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Digestible valine requirements for broilers from 22 and 42 days old

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ABSTRACT. Current experiment established different criteria to evaluate the requirements of digestible valine for broilers from 22 and 42 days of age, by different regression models (quadratic, exponential and Linear Response Plateau) and, in the case of statistical significance, the comparison of means by Duncan test at 5% probability. A total of 1,920 Cobb 500 male broilers were used and distributed in an entirely randomized experimental design, with 6 treatments (6 digestible valine levels: 0.7192, 0.7729, 0.8265, 0.8802, 0.9339 and 0.9876%) and 8 replications, with 40 broilers each. Data on performance and carcass characteristics were evaluated. The level of 0.8265% digestible valine was considered standard. The inclusion of 0.816, 0.848 and 0.903% of digestible valine levels, corresponding to digestible valine:lysine ratios of approximately 76.00%, 79.00% and 84.12%, provided best feed intake, weight gain and feed conversion ratio, respectively for broiler from 22 to 42 days of age.

Keywords: digestible amino acids, ideal protein, performance, regression analyses.

Exigências em valina digestível para frangos de corte de 22 a 42 dias de idade

RESUMO. Um experimento foi realizado com o objetivo de estabelecer critérios de avaliação das exigências de valina digestível para frangos de corte de 22 a 42 dias de idade utilizando-se diferentes modelos de regressão (quadrático, exponencial e de retas segmentadas ou Linear Response Plateau). Foram utilizados 1.920 frangos de corte machos com 22 dias de idade, distribuídos em delineamento inteiramente ao acaso, com seis tratamentos (6 níveis de valina digestível: 0,7192; 0,7729; 0,8265; 0,8802; 0,9339 e 0,9876) e oito repetições de 40 aves. Utilizou-se como padrão o nível de 0,8265% de valina digestível. A inclusão dos níveis 0,8160; 0,8484 e 0,9031% de valina digestível proporcionou os melhores resultados de consumo de ração, ganho de peso e conversão alimentar respectivamente.

Palavras-chave: aminoácidos digestíveis, proteína ideal, desempenho, análises de regressão.

Introduction

Dietary synthetic amino acids, such as dl-methionine, l-lysine and l-threonine, are used in broiler production to lower diet costs and, at the same time, to provide a better amino acids balance. The inclusion of supplemental l-valine in all vegetable maize–soybean meal feeds may further reduce production costs without alterations in their performance since valine is acknowledged to be the fourth limiting amino acid in this type of diet (CORZO et al., 2007).

Valine is a potentially limiting essential amino acid in corn-soybean meal formulations for growing chickens (FERNANDEZ et al., 1994; HAN et al., 1992; THRONTON et al., 2006). This limitation is particularly apparent at older ages when dietary protein decreases and grain extends its contribution.

It has also been elucidated that poultry may be incurred by these effects as a consequence of a nutritional deficiency or imbalance of valine in growth and carcass yields (CORZO et al., 2004; CORZO et al., 2007; FARRAN; THOMAS, 1992b). However, all the nutritional needs of valine in poultry have been supplied by protein-contributing ingredients such as soybean meal and animal by-products. Inadequate dietary valine for chicks not only decreases body weight gain and feed conversion but also causes feather and leg abnormalities (ANDERSON; WARNICK, 1967; FARRAN; THOMAS, 1992a; FARRAN; THOMAS, 1992b; ROBEL, 1977).

Current study evaluates digestible valine requirements for broilers between 22 and 42 days old.

Material and methods

Animals and experimental procedures

The experiment was conducted between the 22[nd] and 42[nd] days of age of the birds. A total of 1,920 oneday-old male Cobb 500 chicks were housed in a masonry poultry house with 80 boxes. The housing and experimental procedures reported herein were approved by the Institutional Animal Care and Use Committee (CEBEA 001771-09) of the State University of São Paulo, Brazil.

The initial heating derived from 250-watt infrared lamps so that temperature between 28 and 30ºC could be maintained during the first two weeks. The chicks were vaccinated in the hatchery against Marek, Gumboro and Bouba disease, followed by vaccination at 5 and 21 days against Gumboro disease, and on the 8th day against Newcastle disease.

The litter was made from wood shavings and the amount placed in each box was 1.2 kg of dry matter/bird housed, so that all treatments had the same initial amount of material used as litter, at a height of 5 cm. The lighting schedule was 24 hours of light throughout the experimental period and birds received feed and water ad libitum throughout the entire experimental period.

