Standardized ileal digestible arginine requirement for broilers

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Preface

In 2017 a new Table has been introduced called; Table ‘Standardized ileal digestibility of amino acids in feedstuffs for poultry’ and has been described in the CVB Documentation report nr. 61. As a feed evaluation system has two pillars – the supply of nutrients by the diet on the one hand and the requirement for these nutrients by the animals on the other hand (both expressed in the same units) – it was also necessary to also update and express the amino acid requirements on a standardized ileal digestibility (SID) basis.
Therefore a large meta-analysis dataset was constructed from studies in which amino acid requirements in broilers were estimated. The SID amino acid concentrations of the diets used in the studies were recalculated based on the new CVB SID amino acid Table (CVB Documentation report nr. 61) and requirements of SID amino acids were subsequently estimated. The results of this meta-analysis for standardized ileal digestible arginine (SID-ARG) are presented in the present CVB Documentation report. Compared to the former CVB apparent faecal digestible ARG recommendation for broilers described in CVB Documentation report nr. 18 and published in 1996 the present established SID-ARG amino acid recommendations for broilers are:

1. Based on a larger dataset of requirement studies
2. Based on studies with modern broiler types in the period 1990 – 2017
3. Based on standardized ileal digestible amino acid values in feedstuffs instead of apparent faecal digestible amino acid values.

The in this report estimated requirement of SID-ARG will be incorporated in the Dutch CVB Tabellenboek Veevoeding Pluimvee 2018 and in the English version CVB Table Poultry Nutrition 2018.

This study was guided and assessed by the Technical Committee of CVB

Wageningen, June 2018

J.W. Spek

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Abbreviations

AA	Amino acids
AFD	Apparent faecal digestible
ARG	Arginine
BWG	Body weight gain
CP	Crude protein
FCR	Feed conversion ratio
ILE	Isoleucine
LYS	Lysine
ME	Metabolic energy
MET	Methionine
M+C	Methionine plus Cysteine
N	Number
R^2	Coefficient of determination
Req	Requirement
SID	Standardized ileal tract digestible
Std. Dev.	Standard deviation
Std. Err.	Standard error
THR	Threonine
TRP	Tryptophan
VAL	Valine

1 Introduction

In 2012 a large meta-analysis was carried out by Veldkamp and others in order to determine the dietary requirements for standardized ileal tract digestible (SID) amino acids (AA) for broilers. This study resulted in a report published by Veldkamp et al. (2016). Before the start of this meta-analysis by Veldkamp et al. another large meta-analysis was carried out in order to determine the SID-AA levels for the various feed ingredients. This meta-analysis resulted in a CVB table with SID-AA concentrations for the various feed ingredients and this Table was used by Veldkamp et al. (2016) in order to recalculate the dietary SID-AA levels for the individual AA titration studies in order to estimate AA requirements. However, in 2017 this CVB Table has been updated with new data published in the years between 2012 and 2017 as there were questions about the SID cysteine digestibility value for soybean meal. As a result, not only the SID-AA values for soybean meal have been updated but also for other feedstuffs. As a consequence it was necessary to recalculate all the diets used in the AA titration studies that Veldkamp et al. (2016) used to determine AA requirements. In this CVB documentation report the results of estimated dietary SID arginine (SID-ARG; %) requirements are presented that are based on the new Table values as presented in CVB documentation report nr. 61. Furthermore, the dataset used by Veldkamp et al. has been extended with new studies that were not included in the study of Veldkamp et al.. This resulted in a dataset that is larger than the dataset used by Veldkamp. The SID-ARG requirements of the individual titration trials were estimated using a quadratic broken-line model. This model was also used in estimation of SID-lysine requirements in the individual lysine titration trials as described in CVB documentation report nr. 62.

