2 = 0.78).

Parameters of the growing phase, uniformity at 40 days of age, carcass weight, feather percentage and protein and fat deposition in the carcass and parameters of laying phase, egg production per bird per day, feed conversion per dozen eggs, egg mass and weight and uniformity of the birds at 110 days of age did not present any effect (P>0.05).

Table 1 – Composition (dry matter basis) and nutritional value of the diets for Japanese quails in the growing phase

Ingredient (g/kg)	tryptophan / lysine ratio				
	0.14	0.16	0.18	0.20	0.22
Ground corn	625.0	625.0	625.0	625.0	625.0
Soybean meal	141.3	141.3	141.3	141.3	141.3
Meat and bone meal	45.0	45.0	45.0	45.0	45.0
Wheat meal	150.0	150.0	150.0	150.0	150.0
Limestone	2.0	2.0	2.0	2.0	2.0
Salt	2.8	2.8	2.8	2.8	2.8
Mineral mix1	0.5	0.5	0.5	0.5	0.5
Vitamin mix2	1.0	1.0	1.0	1.0	1.0
Choline chloride	3.8	3.8	3.8	3.8	3.8
Antioxidant3	0.1	0.1	0.1	0.1	0.1
Coccidiostat4	0.5	0.5	0.5	0.5	0.5
L- Lysine	5.5	5.5	5.5	5.5	5.5
DL- Methionine	3.7	3.7	3.7	3.7	3.7
L- Threonine	1.6	1.6	1.6	1.6	1.6
L- Isoleucine	3.1	3.1	3.1	3.1	3.1
Arginine	1.2	1.2	1.2	1.2	1.2
Valine	1.9	1.9	1.9	1.9	1.9
L- Tryptophan	0.0	0.2	0.4	0.6	0.9
L- Glutamic	9.0	8.7	8.4	8.1	7.7
Starch	2.0	2.1	2.2	2.3	2.4
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated composition					
Metabolizable energy (MJ/kg)	12.14	12.14	12.14	12.14	12.14
Crude protein (g/kg)	174.00	174.00	174.00	174.00	174.00
Calcium (g/kg)	8.00	8.00	8.00	8.00	8.00
Available phosphorus (g/kg)	3.00	3.00	3.00	3.00	3.00

Sodium (g/kg)	1.50	1.50	1.50	1.50	1.50
Crude fiber (g/kg)	32.29	32.29	32.29	32.29	32.29
Digestible amino acid					
Lysine (g/kg)	10.50	10.50	10.50	10.50	10.50
Methionine +Cystine (g/kg)	8.00	8.00	8.00	8.00	8.00
Tryptophan (g/kg)	1.48	1.68	1.88	2.07	2.36
Threonine (g/kg)	6.90	6.90	6.90	6.90	6.90
Arginine (g/kg)	10.39	10.39	10.39	10.39	10.39
Isoleucine (g/kg)	8.23	8.23	8.23	8.23	8.23
Valine (g/kg)	7.98	7.98	7.98	7.98	7.98
Leucine (g/kg)	11,59	11,59	11,59	11,59	11,59
Phenylalanine (g/kg)	5,93	5,93	5,93	5,93	5,93
Histidine (g/kg)	3,31	3,31	3,31	3,31	3,31

[1] Provided g/kg diet: Manganese: 0,08, Iron: 0,05, Zinc: 0,05, Copper: 0,01, Cobalt: 0,001, Iodine: 0,001, Excipient q.s.p.: 1000 g. [2] Provided g/kg diet: Retinol: 36,0 mg, Cholecalciferol: 0,89 mg, Tocopherol: 23,33 mg, Thiamine :2,5 mg, Riboflavin: 8,0 mg, Pyridoxine:5,0 mg, Pantothenic Acid: 12,0 mg, Biotin: 2 mg, Naphthoquinone: 3,0 mg, Folic Acid: 1,5mg, Nicotinic Acid: 40,0 mg, Cobalamin: 20,0 mg, Selenium: 1,5 mg, Vehicle q.s.p.: 1,000g.
[3] Butylated hydroxytolune.[4]Salinomycin.

Table 2 - Composition (dry matter basis) and nutritional value of the diet for quail in the laying phase

Ingredient	g/kg
Ground corn	581.20
Soybean meal	313.80
Limestone	71.10
Dicalcium phosphate	11.00
Soybean meal	12.00
Refined salt	3.30
Mineral mixture[1]	0.50
Vitamin mixture[2]	1.00
DL- Methionine	3.00
L-Lysine HCL	2.00
Antioxidant[3]	0.10
Choline chloride	1.00
Total	1000.00
Calculated composition	
Metabolizable energy (MJ/kg)	11.72
Crude protein (g/kg)	193.10
Digestible lysine (g/kg)	10.80
Digestible methionine+cistine (g/kg)	8.64
Digestible tryptophan (g/kg)	2.26
Digestible threonine (g/kg)	5.93
Calcium (g/kg)	30.90
Available phosphorus (g/kg)	3.00
Sodium (g/kg)	1.45
Fiber (g/kg)	27.00

