Arginine requirement of modern broilers are higher than current breeder recommendations

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Background

Broilers lack some of the enzymes involved in urea cycle thus broilers cannot synthesize arginine (Arg) endogenously. Therefore, Arg is an essential amino acid in broilers due to a lack of mitochondrial carbamylphosphate synthetase I (CPS I), low renal argininosuccinate synthetase (AS), argininosuccinate lyase (AL), and ornithine transcarbamylase (OTC) activity (Ball et al., 2007). Arg is the fifth limiting amino acid under normal conditions and fourth limiting amino acid when the thermal conditions exceed the neutral thermal zone of broilers (Neto et al., 2013). Current breeder recommendations for SID Arg are as follows: 1.37, 1.23, and 1.10% SID Arg for starter, grower, and finisher phases (Aviagen, 2019) and 1.28, 1.18 and 1.07, 1.02% SID Arg for starter, grower, finisher I, and finisher II, respectively (Cobb, 2018). Contrary to current breeder recommendations, Corzo et al. (2021) recently demonstrated that Arg requirement of broilers is age dependent, and it is increasing by age from 106 to 136% SID Arg to SID Lys. The objective of this study was to determine the arginine requirement of male Ross 308 broilers in the starter phase.

Methods

A total of 990 male Ross 308 broilers arrived in the research facility (Poulpharm Bvba, Izegem, Belgium) at the age of zero days. Birds were placed in 66 pens (1m² each). Seven treatment groups (Table 1) were randomly allocated to pens (12 pens in basal diet group; 9 pens per treatment for the other treatments; 15 birds per pen). The feed was prepared by Research Diet Services BV (RDS) (Table 2 and 3). Feed and water were provided ad libitum. The floor was covered with wood shavings in a thickness of about 5 cm. The body weight (BW), daily weight gain (DWG), daily feed intake (DFI) and feed conversion ratio (FCR) were measured at day 0 and 10. Feed samples of the test diets were analysed to determine major nutrients including amino acids which appeared to be at or close to formulated values. Data were analysed with R (version 3.2.5.). Several models (quadratic polynomial model, broken line linear model, broken line quadratic model, and exponential asymptotic model) were fit with dose as a continuous effect to evaluate the dose response for the different performance parameters. The Akaike information criterion (AIC) was calculated. A lower AIC value indicates a better model fit. The model with the lowest AIC is considered as the optimal model that estimates the dose of Arg needed to reach the best performance. If two models are characterized by the same AIC, the model with the best maximum performance was chosen. Mortality was analysed using cox proportional hazard models (procedure coxph of the package survival).

Table 1. Treatment groups and their descriptions

Treatments	Description	Replicates	Birds /replicate	SID Arg (%) Starter
T01	0.00% Arg (basal diet)	12	15	1.02
T02	0.06% Arg	9	15	1.08
T03	0.12% Arg	9	15	1.14
T04	0.18% Arg	9	15	1.20
T05	0.30% Arg	9	15	1.32
T06	0.45% Arg	9	15	1.47
T07	0.61% Arg	9	15	1.63

Table 2. Ingredient composition of the basal diet (%)

Ingredient Name	Starter (0 - 10 days)
Corn	50.00
Soybean meal	20.36
Rape Seed Meal	8.00
Corn starch	6.00
Corn gluten meal	5.55
Corn gluten feed	2.78
Soy oil	1.98
DCP	1.60
Limestone	1.06
L-Lysine HCL	0.61
Broiler premix	0.50
Salt	0.37
L-Methionine	0.37
L-Threonine	0.29
L-Glycine	0.27
L-Isoleucine	0.15
L-Valine	0.11
L-Tryptophan	0.02

Table 3. Calculated nutrient composition of the basal diet

Nutrient %	Starter (0 - 10 days)
AMEn Broiler (kcal/kg)	2960
Crude Protein	21.43
Crude Fat	5.49
Crude Fiber	3.32
Ash	6.15
Calcium	0.90
Available Phosphorous	0.42
Dig. Lysine	1.28
Dig. Methionine	0.65
Dig Met Plus Cys	0.95
Dig. Arginine	1.02
Dig. Threonine	0.86
Dig. Leucine	1.63
Dig. Isoleucine	0.86
Dig. Valine	0.96
Dig. Tryptophan	0.20
Dig. Phenylalanine	0.86
Dig. Histidine	0.47
Choline	1439
Starch	34.63

Results

This study was focused on Arg requirement of broilers in the first 10 days of their life. A basal diet with limited SID Arg was fed. Consequently, birds were not growing properly on the basal diet (Figure 1 and 2). Supplementary Arg was added at 0.06, 0.12, 0.18, 0.30, 0.45 and 0.65% to reach SID Arg concentrations in feed below, at and above the breeder recommendations. Adding supplementary Arg improved performance of the young broilers. From the four different models used, quadratic polynomial, exponential asymptotic, broken line linear and exponential asymptotic showed the best fit to BW, DWG, DFI, and FCR, respectively (Figure 1, Figure 2, Figure 3, Figure 4).