2 Materials and Methods

Arginine titration studies were selected from literature (1990 – 2017) in which only the dietary ARG content was varied by means of addition of graded levels of dietary synthetic ARG. Furthermore, only those titration studies were selected in which non-test apparent digestible amino acid levels of the basal diet (diet with the lowest ARG content) did not come below 10% of the recommended CVB (2012) levels and where dietary digestible ARG levels of the basal diets where at least 15% below the recommended CVB (2012) level. Furthermore, performance characteristics such as body weight gain (BWG: g/d) and feed conversion ratio (FCR; g feed : g BWG) had to be recorded and information with respect to dietary composition, sex, age of the broilers and duration of the experiment had to be provided in the studies.

Requirements were estimated using a quadratic broken-line model. The quadratic broken line model is as follows:

If (SID-ARG (%) < R) then BWG or FCR = L + U × (R – SID-ARG)^2;
Else BWG or FCR = L + U × 0;
Where:
L = plateau value for BWG or FCR
R = break-point value for SID-ARG (%)
U = slope value, representing the increase in BWG or decrease in FCR per unit increase in dietary SID-ARG.

As ARG requirements are normally expressed as a percentage of lysine (LYS) requirement the estimated SID-ARG requirements of the individual ARG titration trials were expressed as a percentage of SID-LYS level as well. The SID-LYS level was in a number of cases the SID-LYS level used in the ARG titration studies. However, in a number of cases the SID-LYS levels used in the ARG titration studies were larger than the SID-LYS requirements as predicted from the factors mean age of the birds and the dietary ME value as described in the prediction formulas F.5. and F.9. in CVB Documentation report nr. 62. in those cases where the SID-LYS levels used in the ARG titration studies were larger than the SID-LYS requirements as predicted from the prediction formula in CVB Documentation report nr. 62 the estimated SID-LYS requirement levels using formulas F.5. (for BWG) and F.9. (for FCR) were used for the calculation of the SID-ARG: SID-LYS ratios (SID-ARG:LYS) of the individual experiments. As well, the estimated SID-LYS requirement levels were used to calculate ratios of other non-test SID-AA with the estimated requirement SID-LYS levels and it was checked whether some of the non-test SID AA were negatively affecting the estimated SID-ARG:LYS levels.

Because of the small number of titration trials (n = 5) it was considered undesirable to check for regression relationships between SID-ARG:LYS and factors such as age, sex and the dietary factors CP, ME and CP : ME ratio.

3 Results and Discussion

In Table 1 a summary of the total dataset is given. The dataset consisted of 4 studies with in total 5 titration trials and 30 observations.

Table 1. Summary of the total dataset

	N	Mean	Std Dev	Minimum	Maximum
ME Recalculated (kcal/kg)	30	3118	145.2	2952	3387
ME Publication (kcal/kg)	30	3199	84.1	3075	3340
CP Recalculated (%)	30	21	2.7	17	24
CP Publication (%)	25	21	2.2	17	23
Year	30	2003	4.4	1999	2012
Starting age (d)	30	8	8.2	1	20
Duration (d)	30	16	2.7	13	20
finishing age (d)	30	24	9.4	14	40
Mean age (d)	30	16	8.7	7	30
BWG (g/d)	30	43.5	24.35	8.9	85.3
FCR	30	1.541	0.1399	1.300	1.855

In Appendix A for each titration trial the relationship between dietary SID-ARG supply and FCR between dietary SID-ARG and BWG is presented graphically together with the estimated SID-ARG requirements. In Appendix B the estimated quadratic broken-line model parameters for each titration trial is given.

It was observed that for trial 1 (study of Chamruspollert et al. 2004), the estimated SID-ARG requirement for BWG was substantially larger than would be expected from a visual interpretation of the curve. This overestimation of the SID-ARG requirement in trial 1 could be avoided by removing the first observation leaving still some 5 observations on which the curve fitting could be carried out. Removing the observation with the lowest SID-ARG content resulted in a substantially lower estimated SID-ARG requirement which more closely agreed with the SID-ARG requirement as would be judged from a visual interpretation of the relationship between SID-ARG supply and BWG as shown in Appendix A in trial 1a and was also more comparable to the SID-ARG requirement estimated for FCR. In Appendix A and Appendix B the titration results for trial 1 with all observations is represented with the letter ‘a’ whereas the titration results in which the lowest SID-ARG level was removed before estimation of the SID-ARG requirement is represented with the letter ‘b’. For all other trials all observations were used for the estimation of SID-ARG requirements for both BWG and FCR.

