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Optimum Digestible Valine to Lysine Ratio for Meat-Type Quails from 15 to 35 Days of Age

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ABSTRACT

This study was conducted to estimate the dig. valine to lysine (Val:Lys) ideal ratio for meat-type quails from 15 to 35 d of age. A total of 385, 15-day-old not sexed quails, were randomly assigned to five treatments, each one seven times replicated with eleven quails per experimental unit. Experimental treatments consisted of five dig. Val:Lys ratios (0.65; 0.70; 0.75; 0.80 and 0.85). Ideal dig. Val:Lys ratio was estimated using polynomial regression and linear broken-line regression model. Significant effect was considered when $p \leq 0.05$. Feed conversion ratio was not affected by dig. Val:Lys ratios in any of the assessed phases. From 15 to 21 d of age Val:Lys ratios increased linearly feed intake, weight gain and body weight. From 15 to 28 d of age, weight gain and body weight were both optimized by the Val:Lys ratio of 0.77. A linear effect of dig. Val:Lys ratios was observed on weight gain and final body weight from 15 to 35 d of age. From 15 to 35 d of age, according to linear broken-line regression model, the dig. Val:Lys ideal ratios for optimum final body weight and weight gain were 0.77 and 0.76, respectively. Based on the results the estimated dig. Val:Lys ratio for optimum meat-type quail performance from 15 to 35 d of age is 0.77

INTRODUCTION

Increasing on commercial amino acid availability and rising on soybean meal and corn prices has become crystalline amino acid supplementation on low-protein diets an efficient strategy to reduce poultry production costs (Burley *et al.*, 2013). Published reports have indicated that crystalline amino acid supplementation in low-protein diets can support similar broiler performance to high-protein diets in different phases. Nevertheless, the decrease in dietary crude protein (CP) content has become possible due to the establishment of broiler digestible amino acid requirements (*e.g.* methionine, lysine, threonine, tryptophan), which deficiency resultant from reduction on dietary CP, is generally corrected by their dietary supplementation in crystalline form.

Digestible lysine requirements and its optimum relative ratio with dig. methionine + cysteine, threonine and tryptophan for meat-type quails from 15 to 35 d of age have been widely studied (Scherer *et al.*, 2009; Ton *et al.*, 2012; Ton *et al.*, 2013; Ribeiro, 2015). Valine is considered the 4th limiting amino acid in corn and soybean meal-based diets for broilers (Corzo *et al.*, 2007; Rostagno *et al.*, 2011). Based on this hypothesis, L-valine supplementation, as well as the amino acids afore mentioned, could potentially allow further reductions in dietary CP without compromising meat-type quail performance. Broiler responses to valine supplementation in different phases are available in literature (Corzo *et al.*, 2007; Tavernari *et al.*, 2013; Duarte *et al.*, 2014), whereas data about meat-type quail valine needs, as well as its ideal relative ratio with dig.lysine are sparse.

The publication of Tables for Japanese and European Quails (Silva & Costa, 2009) represented an important advance in quail nutrition. However, as described by the authors, some amino acid nutritional recommendations for meat-type quails are based on broiler nutritional requirements described by NRC, (1994). Therefore, the determination of Val:Lys ideal ratio, on digestible basis, for meat-type quails could contribute for the update or creation of tables containing quail nutritional requirements. Thus, this study was conducted to determine the dig. Val:Lys ratio for optimum meat-type quail performance from 15 to 35 d of age.

MATERIALS AND METHODS

Animal care and use

All the procedures involving animal care and use were previously approved by the institutional Animal Care and Use Committee of the Universidade Federal de Viçosa (protocol no. 07/2016).

Table 1 – Ingredients and calculated composition of experimental diets.