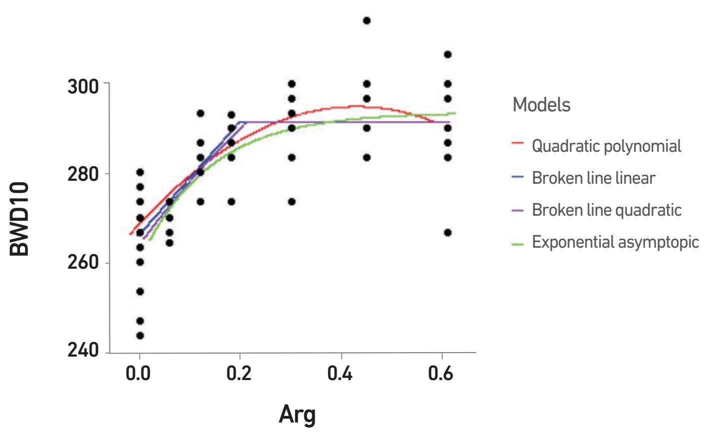

Figure 1. BW response to different Arg doses. Different models are fit to estimate Arg requirements. Quadratic polynomial, Broken line linear, Broken line quadratic, and Exponential asymptotic models had an AIC equal to 501.1, 501.5, 503.4 and 500.5. Quadratic polynomial model showed the best fit for maximum response. Exponential asymptotic model showed no fit for maximum body weight.

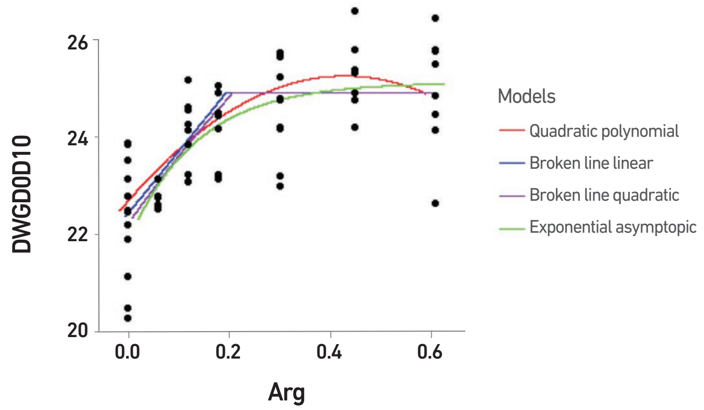

Figure 2. DWG response to different Arg doses. Different models are fit to estimate Arg requirements. Quadratic polynomial, Broken line linear, Broken line quadratic, and Exponential asymptotic models had an AIC equal to 202.1, 201.6, 203.5 and 201.1. Exponential asymptotic model showed the best fit to achieve 99% of maximum response.

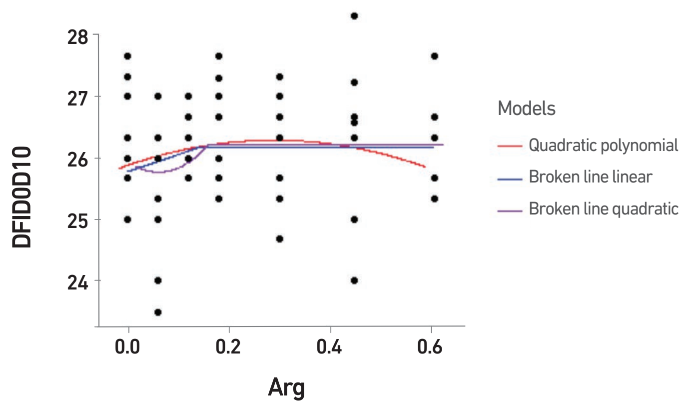

Figure 3. DFI response to different Arg doses. Different models are fit to estimate Arg requirements. Quadratic polynomial, Broken line linear, and Broken line quadratic models had an AIC equal to 207.4, 207.7 and 209.3. Quadratic polynomial model showed the best fit for maximum response.