Furthermore, for 1 titration trial for BWG it was not possible to estimate a reliable or unique SID-ARG requirement.

The estimated SID-ARG:LYS requirement ratios for BWG and FCR for the individual titration trials are presented in Table 2.

Table 2. Estimated SID-ARG-LYS ratios for BWG and FCR for the various titration trials

Publication	trial	SID-ARG:SID-LYS ratio	
		BWG	**FCR**
Chamruspollert et al. (2004)	1b	107	110
Labadan et al. (2001)	2	106	103
Labadan et al. (2001	3		112
Mack et al. (1999)	4	154	153
Corzo (2012)	5	109	123
Average		**119**	**120**
Std. Dev.		23.6	19.6
Average*		**107**	**112**
Std. Dev.*		1.8	8.3

*Average and Std. Dev. after removing the results of the study from Mack et al. (1999)

In Table 3 the dietary non-test SID-AA : estimated SID-LYS requirements ratios using the quadratic broken-line procedure for FCR and BWG are given together with the recommended CVB apparent fecal digestible (AFD) ratios. Results in Table 3 show that at least in one of the trials some non-test AA levels could have had a negative impact on estimated SID-ARG levels as a comparison between recommended CVB ratios and minimal ratios for both FCR and BWG observed in this study show. Indeed, in the study of Mack et al. (1999) the SID-ILE:SID-LYS ratio of 51% for FCR and 54% for BWG was substantially lower than the CVB recommendation of the AFD ILE:LYS ratio of 66%. The estimated SID-ARG:LYS requirement ratios of the study of Mack et al. (1999) differed also substantially from the estimated SID-ARG:LYS requirement ratios of the other studies. Discarding the results of Mack et al. (1999) resulted in average estimated SID-ARG:LYS requirement ratios of 107±1.8% for BWG and 112±8.3% for FCR.

Table 3. Dietary non-test SID-AA : SID-LYS ratios.

Ratio	Rec. CVB AFD ratio	FCR				BWG			
		Mean	**St.dev**	**Min**	**Max**	**Mean**	**St.dev**	**Min**	**Max**
M+C:LYS	73	77	10.3	61	88	79	11.6	61	93
THR:LYS	65	73	9.9	62	89	75	9.0	65	89
TRP:LYS	16	18	1.4	17	21	19	1.7	18	22
ILE:LYS	66	70	11.0	51	79	72	10.9	54	83
VAL:LYS	80	86	6.1	79	93	89	7.2	79	98

4 Conclusions

Based on the results of this study it is concluded that it is most prudent to base dietary SID-ARG:LYS requirement ratios on the dataset of SID-ARG trials in which the results from the study of Mack et al. (1999) are excluded. This results in the following SID-ARG:LYS requirements:

SID-ARG:LYS for BWG = 107%
SID-ARG:LYS for FCR = 112%

List of studies included in the meta-analysis

Chamruspollert, M., G. M. Pesti, and R. I. Bakalli. 2004. Chick responses to dietary arginine and methionine levels at different environmental temperatures. British Poultry Science 45(1):93-100.

Corzo, A. 2012. Determination of the arginine, tryptophan, and glycine ideal-protein ratios in high-yield broiler chicks. Journal of Applied Poultry Research 21(1):79-87.

Labadan Jr, M. C., K. N. Hsu, and R. E. Austic. 2001. Lysine and arginine requirements of broiler chickens at two-to three-week intervals to eight weeks of age. Poultry Science 80(5):599-606.

Mack, S., D. Bercovici, G. De Groote, B. Leclercq, M. Lippens, M. Pack, J. B. Schutte, and S. Van Cauwenberghe. 1999. Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. British Poultry Science 40(2):257-265.