During the initial period (1-21 days old), the birds were reared in an experimental shed, fed on diets with 3,005 kcal ME kg^{-1} and 21.6% CP to reach their nutritional requirements, according to recommendations by Rostagno et al. (2005) for phases 1 to 7 and 8 to 21 days of age. At the end of the 21st day of age, the broilers were weighed, selected according to the criterion of average weight of each box (750 ± 35 grams) and distributed in a completely randomized design involving six treatments (levels of digestible valine), with eight replications of 40 birds each.

Nutritional recommendations of crude protein, metabolizable energy, calcium, available phosphorus and digestible amino acids used in the experimental diets were established by Rostagno et al. (2005) following recommendations from 22 to 33 and 34 to 42 days of age.

Chemical-bromatological analyses of the ingredients used in the experimental diets (Table 1) were performed according to methodology described by Silva (1990). The metabolizable energy (ME) and digestibility coefficients used established by Rostagno et al. (2005).

Treatments consisted of a valine-deficient basal diet, formulated with digestible amino acids, according to the ideal protein concept, or rather, from 22 to 42 days of age, supplemented with five different digestible valine levels, using 0.7642% of digestible threonine and 0.1919% of digestible tryptophan, following Duarte et al. (2012) and Duarte et al. (2013), respectively.

Table 1. Chemical-bromatological analyses and composition in total (TAA) and digestible (DAA) amino acids of the ingredients in the experimental diets.

	Corn		Soybean meal	
Dry matter (%)	88.90		89.10	
Crude protein (%)	8.11		44.40	
Metabolizable energy (kcal kg^{-1})	3381		2256	
Ether extract (%)	3.61		1.66	
Crude fiber (%)	1.73		5.41	
Calcium (%)	0.03		0.24	
Available phosphorus (%)	0.08		0.18	
Sodium (%)	0.02		0.02	
%	TAA[1]	DAA[2]	TAA	DAA
Total alanine	0.59	0.55	1.94	1.90
Total arginine	0.36	0.33	3.19	3.06
Total glycine	0.31	0.30	1.89	1.88
Total isoleucine	0.27	0.24	2.01	1.83
Total leucine	0.97	0.92	3.42	3.12
Total lysine	0.23	0.20	2.72	2.50
Total cystine	0.18	0.16	0.62	0.60
Total methionine	0.17	0.16	0.60	0.54
Total meth + cys	0.35	0.32	1.22	1.06
Total phenylalanine	0.39	0.35	2.32	2.15
Total tyrosine	0.24	0.21	1.50	1.47
Total threonine	0.29	0.24	1.74	1.53
Total tryptophan	0.06	0.05	0.58	0.52
Total valine	0.39	0.34	2.13	1.90
Total histidine	0.24	0.22	1.16	1.10
Total serine	0.39	0.34	2.29	2.24

[1]Total amino acids, determined by Degussa Laboratory - Animal Nutrition Service - São Paulo SP Brazil. [2]Digestible amino acids, based on digestibility coefficients of the Rostagno et al (2005).

The basal diet (Table 2) was formulated to contain 0.7197% digestible valine, representing 67% of 1.0735 digestible lysine level and the other diets with increasing levels of 2% in relation to the basal diet. The latter contained 0.7729, 0.8265, 0.8802, 0.9339 and 0.9876 – that is, two levels below and three levels above the 0.8265% level recommended by Rostagno et al. (2005), as the levels of lysine, methionine + cystine and other amino acids used in the diet formulation. L-Valine was added to the basal diet to replace L-Glutamic acid so that all treatments would have the same level of nitrogen and eliminate any effects related to differences in their concentration. Thus, diets with low levels of L-Valine contained higher levels of L-Glutamic acid.

Growth performance and carcass yields traits

The birds were weighed at the beginning and at the end of experiment to determine weight gain, by weight difference at 21 and 42 days of age. Likewise, feed intake was obtained by the difference between the feed provided and feed left over in the troughs. Subsequently, feed conversion was calculated by the ratio between feed intake and bird weight gain. Viability (VC) was obtained from the total number of birds housed minus dead birds, represented by dead or removed experimental unit, divided by the total number of birds housed (multiplied by 100).

Table 2. Percentage composition of experimental diets for 22 - 42-day-old broilers.