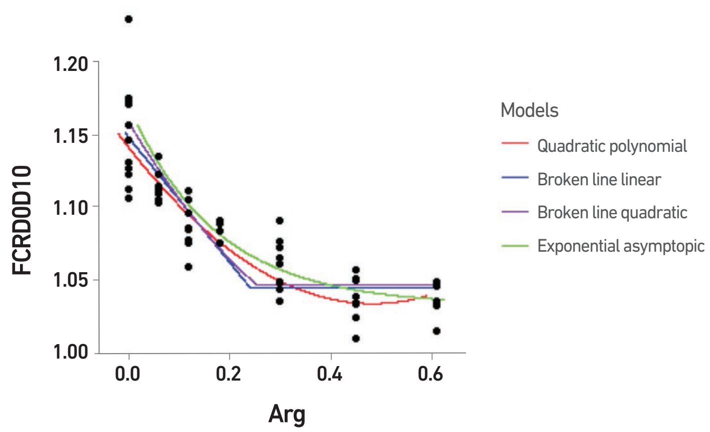

Figure 4. FCR response to different Arg doses. Different models are fit to estimate Arg requirements. Quadratic polynomial, Broken line linear, Broken line quadratic, and Exponential asymptotic models had an AIC equal to -279.7, -275.0, -274.0 and -282.7. Exponential asymptotic model showed the best fit for 99% of maximum response.

Birds were reaching their maximum BW, DWG, DFI and minimum FCR with 0.45, 0.33, 0.31, and 0.43% Arg supplementation, respectively. Therefore, 1.47, 1.35, 1.33 and 1.45% SID Arg was estimated to be required to achieve the best BW, DWG, DFI, and FCR results (Table 4 and 5). The SID Arg to SID Lys was calculated to be 115, 105, 104, and 113% to achieve the best BW, DWG, DFI, and FCR results.

Table 4. Summary of results derived for the best L-Arg dose to reach maximum performance of broilers according to the best fitted model.

Parameter	Estimated L-arginine dose
	Starter (0 - 10 days)
Body weight	0.45% (1.47, 115)
Daily weight gain	0.33% (1.35, 105)
Daily feed intake	0.31% (1.33, 104)
Feed conversion ratio	0.43% (1.45, 113)

- SID Arg recommendations (%) and calculated ratios of SID Arg to SID Lys are mentioned in brackets.

Table 5. Comparison of results derived for the best L-Arg dose for maximum BW and FCR with broiler breeder recommendations during starter phase

	SID Arg		ratios	
Period	Ross 308 recommendations, SID Arg	Trial results, (max BW and min FCR) SID Arg	Ross 308 recommendations, SID Lys	Trial results (max BW and min FCR) Calculated SID Arg to SID Lys
Starter	1.37	1.47 and 1.45	1.28	115 and 113

Discussion

Arg is a limiting amino acid in broilers. Therefore, the Arg requirement of broilers needs to be fortified via feed. Deficiency of Arg can compromise not only animal growth but also animal health because Arg has also different functional roles such as immune related functions (Zhang et al., 2018). The industrial inclusion of SID Arg to SID Lys in broiler feed ranges from 95 to 108% which means in many cases it is below breeder recommendations (105 to 108% SID Arg to SID Lys). Recently, the optimum SID Arg to SID Lys for male Ross 708 broilers was measured to be 106 between 1 and 14 days of age (Corzo et al., 2021). Between days 25 and 42 days, the broilers needed 129 and 116% SID Arg to SID Lys to achieve an optimum BW and FCR, respectively, indicating the Arg requirement of broilers is age dependent. Others have also observed that extra Arg compared with broiler breeder tables not only supports extra performance but also improves meat quality (Zampigna et al., 2018; Bodle et al., 2018). In current study, maximum BW and minimum FCR of male Ross 308 broilers also benefited from extra Arg in their feed. Thus, the previous observations from chickens between days 25 and 42 were extended to early life chickens demonstrating that young modern chickens have a higher Arg requirement as compared to broiler recommendations in the past five years.

Conclusions

Herein, we have demonstrated that male Ross 308 broilers need higher Arg content in their feed to achieve their genetic potential. The estimated Arg requirement (1.47, 1.35, 1.33 and 1.45% SID Arg for BW, DWG, DFI, and FCR, respectively) is higher than current broiler breeder recommendations.

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