References

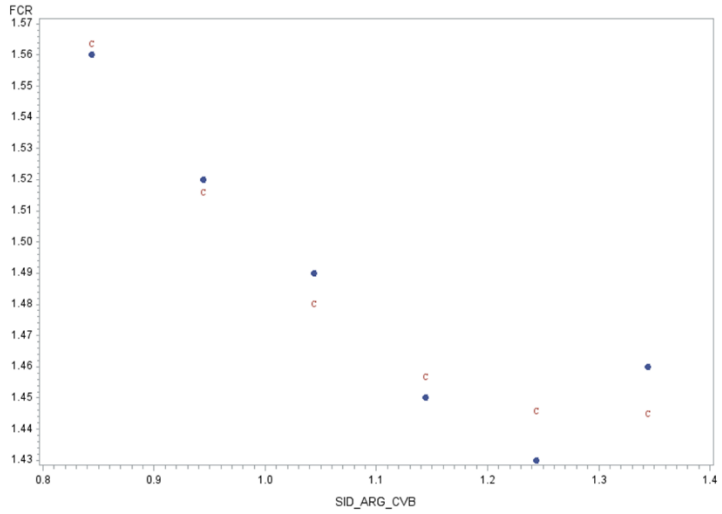
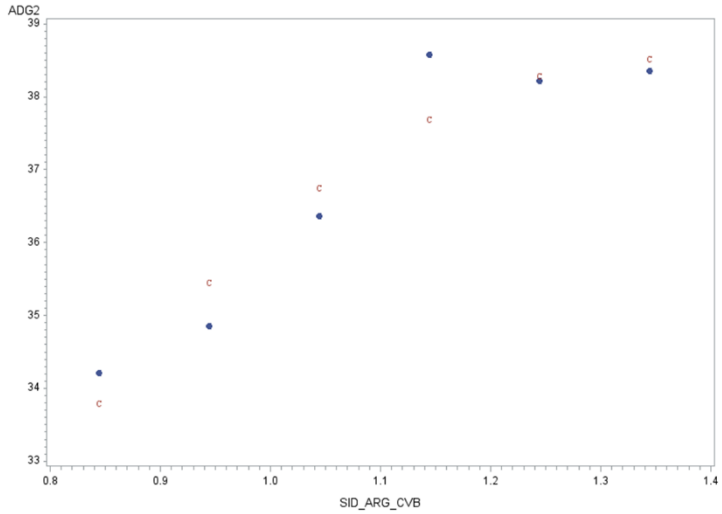
Blok and Dekker. 2017. Table ‘Standardized ileal digestibility of amino acids in feedstuffs for poultry’. CVB Documentation report nr. 61.