Ingredients	Digestible valine levels					
	0.7192	0.7729	0.8265	0.8802	0.9339	0.9876
Corn	66.446	66.446	66.446	66.446	66.446	66.446
Soybean meal	25.269	25.269	25.269	25.269	25.269	25.269
Soybean oil	3.545	3.545	3.545	3.5450	3.545	3.545
Dicalcium phosphate	1.636	1.636	1.636	1.636	1.636	1.636
Limestone	0.964	0.964	0.964	0.964	0.964	0.964
L-Glutamic acid (99%)	0.3719	0.2975	0.2231	0.1487	0.0743	0.000
L-Lysine (78.5%)	0.286	0.286	0.286	0.286	0.286	0.286
DL-Methionine (99%)	0.208	0.208	0.208	0.208	0.208	0.208
L-Tryptophan (98%)	0.059	0.059	0.059	0.059	0.059	0.059
L-Threonine (98%)	0.232	0.232	0.232	0.232	0.232	0.232
L-Arginine (99%)	0.080	0.080	0.080	0.080	0.080	0.080
L-Valine (96.5%)	0.000	0.0537	0.1074	0.1611	0.2148	0.2685
L-Isoleucine (99%)	0.062	0.062	0.062	0.062	0.062	0.062
Vit. + min. supplement[1]	0.400	0.400	0.400	0.400	0.400	0.400
Salt	0.441	0.441	0.441	0.441	0.441	0.441
Inert (washed sand)	0.000	0.0207	0.0414	0.0621	0.0828	0.1034
Total	100.00	100.00	100.00	100.00	100.00	100.00
	Calculated values					
Crude protein	17.43	17.43	17.43	17.43	17.43	17.43
Metabolizable energy (kcal kg^{-1})	3,175	3,175	3,175	3,175	3,175	3,175
Calcium	0.874	0.874	0.874	0.874	0.874	0.874
Sodium	0.210	0.210	0.210	0.210	0.210	0.210
Total phosphorus	0.625	0,6255	0,625	0.625	0.625	0.625
Available phosphorus	0.406	0.406	0,406	0.406	0.406	0.406
Digestible lysine	1.0735	1.0735	1.0735	1.0735	1.0735	1.0735
Digestible methionine	0.4663	0.4663	0.4663	0.4663	0.4663	0.4663
Digestible met. + cyst.	0.773	0.7730	0.7730	0.7730	0.7730	0.773
Digestible tryptophan [2]	0.1919	0.1919	0.1919	0.1919	0.1919	0.1919
Digestible threonine [3]	0.7642	0.7642	0.7642	0.7642	0.7642	0.7642
Digestible arginine	1.127	1.1270	1.1270	1.1270	1.1270	1.127
Digestible valine	0.7192	0.7729	0.8265	0.8802	0.9339	0.9876
Digestible isoleucine	0.719	0.719	0.719	0.719	0.719	0.719

[1]Enrichment per kilogram of diet: 8,000 IU vitamin A, 1,800 IU vitamin D3, 12 mg vitamin E, 2 mg vitamin K3, 1 mg vitamin B1, 4 mg vitamin B2, 1 mg Vitamin B6, 10 mcg Vitamin B12, 0.40 mg folic acid, 0.04 mg biotin, 28 mg niacin, 11 mg of calcium pantothenate, 6 mg Cu, 0.10 mg Co, 1 mg I, 50 mg Fe, 65 mg Mn, 45 mg Zn, 0.21 mg Se, 500 mg choline chloride 50%, 60 mg coccidiostat, 12 mg antioxidant. [2]Duarte et al. (2013). [3]Duarte et al. (2012).

To calculate the production efficiency index (IEP = [average daily weight gain (g) x VC (%)] / (feed conversion x 10), average weight gain, feed intake and feed conversion of the birds were considered at that age. The above averaging was performed due to the fact that all birds received the same diet during the first 22 days of age when they were weighed and selected for the early experimental period.

At the end of the experimental period, eight birds per experimental unit, with body weight near plot average, were selected and submitted to a fasting period of 6 hours; they were then laid down by jugular bleeding, plucked and eviscerated. After weight of carcass, they were cut to evaluate carcass yield (excluding head, neck and feet), breast yield, thigh + drumstick yield, wing yield and back yield.

Statistical analysis

Statistical analyses were performed with Statistical Analysis System software 9.2 (SAS, 2008). In the case of statistical significance, the comparison of means procedure was also adopted using Duncan's test at 5% probability. To determine digestible valine requirements, three regression models were used: the quadratic model described by Robbins et al. (1979), the exponential model described by Noll and Waibel (1989) and the Linear Plateau Response (LRP) described by Braga (1983) with 90% maximum square, according to the best fit obtained for each variable studied.

