Standardized ileal digestible valine 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 valine (SID-VAL) are presented in the present CVB Documentation report. Compared to the former CVB apparent faecal digestible VAL recommendation for broilers described in CVB Documentation report nr. 18 and published in 1996 the present established SID-VAL 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-VAL 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 valine (SID-VAL; %) 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-VAL 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

Valine titration studies were selected from literature (1990 – 2017) in which only the dietary VAL content was varied by means of addition of graded levels of dietary synthetic VAL. Furthermore, only those titration studies were selected in which dietary digestible VAL levels of the basal diets where at least 15% below the recommended CVB (2012) levels of the other non-test amino acids. 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-VAL (%) < R) then BWG or FCR = L + U × (R – SID-VAL)$^{\wedge 2}$;
Else BWG or FCR = L + U × 0;
Where:
L = plateau value for BWG or FCR
R = break-point value for SID-VAL (%)
U = slope value, representing the increase in BWG or decrease in FCR per unit increase in dietary SID-VAL.

As VAL requirements are normally expressed as a percentage of lysine (LYS) requirement the estimated SID-VAL requirements of the individual VAL 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 VAL titration studies. However, in a number of cases the SID-LYS levels used in the VAL 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 VAL 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-VAL : SID-LYS ratios (SID-VAL:LYS) of the individual experiments.

Via the PROC MIXED procedure of SAS the estimated SID-VAL:SID-LYS requirements for BWG and FCR were regressed against factors such as age, sex and the dietary factors CP, ME and CP : ME ratio with study effect included as a random factor. Furthermore, the estimated SID-LYS requirement levels were also used to calculate ratios of other non-test SID-AA and it was checked whether some of the non-test SID-AA were negatively affecting the estimated SID-VAL:SID-LYS levels.

3 Results and Discussion

In Table 1 a summary of the total dataset is given. The dataset consisted of 6 studies with in total 9 titration trials and 54 observations.

Table 1. Summary of the total dataset

	N	Mean	Std Dev	Minimum	Maximum
ME Recalculated (kcal/kg)	54	3118	168.5	2957	3572
ME Publication (kcal/kg)	54	3147	103.0	3000	3400
CP Recalculated (%)	54	19	1.9	16	23
CP Publication (%)	54	19	1.9	16	23
Year	54	2009	5.2	1999	2017
Starting age (d)	54	17	9.4	1	30
Duration (d)	54	16	3.4	13	21
finishing age (d)	54	32	10.9	14	42
Mean age (d)	54	25	10.0	8	36
BWG (g/d)	54	71.9	30.60	9.2	107.4
FCR	54	1.668	0.2618	1.190	2.170

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

The estimated SID-VAL:LYS requirement ratios for BWG and FCR were not significantly related to sex, age, dietary protein concentration, and dietary ME.

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

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

Publication	trial	SID-VAL:SID-LYS ratio	
		BWG	FCR
Berres et al. (2011)	1	96	87
Corzo et al. (2008)	2	81	81
Corzo et al. (2008)	3	85	74
Corzo et al. (2008)	4	79	70
Mack et al. (1999)	5	70	65
Ospina Rojas et al. (2017)	6	77	73
Taverni et al. (2013)	7	84	77
Taverni et al. (2013)	8	76	76
Baker (2002)	9	73	68
Average		80	75
Std. Dev.		7.6	6.7
Average*		78	73
Std. Dev.*		5.0	5.2

*The estimated SID-VAL:SID-LYS requirement ratio for BWG of Berres et al. (2011) differed more than two standard deviations from the mean. Therefore the average and the standard deviation for BWG and for FCR were also calculated without the values of Berres et al. (2011).

In Table 3 the dietary non-test SID-AA : SID-LYS requirements ratios are given together with the recommended CVB apparent faecal 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-VAL levels as a comparison between recommended CVB ratios and minimal ratios for both FCR and BWG observed in this study show. However, a visual inspection indicated that the trial with the lowest non-test SID-AA:SID-LYS ratios did not result in abnormal estimated SID-VAL:LYS levels.

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

		FCR				BWG			
Ratio	**Rec. CVB AFD ratio**	**Mean**	**Std Dev**	**Min**	**Max**	**Mean**	**Std Dev**	**Min**	**Max**
M+C:LYS	73	78	5.0	69	87	81	6.3	69	92
THR:LYS	65	66	2.6	62	70	69	3.0	65	74
TRP:LYS	16	18	1.6	16	21	19	1.8	16	21
ILE:LYS	66	70	3.1	67	77	73	4.0	68	82
ARG:LYS	105	116	11.5	103	135	121	13.4	103	142

There was one study that contained three titration, another study that contained two trials whereas the other four studies contained only one titration trial. This may result in average calculated SID-VAL:LYS requirement ratios for BWG and FCR that are strongly influenced by the two studies containing multiple titration trials. In order to weigh the estimated SID-VAL:LYS ratios from each study equally it is possible to take into account the effect of study. When this was done (using the PROC MIXED procedure of SAS and by including study as a random effect in the model) the estimated SID-VAL:LYS ratios for BWG and FCR became:

SID-VAL:LYS for BWG = 79.9±3.54 % (estimate ± Std. Err.)
SID-VAL:LYS for FCR = 74.7±2.31 % (estimate ± Std. Err.)