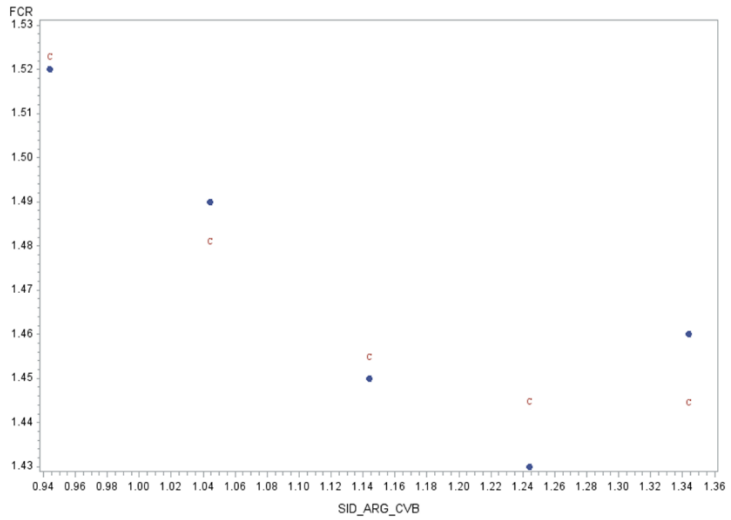
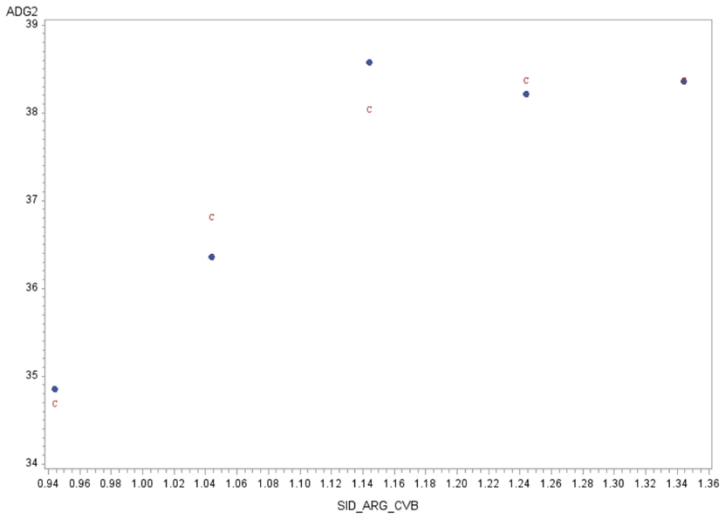
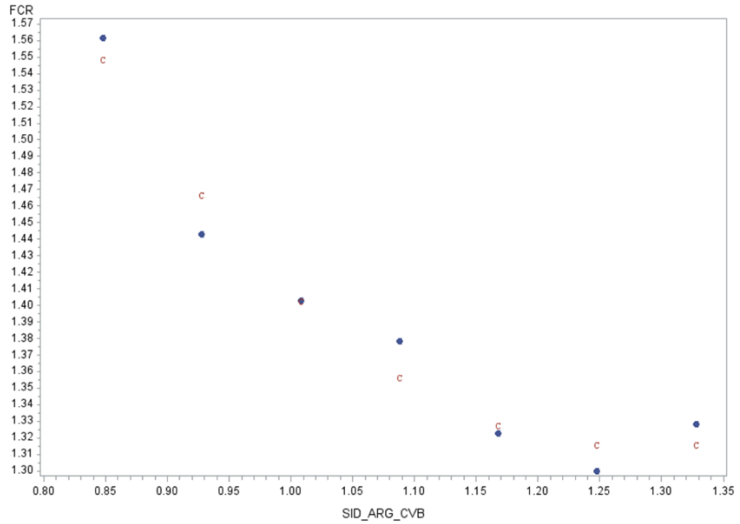
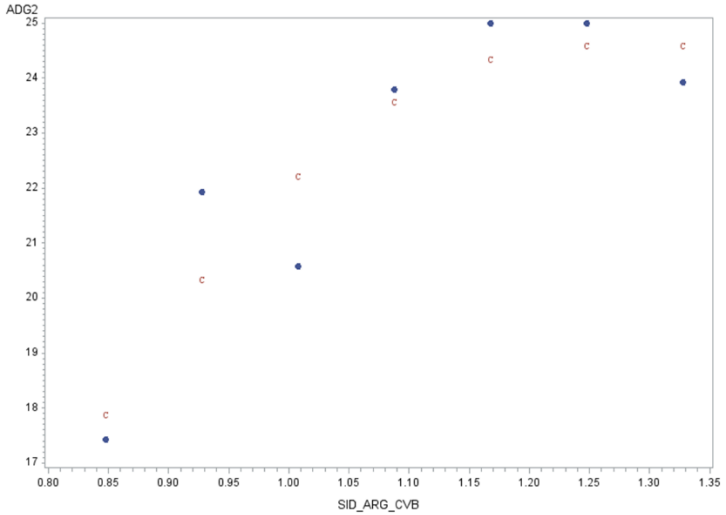
Spek, J.W. 2018. Standardized ileal digestible lysine requirement for broilers. CVB Documentation report nr. 62.