Ingredients (g/kg)	Digestible valine-to-lysine ratios				
	0.65	0.70	0.75	0.80	0.85
Corn (7.88%)	687.90	687.90	687.90	687.90	687.90
Soybean meal (45.22%)	228.70	228.70	228.70	228.70	228.70
Corn gluten meal (60%)	14.00	14.00	14.00	14.00	14.00
Limestone	9.30	9.30	9.30	9.30	9.30
Dicalcium phosphate	11.20	11.20	11.20	11.20	11.20
Salt	3.30	3.30	3.30	3.30	3.30
L-Lysine HCL (78%)	4.68	4.68	4.68	4.68	4.68
DL-Methionine (99%)	4.39	4.39	4.39	4.39	4.39
L-Threonine (98%)	2.57	2.57	2.57	2.57	2.57
L-Tryptophan (98%)	0.27	0.27	0.27	0.27	0.27
L-Valine (96.5%)	0.00	0.55	1.14	1.71	2.28
Corn Starch	30.00	29.50	28.90	28.30	27.70
Mineral premix[1]	1.00	1.00	1.00	1.00	1.00
Vitamin premix[2]	1.00	1.00	1.00	1.00	1.00
Choline chloride (60%)	1.00	1.00	1.00	1.00	1.00
Coccidiostatic[3]	0.50	0.50	0.50	0.50	0.50
Antibiotic[4]	0.10	0.10	0.10	0.10	0.10
Antioxidant[5]	0.10	0.10	0.10	0.10	0.10
Calculated composition					
AMEn (kcal/kg)	3,050	3,050	3,050	3,050	3,050
Crude protein (g/kg)	175.00	175.00	175.00	175.00	175.00
Calcium (g/kg)	7.00	7.00	7.00	7.00	7.00
Non-phytate phosphorous (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
Potassium (g/kg)	6.20	6.20	6.20	6.20	6.20
Digestible amino acids (g/kg)					
Lysine	11.00	11.00	11.00	11.00	11.00
Methionine + Cysteine	9.24	9.24	9.24	9.24	9.24
Methionine	6.78	6.78	6.78	6.78	6.78
Threonine	8.25	8.25	8.25	8.25	8.25
Tryptophan	1.98	1.98	1.98	1.98	1.98
Valine	7.15	7.70	8.25	8.80	9.35
Isoleucine	6.38	6.38	6.38	6.38	6.38
Leucine	14.93	14.93	14.93	14.93	14.93

[1]Composition/kg of product: Manganese 160g. Iron 100g. Zinc 100g. Copper 20g. Cobalt: 2g. Iodine: 2g and excipient. [2] Composition/kg of product: Vit. A:12.000.000 U.I.. Vit D3:3.600.000 U.I.. Vit. E: 3.500 U.I.. Vit B1:2.500 mg. Vit B2: 8.000 mg. Vit B6:5.000 mg. Pantothenic acid: 12.000 mg. Biotin: 200 mg. Vit. K:3.000 mg. Folic acid: 1.500mg. Nicotinic acid: 40.000 mg. Vit. B12: 20.000 mg. Selenium: 150 mg. and excipient. [3]Salinomicin 60%. [4]Avilamicin. [5]Butil-hidroxy-toluen.

Bird husbandry and experimental design

One-day-old meat-type quails, vaccinated for Marek disease, were obtained from a local commercial hatchery. From 1 to 14 d post hatch, quails were housed in a controlled temperature room with a concrete floor covered with wood-shavings litter. Birds were fed diets (mash form) formulated according to Silva & Costa (2009) nutritional recommendations for meat-type quails at initial phase. On d 15 post-hatch, 385 not sexed quails (initial body weight of 64 g ± 0.98 g), were housed in a ventilated double curtain-sided house; and randomly allotted to five treatment groups, each one seven times replicated. The experimental unit consisted of a 50 x 50 x 30 cm stainless steel cage, equipped with one nipple drinker and one stainless steel self-feeder, with eleven quails each. Quails had free access to feed (mash form) and water throughout the 20-day feeding trial. Environmental temperature and humidity were daily measured by four thermo-hygrometers, in different places inside the experimental room. Lighting program consisted of the supply of 24 hours of light a day (natural + artificial).

Experimental diets

The experimental diets (Table 1) were formulated to contain 175.00 g crude protein/kg diet and 3,050 kcal AMEn/kg diet. The other nutrients were supplied according to Silva & Costa (2009) nutritional recommendations, except for digestible amino acids. Basal diet was formulated to meet the dig. methionine + cysteine, threonine and tryptophan relative ratios to dig. lysine described by Ribeiro (2015). A suboptimal level of digestible lysine (11.00 g/kg diet) was considered to formulate the diets. The values of chemical and nutritional composition of the ingredients used to formulate diets were those described by Rostagno *et al.* (2011). The experimental treatments consisted of five dig. Val:Lys ratios (0.65; 0.70; 0.75; 0.80 and 0.85), which were obtained through the graded supplementation of L-Valine in a basal diet, valine-deficient, in replacement to cornstarch.

Performance measurements

At 21, 28 and 35 d of age, all quails and feeders were weighed to determine bird performance. Feed intake was divided by weight gain to obtain feed conversion ratio. Mortality was daily recorded to adjust feed intake and feed conversion.