In case the results of the study of Berres et al. (2011) were excluded the estimated SID-VAL:LYS ratios for BWG and FCR became:

SID-VAL:LYS for BWG = 77.3±2.11 % (estimate ± Std. Err.)
SID-VAL:LYS for FCR = 72.9±1.95 % (estimate ± Std. Err.)

It furthermore appeared that the estimated SID-VAL:LYS requirement ratios were related to the model estimated steepness of the increase in BWG or decrease in FCR per unit increase in dietary SID-VAL as shown in Figure 1 (for BWG) and Figure 2 (for FCR). However, contrary to what would be expected the model estimated steepness of the curve was not related to the difference between the basal level of FCR and the estimated minimum FCR (P=0.980). Furthermore, there was an almost significant relationship between the difference between the basal level of FCR and the estimated minimum FCR and the estimated SID-VAL:LYS requirement ratio for minimum FCR (Fig. 3) and a significant relationship between the difference between the basal level of FCR and the estimated minimum FCR and the estimated SID-VAL:LYS requirement ratio for maximum BWG (Fig. 4). These relationships indicate that choice of the basal level of VAL in a titration study affects the estimated SID-VAL:LYS ratio (the lower the basal level, the higher the difference between the basal level of FCR and the estimated minimum FCR and the lower the estimated SID-VAL:LYS requirement ratio). These relationships furthermore suggest that a SID-VAL:LYS ratio of around 75% is the absolute minimum requirement ratio for BWG and that a SID-VAL:LYS ratio of around 69% is the absolute minimum requirement ratio for FCR resulting in a strong impairment of BWG and FCR below these requirement ratios whereas smaller improvements in BWG and FCR may be expected above these requirements of 75 and 69% for, respectively, BWG and FCR.

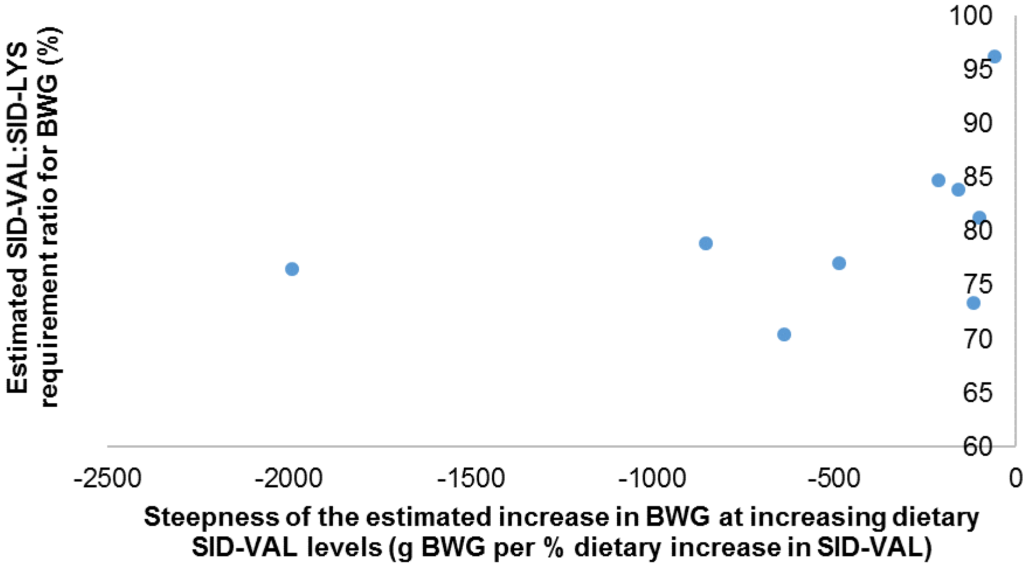

Figure 1. Relationship between the estimated SID-VAL:SID-LYS requirement ratio for BWG (%) and the model estimated steepness of the increase in BWG at increasing dietary SID-VAL levels (g BWG per percent increase in dietary SID-VAL).