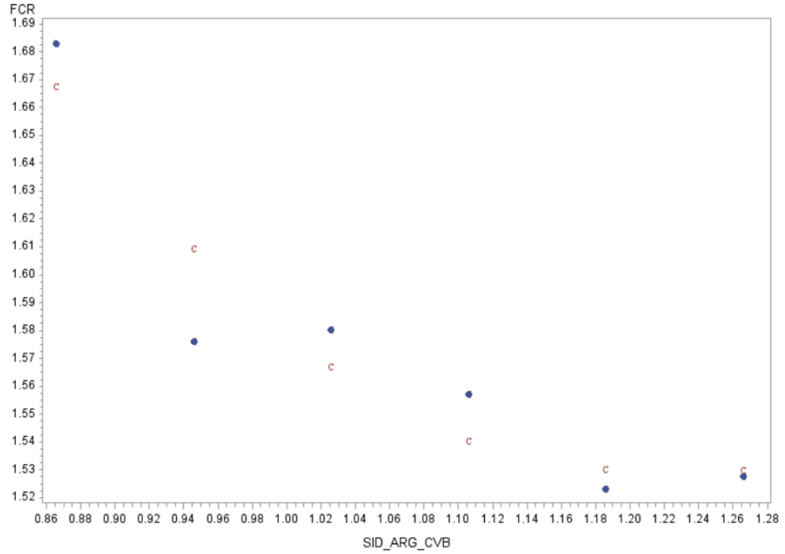
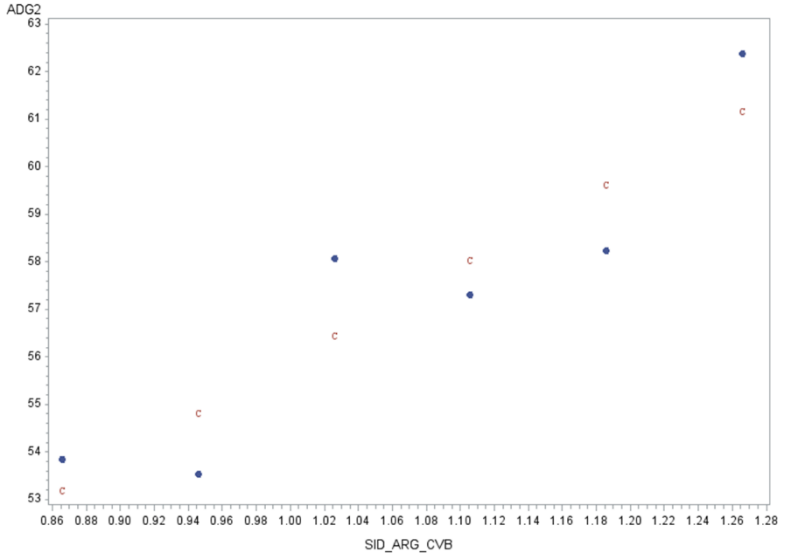
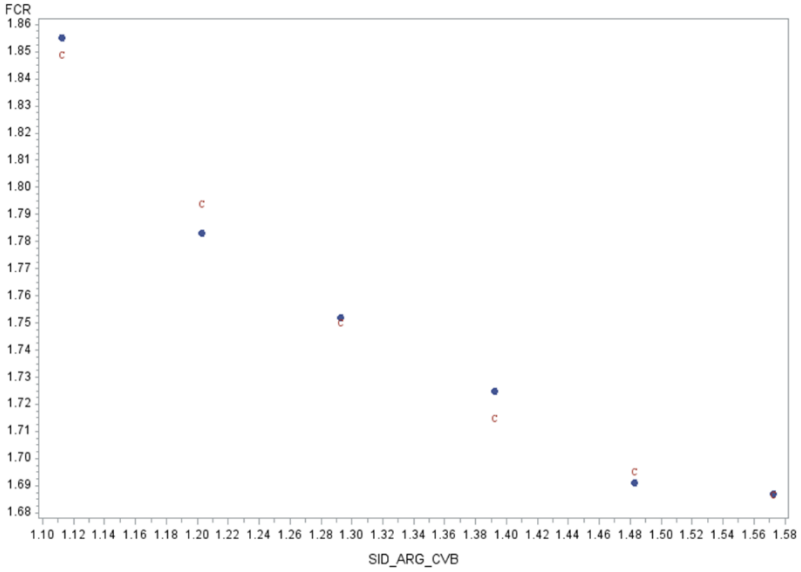
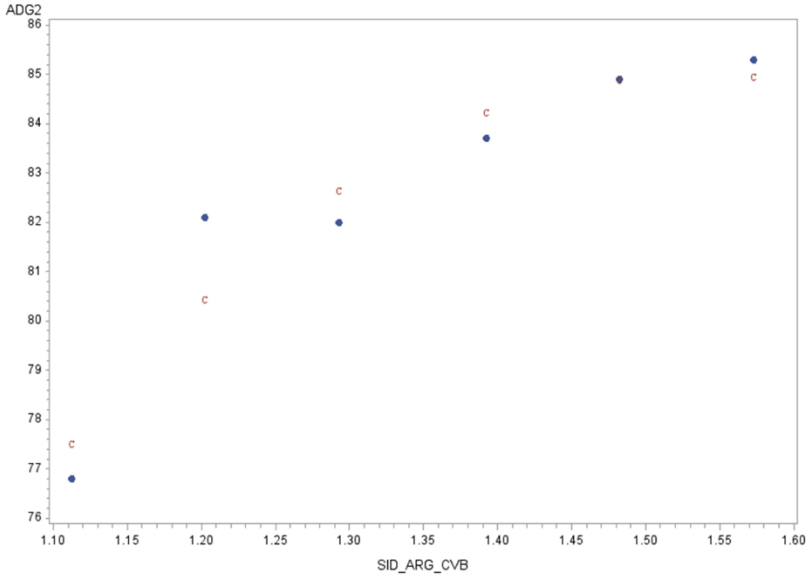
Veldkamp, T., J.W. van Riel, R.A. Dekker, S. Khalaji, V. Khaksar, H. Hashemipour, M.M. van Krimpen, and M.C. Blok. 2016. Estimating requirement values for apparent faecal digestible and standardised ileal digestible arginine in broilers by a meta-analysis approach.