Results and discussion

Growth performance from 22 to 42 days of age

Table 3 presents the average performance of 22 – 42-day-old broilers and a summary of the statistical analyses for the different variables. Digestible valine levels influenced all studied variables ($p < 0.05$), except production viability and productive efficiency ($p > 0.05$), agreeing with Corzo et al. (2011) who observed that mortality was unaffected by the addition of L-valine to the experimental diets.

Table 3. Feed intake (FI), weight gain (WG), feed conversion (FC), viability (VC) and productive efficiency index (IEP) of broilers fed diets with different digestible valine levels from 22 to 42 and 1 to 42 days of age.

Digestible valine levels (g 100 g^{-1})	Performance				
	FI (kg)	WG (kg)	FC (kg kg^{-1})	VC (%)	IEP 1-42 days of age
0.7192	2.922	1.618	1.806	98.533	336.58
0.7729	2.984	1.639	1.821	99.562	341.09
0.8265	2.905	1.621	1.793	97.163	334.13
0.8802	2.947	1.667	1.768	98.475	347.97
0.9339	2.918	1.632	1.788	98.629	341.16
0.9876	2.868	1.600	1.793	96.942	330.95
P values	0.0452*	0.0145*	0.0250*	0.1705^{NS}	0.2059^{NS}
F values	2.37	1.75	1.38	1.64	1.51
CV(%)	2.45	2.98	2.38	2.22	4.10

NS = not significant; VC = viability (number of birds terminated); IEP = [average daily WG (g) x VC (%)] / (FC x 10). *$p < 0.05$. Medium in the column followed by different letters differ ($p < 0.05$) by Duncan test.

An appropriate fit was not obtained by linear and LRP models to birds´ performance data, since these models were not significant ($p > 0.05$) by regression analysis of variance. However these variables allowed a proper fit for the quadratic model whose regression equations for different variables, coefficients of determination (R^2) and levels of estimated digestible valine (NVal) are presented in Table 4.

Table 4. Adjusted equation for feed intake (FI), weight gain (WG) and feed conversion (FC) according to digestible valine levels, determination coefficients (R2), and estimated digestible valine levels (NVal) by the quadratic model.

Regression model	Variable / equation	NVal (%)	R^2
Quadratic	$FI = -2.7711 * NVal^2 + 4.5222 * NVal + 1.1097$	0.8160	97.52
Quadratic	$WG = -2.5056 * NVal^2 + 4.2513 * NVal - 0.1489$	0.8484	86.59
Quadratic	$FC = 1.0088 * NVal^2 - 1.8221 * NVal + 2.6051$	0.9031	58.93

The first derivative of the quadratic equation showed that 0.8160, 0.8484 and 0.9031% digestible valine levels were estimated to maximize feed intake, weight gain and feed conversion ratio of broilers, respectively. Comparing these results with those reported by Corzo et al. (2008) for feed intake, the recommendations had discrepant rates, with the digestible valine levels estimated at 0.8160 and 0.78%, respectively, for broilers from 28 to 42 days of age. In the case of weight gain, the requirement digestible valine estimated at 0.8484% was higher than 0.77% suggested by the same authors.

Accordingly, Corzo et al. (2011) using six incremental l-Val inclusion levels in feed to broilers from 28 to 42 days of age, observed a linear trend, whereby each subsequent addition of the amino acids led to a decrease in body weight gain. Conversely, based on feed intake data, birds increased their intake in a linear manner as l-Val was increased in the diet. A similar linear response was observed for feed conversion ratio, although diets supplemented with up to 0.52 kg m^{-1} ton had a similar response to the industry control diet as well as to the diet devoid of l-Val. It is likely that levels above 0.52 kg m^{-1} ton failed to support body weight gain and feed conversion because of dietary inadequacy of other limiting amino acids.

Mack et al. (1999) in an experiment with 20 to 40 days old ISA Label male broilers estimated a 0.73% weight gain of digestible valine level, corroborating data of current present study that recommends 0.8484% of digestible valine.

In this study the digestible valine requirements were greater than requirements recently proposed by other researches during similar breeding periods, corroborating with Berres et al. (2010) that found a quadratic response for weight gain and feed conversion, estimating 0.85% and 0.84% of digestible valine, respectively. However, they used the LRP model and estimated the requirement at 0.82 and 0.81% digestible valine for the same variables.