[1] Provided g/kg diet: Manganese: 0,08, Iron: 0,05, Zinc: 0,05, Copper: 0,01, Cobalt: 0,001, Iodine: 0,001, Excipient q.s.p.: 1000 g. [2] Provided g/kg diet: Retinol: 36,0 mg, Cholecalciferol: 0,89 mg, Tocopherol: 23,33 mg, Thiamine:2,5 mg, Riboflavin: 8,0 mg, Pyridoxine:5,0 mg, Pantothenic Acid: 12,0 mg, Biotin: 2 mg, Naphthoquinone: 3,0 mg, Folic Acid: 1,5mg, Nicotinic Acid: 40,0 mg, Cobalamin: 20,0 mg, Selenium: 1,5 mg, Vehicle q.s.p.: 1,000g. [3] Butylated hydroxytolune.

Table 3 - Performance of growing Japanese quails with repercussion on egg laying due to the ratios between digestible tryptophan and digestible lysine in the growing phase diet

Parameter	Digestible tryptophan : lysine dig (%)					SEM[a]	P-value	P-value
	0.14	0.16	0.18	0.20	0.22		Linear	Quadr.
Growing phase (from 1 to 40 days of age)								
Weight at 40 days of age (g)[1]	124.23	130.7	129.87	133.90	133.68	1.19	<0.001	0.066
Weight gain at 40 days of age (g)[1]	115.93	122.32	121.48	125.50	125.33	1.21	<0.001	<0.001
Feed intake (g/bird/day)[2]	9.60	10.84	10.97	10.83	11.01	0.19	<0.001	<0.001
Tryptophan intake (mg/bird/day)[3]	14.21	18.22	20.63	22.41	26.10	0.26	<0.001	0.224
Feed conversion (g/g)[2]	3.23	3.46	3.52	3.36	3.43	0.06	0.003	0.046
Uniformity at 40 days of age (%)[ns]	79.43	86.02	81.04	90.36	87.33	3.10	Ns	Ns
Carcass weight (g)[ns]	93.57	97.95	100.20	97.52	98.84	1.77	Ns	Ns
Feather percentage [ns]	5.72	5.84	5.50	6.09	5.51	0.22	Ns	N
Fat deposition (g/day)[ns]	0.08	0.08	0.07	0.09	0.10	0.01	Ns	Ns
Protein deposition (g/day)[ns]	0.52	0.54	0.57	0.56	0.56	0.01	Ns	Ns
Bird viability (%)[2]	84.37	96.87	98.12	90.62	92.50	1.72	0.092	<0.001
Laying phase (41 to 110 days of age)								
Egg production per bird per day (%)[ns]	61.00	60.38	57.82	59.99	55.16	1.93	Ns	Ns
Egg production /housed bird (%)[2]	61.00	59.39	57.26	58.68	54.14	1.94	Ns	<0.001
Eggs/housed bird at 1 day of age (%)[2]	42.9	53.1	53.8	50.0	47.2	0.84	Ns	<0.001
Feed intake (g/bird/day)[1]	23.59	23.09	22.53	22.85	22.60	0.31	0.037	0.198
Feed conversion /dozen (kg/dz) [ns]	0.50	0.49	0.50	0.49	0.52	0.01	Ns	Ns
Egg weight (g)[2]	10.75	10.56	10.45	10.72	10.80	0.07	0.254	0.001
Egg mass (g/bird/day)[ns]	5.65	5.43	5.04	5.42	4.92	0.21	Ns	Ns
Conversion/egg mass (kg/kg)[2]	2.69	3.41	3.83	3.20	3.61	0.21	0.023	0.046
Weight at 110 days of age (g)[ns]	171.70	170.62	170.77	172.73	173.70	1.94	Ns	Ns
Weight gain at 110 days of age (g)[2]	47.47	39.85	40.90	38.83	40.02	1.78	0.008	0.039
Uniformity at 110 days of age (%)[ns]	82.77	88.41	73.69	81.58	79.59	3.42	Ns	Ns
Bird viability (%)[ns]	100.00	97.60	98.60	95.91	96.70	1.45	Ns	Ns

[1]LRP (P<0.05); [2]Quadratic effect (P<0.05); [3]Linear effect (P<0.05); [ns]Non-siginifcant effect (P>0.05). [a] SEM, pooled standard error of the means.

4. Discussion

The digestible tryptophan and digestible lysine ratio of 0.20 provided a greater weight and weight gain of birds at 40 days of age and feed intake estimated in the growing phase. This fact may be related to the functions of the neurotransmissions which are influenced by the storage of their dietary precursors, more specifically to serotonin formed from tryptophan. Because serotonin is related to the stimulus of feed ingestion, the greater ratio between tryptophan and lysine provided up to the ratio of 0.20, greater feed intake and greater growth of quails, as a consequence.