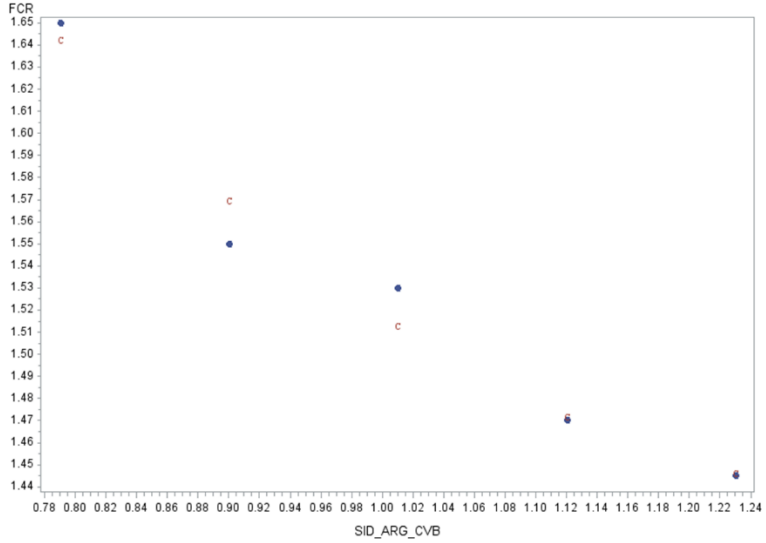
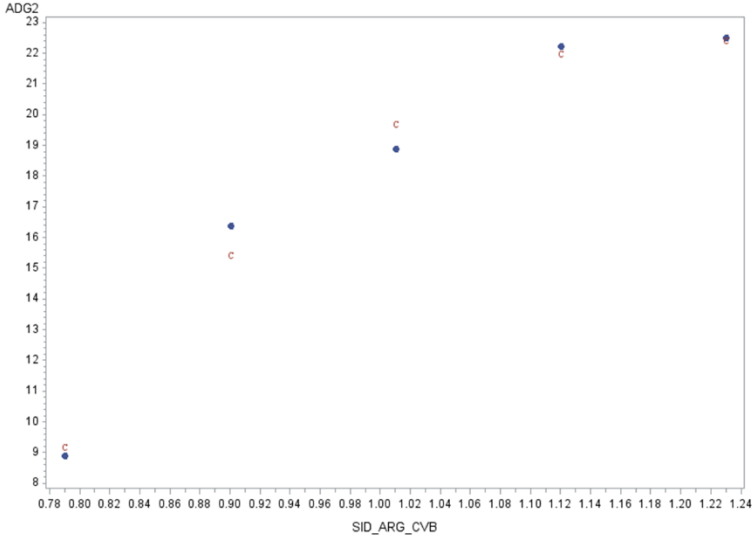
Appendix A. Relationship between dietary SID-ARG supply and performance parameters FCR and BWG for the various titration trials.