In current assay, the digestible lysine level of the experimental diets was 1.0735%, taking into consideration the 90.7% digestibility coefficient of lysine (ROSTAGNO et al., 1995). The best digestible valine levels for better feed intake, body weight and feed conversion were respectively 0.8160, 0.8484 and 0.9031%. According to this information, the ratio digestible valine: digestible lysine, within the ideal protein concept, was approximately 76.00% of feed intake, 79.00% of body weight and 84.12% of feed conversion. Feed conversion rate is greater than rates by Rostagno et al. (2005, 2011), Corzo et al. (2007) and Mack et al. (1999), namely, 77, 78 and 81%, respectively. Baker et al. (2002) calculated a 77.5% rate for valine: lysine, using weight gain and feed efficiency as evaluation criteria, or rather, a rate very close to that in current study.

Mack et al. (1999) observed better performance of broilers from 20 to 40 days fed on rations formulated with 81% valine:lysine ratio. However, Corzo et al. (2007), using vegetable diets based on corn and peanut meal containing different digestible valine levels (0.59 to 0.84%), concluded that the ratio valine: lysine of 78% (0.74% in diet) was adequate for broilers from 21 to 42 days old. Subsequently, Corzo et al. (2008) registered that the ratio valine: lysine for broilers Ross from 28 to 42 days was 74% or 0.78% of digestible valine.

Campos et al. (2012) analyzed the effect of ratio valine: lysine on broiler performance and observed that feed conversion ratio, body weight, breast yield and weight breast fillet showed a linear response. On the other hand, weight gain had a quadratic response, with maximum gain obtained in 76% valine: lysine ratio.

Tavernari et al. (2013) concluded that the optimal digestible Val Lys^{-1} ratio for Cobb × Cobb 500 broilers is 77% on the starter phase data and 76% for birds in the finishing phase (30 to 43 days old).

Effect on the weight of several parts in broilers

According to Table 5, it was not possible to describe the behavior of the data by the regression models proposed. Due to the non-significance effect ($p > 0.05$) of digestible valine levels on the variables, the means were compared using Duncan test at 5% probability. The compilation of the data for carcass parameter showed a strong effect of valine: lysine ratio on weight of carcass and breast meat (CORZO et al., 2004; CORZO et al., 2007). However, carcass yield (CORZO et al., 2004; CORZO et al., 2007; THORNTON et al., 2006) and breast meat yield (CORZO et al., 2004; CORZO et al., 2007; LECLERQ, 1998; THORNTON et al., 2006) were not affected. As carcass weight and breast meat weight increased together with increased valine: lysine ratios, the ratio between breast meat and carcass weight did not change. However, meeting the bird's requirement for valine is of key importance in ensuring the optimal usage of lysine which is well known to increase breast meat yield (BERRI et al., 2008).

Table 5. Carcass yield (CY), breast yield (BY), thigh + drumstick yield (TH+DR), back yield (BY) and wing yield (WY) of broilers fed diets with different digestible valine levels from 22 to 42 days of age.

Digestible valine levels (g 100 g^{-1})	Carcass characteristics[1]				
	CY	BY	TH+DR	BY	WY
0.7192	77.11	36.90	29.56	22.19	10.23
0.7729	75.66	36.47	30.17	22.63	10.30
0.8265	75.42	36.88	29.35	22.93	10.22
0.8802	76.25	37.00	29.68	22.33	10.06
0.9339	77.51	37.04	29.74	21.28	10.14
0.9876	76.24	36.56	29.84	22.74	10.16
P values	0.4062	0.8699	0.6940	0.2084	0.8641
F values	1.04 NS	0.36 NS	0.61 NS	1.51NS	0.37 NS
CV (%)	2.94	3.01	3.38	6.07	3.77

NS = not significant, [1]eviscerated carcass without feet, head and neck.

Corzo et al. (2008) observed a quadratic response for carcass weight, carcass yield without bone and skin and thigh + drumstick yield, and reported best valine levels 0.82, 0.82 and 0.83% respectively. For the period studied, the authors recommended that total valine levels ranged between 0.82 and 0.85%, or rather, 0.85% significantly higher than 0.72% recommended by Mendoça and Jensen (1989), 0.70% recommended by NRC (1994), 0.73% recommended by Thornton et al. (2006) and Corzo et al. (2004).

Conclusion

Research results showed that the digestible valine levels 0.816, 0.848 and 0.903%, respectively for maximum feed intake, weight gain and feed conversion, could be recommended. However, 0.903% is the recommended digestible valine level for a better overall performance of 22 – 42-days-old broilers. Research also indicated that the recommended digestible valine level was higher than that found in the literature.

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