The above mentioned can be confirmed by the intake of tryptophan which increased with the increase in the ratios, providing more tryptophan and consequently more serotonin. However, it can be inferred by the results that there was a peak in the ratio of 0.20 for availability of tryptophan for the synthesis of serotonin. This may be explained due to a small proportion of tryptophan used as precursors for the synthesis by the brain, which produces only 1 to 2% of body serotonin (Kerr et al., 2005). Therefore, the smaller ratios did not provide sufficient tryptophan for an adequate growth of quails and even though the requirement of this amino acid for the formation of serotonin was small, this one cannot be supplied and it is likely that there was a deficiency of tryptophan associated to the function of the immune system.

Thus, quails fed diets with a ratio of 0.14 presented lower diet intake in the growing phase, with a need of a higher feed intake in the laying phase to achieve a greater weight gain and the same uniformity at 110 days of age of the other birds. The negative effect of the deficiency of tryptophan on the feed voluntary intake and on the performance in the growing phase may be also related to the decrease of crude protein in the diet since the transport of tryptophan by cell membranes, in the intestine as well as in the brain, competes with the transport of long chain neutral amino acids (valine, leucine, isoleucine, tyrosine and phenylalanine). Therefore, the smaller ratio between tryptophan and lysine, by keeping Constant the ratio between lysine with the other amino acids, may have provided a smaller amount of tryptophan metabolized into serotonin, and therefore, a lower ingestion of this diet.

It was not found data on the ratios between tryptophan and lysine in diets for growth with repercussion in the laying phase of quails in the literature. Because egg mass was related to egg production per bird per day, it did not present differences in function of the ratios. However, quails fed diets containing the ratio of 0.14 presented the best feed conversion in the growing phase and the best conversion per egg mass, the highest egg production per housed bird in the laying phase and a satisfying viability in the laying phase. Despite all that, those birds achieved a low viability in the growing phase, which may be related to the fact that the products formed from the oxidation of tryptophan as well as from the oxidation of melatonin are potential regulators of the immune response and can take part into the immunosuppressive effect, in which tryptophan depletion has been suggested as the main mechanism of regulation (Pedrosa, 2007).

Also, because of the involvement of the tryptophan in the serotonergic system and therefore in the animal behavior, the small ratio between digestible tryptophan and digestible lysine caused a greater mortality of birds likely because in addition of depress the immune system, it accentuated the aggressive behavior of quails, increasing the accidents inside the cages. Head injuries are frequently in quails raised in cages (Cheng, 2002). Aggressions occur in the intensive system as well as in small groups of quails kept in semi-intensive systems (Schmid & Wechsler, 1997) and they may result in serious injuries, high mortality and variability in the production (Jones & Mills, 1999). Some studies had shown the inhibitory effect of the serotonin in the aggressiveness.

Domestic quails still preserve many traits of a wild bird so confinement is sufficient to cause an increase in mortality (Ito et al., 2009). The physiologic parameters of stress assessment, the ratio between heterophil/lymphocyte and plasma concentration of corticosterone studied by Rizzo et al. (2008) did not differ among the assessed levels of tryptophan for growing Japanese quails, considering the first housing from 30 days of age of birds. However, the lower level of tryptophan used by those authors (2.7g/kg) is higher than the one used for a greater ratio between tryptophan and lysine in this study (2.36 g/kg). Therefore, the smallest ratio studied here may have been potentiating agents of stress in quails due to deficiency of tryptophan.

Although the ratio of 0.18 had not provided the best results of feed conversion and egg weight, it was the one which caused the greatest viability of birds in the growing phase, providing more birds in the laying phase and higher egg production by housed birds from one day of age. Quails fed diets with the tryptophan and lysine ratio 0.18 presented adequate carcass weight and fat and protein deposition in the carcass as the other birds, showing an adequate body support for sexual maturity. However, because of the greater viability in the growing phase, quails which consumed diets with the ratio of 0.18 presented egg production per housed bird at 1 day of age 25.4% higher than birds fed diets with the ratio of 0.14.

It can be inferred that the reduction of crude protein in the diet based on the concept of ideal protein, according to recommendation of NRC (1994) from 240 g/kg to 174 g/kg, by keeping the ratio between digestible tryptophan and digestible lysine at 0.18 provided an adequate growth to quails, a normal diet intake and a lower mortality, that is, a greater viability of birds in the growing phase, providing a larger number of birds to start egg production phase. This ratio is higher than the one of NRC (1994) and the one of Silva and Costa (2009) of 0.17 and 0.14 respectively, lower than 0.19 recommended by Rostagno et al. (2011) and similar to the one of 0.18 recommended by Leeson and Summers (2005).

The ratio between digestible tryptophan and digestible lysine of 0.18 (1.88 g tryptophan/kg and 10.5 g of lysine/kg of diet) in the growing phase, corresponding to an intake of 20.63 mg of tryptophan per bird per day provides a greater viability of birds in the growing phase and a satisfying performance of Japanese quails in the laying phase.

5. Conclusion

The ratio between digestible tryptophan and digestible lysine of 0.18 (1.88 g tryptophan / kg and 10.5 g lysine / kg diet) in the growing diet, corresponding to an intake of tryptophan 20.63 mg per quail/day, provides greater viability of birds in the growing phase and satisfactory performance of Japanese quails in the laying phase.

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