Statistical analysis

The effects of dietary dig. Val:Lys ratios were analyzed as one-way ANOVA and the optimum dig. Val:Lys ratio for each dependent variable assessed was estimated using both polynomial (linear or quadratic) and linear broken-line regression model. Significant effect was considered when $p \leq 0.05$. The software package used to analyze data was Sistema de Análises Estatísticas e Genéticas (SAEG, 2007).

RESULTS

Maximum and minimum temperature means recorded inside the experimental room during the current trial were respectively 21.34 and 26.59 °C, whereas the average humidity was 72.59%. Digestible Val:Lys ratios increased linearly ($p<0.05$) meat-type quail feed intake, weight gain and final body weight from 15 to 21 d of age (Table 2). From 15 to 28 d of age (Table 3), feed intake was not affected ($p>0.05$) by dig. Val:Lys ratios, whereas weight gain and final body weight showed a quadratic ($p<0.05$) response to dig. Val:Lys ratios, being both optimized at 0.77dig. Val:Lys ratio. From 15 to 35 d of age, a linear increase ($p<0.05$) on weight gain and final body weight was observed as dig. Val:Lys ratios increased, whereas feed intake was unaffected ($p>0.05$) by treatments (Table 4). From 15 to 35 d of age, according to linear broken-line regression model, the breakpoint ($p<0.05$) for weight gain and final body weight occurred at 0.76 and 0.77dig. Val:Lys ratio, respectively. Feed conversion ratio was not influenced ($p>0.05$) by treatments in any of the phases herein assessed.

Table 2 – Performance of meat-type quails fed experimental diets from 15 to 21 d of age.

Val:Lys ratio	FI[1] (g)	WG[2] (g)	FCR[3] (kg/kg)	BW[4] (g)
0.65	128.78	56.38	2.29	120.42
0.70	131.95	59.08	2.23	122.97
0.75	132.10	60.09	2.20	124.30
0.80	132.37	60.35	2.19	124.33
0.85	134.88	60.84	2.22	124.94
CV[5] (%)	3.00	3.40	3.67	1.85
p-Value				
Linear	<0.05	<0.01	0.09	<0.01
Quadratic	0.99	0.08	0.12	0.18
Linear broken-line	0.15	0.99	0.99	0.31

Item	Regression equations	R^2
FI[1]	$Y = 113.07 + 25.27x$	0.85
WG[2]	$Y = 44.03 + 20.42x$	0.82
BW[4]	$Y = 107.79 + 20.80x$	0.82

1 – feed intake. 2 – weight gain. 3 – feed conversion rate. 4 – body weight. 5 – Coefficient of variation

Table 3 – Performance of meat-type quails fed experimental diets from 15 to 28 d of age.

Val:Lys ratio	FI[1] (g)	WG[2] (g)	FCR[3] (kg/kg)	BW[4] (g)
0.65	275.27	106.98	2.57	171.02
0.70	281.03	110.45	2.55	174.35
0.75	280.65	111.77	2.51	175.97
0.80	279.31	111.71	2.50	175.68
0.85	276.12	110.07	2.51	174.12
CV[5] (%)	3.70	3.01	3.85	2.01
p-Value				
Linear	0.99	0.07	0.16	0.08
Quadratic	0.19	<0.05	0.99	<0.05
Linear broken-line	0.99	0.99	0.99	0.12
Item	Regression equations		R^2	Val:Lys ratio
WG[2]	$Y = -85.74 + 512.02x - 331.43x^2$		0.99	0.77
BW[4]	$Y = -23.27 + 516.06x - 334.00x^2$		0.99	0.77

1 – feed intake. 2 – weight gain. 3 – feed conversion rate. 4 – body weight. 5 – Coefficient of variation

Table 4 – Performance of meat-type quails fed experimental diets from 15 to 35 d of age.

Val:Lys ratio	FI[1] (g)	WG[2] (g)	FCR[3] (kg/kg)	BW[4] (g)
0.65	445.20	146.39	3.04	210.43
0.70	457.12	149.91	3.05	213.81
0.75	459.09	151.19	3.04	215.40
0.80	460.03	153.31	3.00	217.29
0.85	459.44	151.90	3.05	216.14
CV[5] (%)	5.04	3.67	6.28	2.52
p-Value				
Linear	0.27	<0.05	0.99	<0.05
Quadratic	0.99	0.26	0.99	0.26
Linear broken-line	0.99	<0.05	0.13	<0.05
Item	Regression equations	R^2	Plateau	Val:Lys ratio
WG[2]	118.22 + 44.12x	0.96	151.90	0.76
BW[4]	182.09 + 44.33x	0.97	216.14	0.77

1 – feed intake. 2 – weight gain. 3 – feed conversion rate. 4 – body weight. 5 – Coefficient of variation

DISCUSSION

Trials conducted to determine ideal amino acid profile for poultry involve expressing amino acid requirements as percentage of dig. lysine requirement, which is generally supplied in a suboptimal level. In the current study, dietary dig. lysine, as well as dig. valine, was limiting in basal diet. The suboptimal level of dig. lysine used to formulate the basal diet was 11.00 g/kg diet, which corresponds to 90% of dietary digestible lysine recommended by Silva & Costa (2009) for growing-finishing meat-type quails. Therefore, our discussion did not have focus on dig. valine requirement, but rather on its ideal ratio with dig. lysine.