On the x-axis of the Figures the dietary SID-ARG concentration (%) is given and on the y-axis of the Figures the FCR (left hand Figures) and BWG (right hand figures) are given. The closed circles are the observed values and the 'c' symbols are the fitted values. The letter 'a' behind the trial number (shown in the first column) means the model is fitted on all observations whereas the letter 'b' behind the trial number (shown in the first column) means the model is fitted on all observations except the observations with the lowest dietary SID-ARG level. If no letter is shown behind the trial number it means that the model is fitted based on all observations of the trial.

Trial	FCR	BWG
1a. Chamruspollert et al. (2004) Optimal SID-ARG FCR (%): 1.285 Optimal SID-ARG BWG (%): 1.360		

1b. Chamruspollert et al. (2004) Optimal SID-ARG FCR (%): 1.258 Optimal SID-ARG BWG (%): 1.229		
2. Labadan et al. (2001) Trial 1 Optimal SID-ARG FCR (%): 1.260 Optimal SID-ARG BWG (%): 1.360		

3. Labadan et al. (2001) Trial 2 Optimal SID-ARG FCR (%): 1.198 Optimal SID-ARG BWG (%): 7.421 (value far beyond measurment range)		
4. Mack et al. (1999) Optimal SID-ARG FCR (%): 1.596 Optimal SID-ARG BWG (%): 1.520		

5. Corzo (2012) Optimal SID-ARG FCR (%): 1.353 Optimal SID-ARG BWG (%): 1.192		

Appendix B. SID-ARG model estimates using the quadratic broken-line model for minimum FCR and maximum BWG

SID-ARG model estimates using the quadratic broken-line model for minimum FCR. The letter 'a' behind the trial number (shown in the first column) means the model is fitted on all observations whereas the letter 'b' behind the trial number (shown in the first column) means the model is fitted on all observations except the observation with the lowest dietary SID-ARG level. If no letter is shown behind the trial number it means that the model is fitted based on all observations of the trial.

Trial nr.	Estimate L	Std. Err. L	Estimate R	Std. Err. R	Estimate U	Std. Err. U	R^2
1a	1.445	0.0118	1.285	0.1146	0.61	0.314	0.944
1b	1.445	0.0127	1.258	0.1465	0.79	0.742	0.886
2	1.316	0.0145	1.260	0.0683	1.37	0.459	0.966
3	1.530	0.0181	1.198	0.1198	1.25	0.904	0.892
4	1.687	0.0104	1.596	0.0703	0.70	0.187	0.986
5	1.437	0.0450	1.353	0.2293	0.65	0.427	0.971

SID-ARG model estimates using the quadratic broken-line model for maximum BWG. The letter 'a' behind the trial number (shown in the first column) means the model is fitted on all observations whereas the letter 'b' behind the trial number (shown in the first column) means the model is fitted on all observations except the observation with the lowest dietary SID-ARG level. If no letter is shown behind the trial number it means that the model is fitted based on all observations of the trial.

Trial nr.	Estimate L	Std. Err. L	Estimate R	Std. Err. R	Estimate U	Std. Err. U	R^2
1a	38.5	0.71	1.360	0.1788	-18	11.5	0.919
1b	38.4	0.36	1.229	0.0846	-45	27.3	0.948
2	24.6	0.86	1.242	0.1384	-43	31.0	0.857
3	120.7	1756.70	7.422	176.0000	-2	43.5	0.837
4	85.0	0.93	1.520	0.1348	-45	29.3	0.915
5	22.4	0.83	1.192	0.0637	-82	25.2	0.986