Although data suggest that L-valine supplementation increases broiler feed intake (Corzo *et al.*, 2008), quail feed intake was only influenced from 15 to 21d of age (p<0.05). Likewise, Batista *et al*. (2016) did not observe influence of dig. Val:Lys ratios on meat-type quail feed intake from 15 to 35 d of age. According to linear broken-line regression model, the estimated dig.Val:Lys ratio for optimum weight gain and final body weight from 15 to 35 d of age was 0.76 and 0.77, respectively. Similarly, Silva & Costa, (2009) recommended a 0.75 dig. Val:Lys ratio for meat-type quails at the same phase, while Corzo *et al.* (2007) and Rostagno *et al.* (2011) proposed a 0.78 dig. Val:Lys ratio for growing-finishing broilers. The estimate found in the current study was greater than that determined by Batista *et al.* (2016), who recommended a dig. Val:Lys of 0.52 for growing-finishing meat-type quails.

Valine, leucine and isoleucine dietary supply is essential to maintain poultry growth. However it is crucial to provide the ideal dietary balance of these branched-chain amino acids (BCAA), once they share the same absorptive system in the intestine and may compete for the intestinal transporters (Broer, 2008). Moreover, antagonism among BCAA extrapolates intestinal absorption. The first step of BCAA catabolism involves their transamination, which results in their α-keto acid production. Literature data have demonstrated that alpha-ketoisocaproate, the α-keto acid produced from leucine transamination, enhances the branched-chain α-keto acid dehydrogenase complex (BCKDH), resulting in valine and isoleucine catabolism in pig and rat liver (Langer *et al.*, 2000).

Table 5 – Regression equations of performance of meat-type quails at 21d.

Variable	Regression equations	R^2
FI	113.066 + 25.2686x	0.85
WG	44.0340 + 20.4189x	0.82
FBW	107.792 + 20.8000x	0.82

The calculated leucine concentration in basal diet used in our study was 14.93 g/kg diet, which corresponds to the ratio with digestible lysine of 136%. Few data about meat-type quail leucine requirement are available in literature. However, considering that the estimative of the optimum dig. Val:Lysratio for meat-type quails herein obtained was close to that recommended by Rostagno *et al.* (2011) for broilers; it is probable that the ideal dig. ratio of leucine relative to dig.lysine for meat-type quails follows the same behavior. Based on such hypothesis, leucine-to-lysine ideal ratio for meat-type quails could be probably close to the ideal ratio described by Rostagno *et al.* (2011) for broilers (108%). Thus, the higher leucine content in basal diet could have influenced the optimum dig. Val:Lys herein estimated.

Table 6 – Regression equations of performance of meat-type quails at 28d.

Variable	Regression equations	R^2	Val:Lys ratio
WG	-80.0275 + 496.937Val/Lys – 321.373Val/Lys^2	0.99	0.77
FBW	17.3108 + 500.318Val/Lys – 323.522Val/Lys^2	0.99	0.77

Maia (2013) reported negative effects of increasing dig. leucine-to-lysine ratio from 108 to 150% on broiler weight gain. Similarly, Allen & Baker (1972), observed detrimental effects of excessive dietary leucine in broiler performance. According to these authors, such negative effects were attenuated by increasing in L-valine supplementation. Excessive valine supply has shown to decrease isoleucine concentration in laying hen plasma (Peganova & Eder, 2003). However, in the current study valine appeared not to have interfered in isoleucine metabolism, once Val:Lys ratio greater than the ideal ratio estimated (0.77) did not compromise quail performance. Based on results, the dig. Val:Lys ratio for optimum meat-type quail performance from 15 to 35 d of age is 0.77.

Table 7 – Regression equations of performance of meat-type quails at 35d.

Variable	Regression equations	R^2	Plateau	Val:Lys ratio
WG	118.2183 + 44.117x	0.96	151.90	0.76
FBW	182.0919 + 44.331x	0.97	216.14	0.77

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