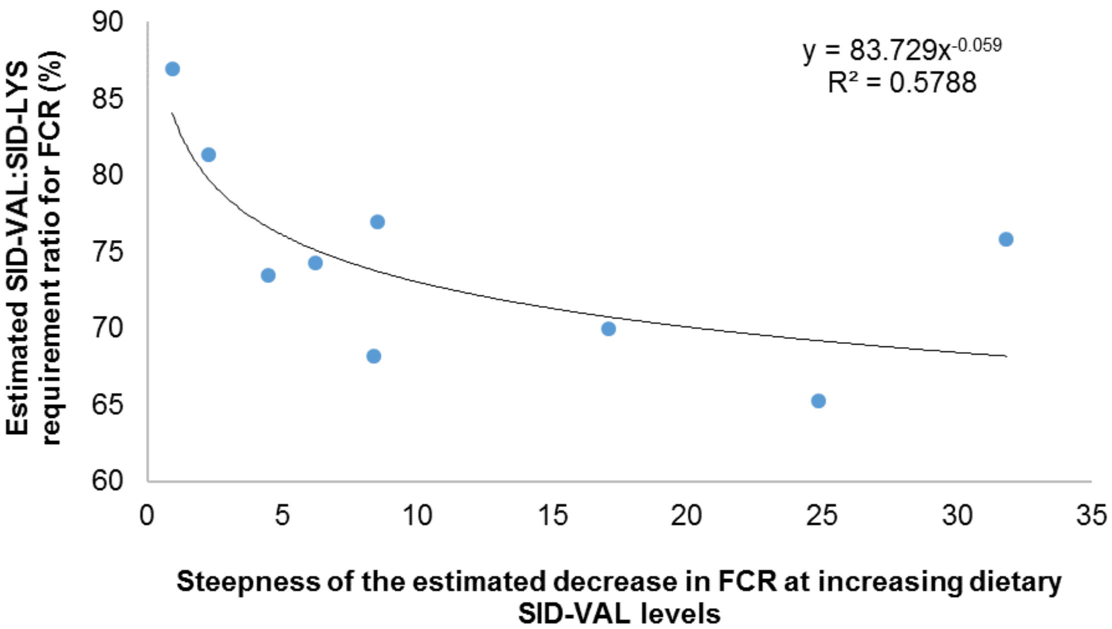

Figure 2. Relationship between the estimated dietary SID-VAL:SID-LYS requirement ratio for minimum FCR (%) and the model estimated steepness of the decrease in FCR at increasing dietary SID-VAL levels.

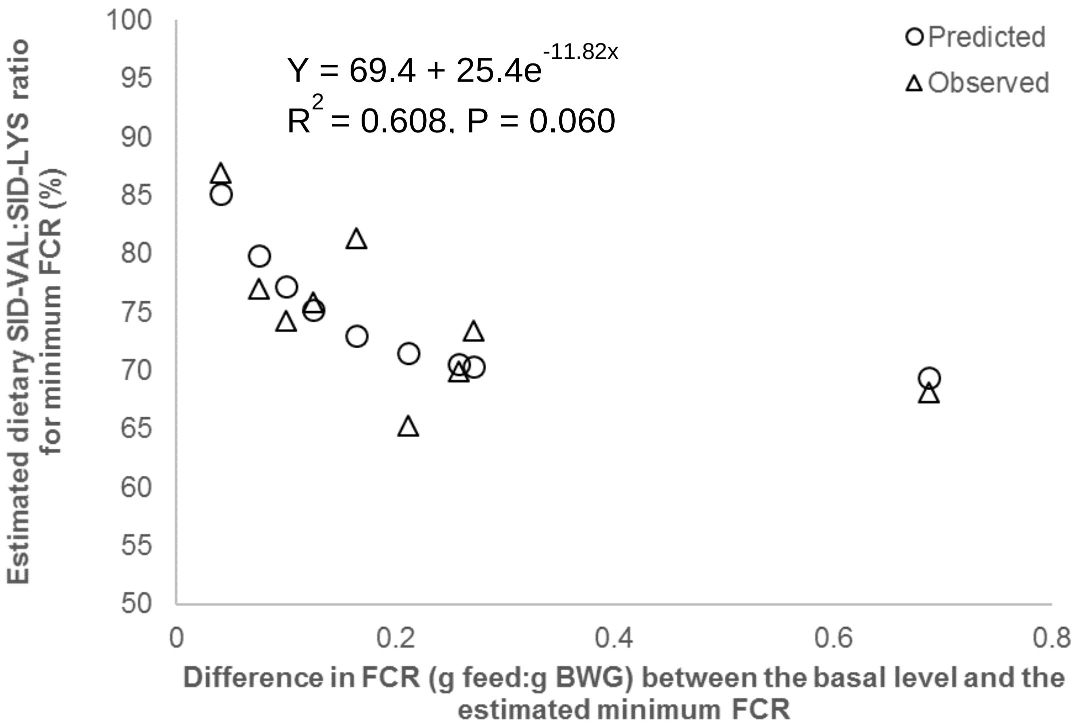

Figure 3. Relationship between the difference in FCR between the basal diet and the estimated minimum FCR and the estimated SID-VAL:SID-LYS requirement ratio for minimum FCR.

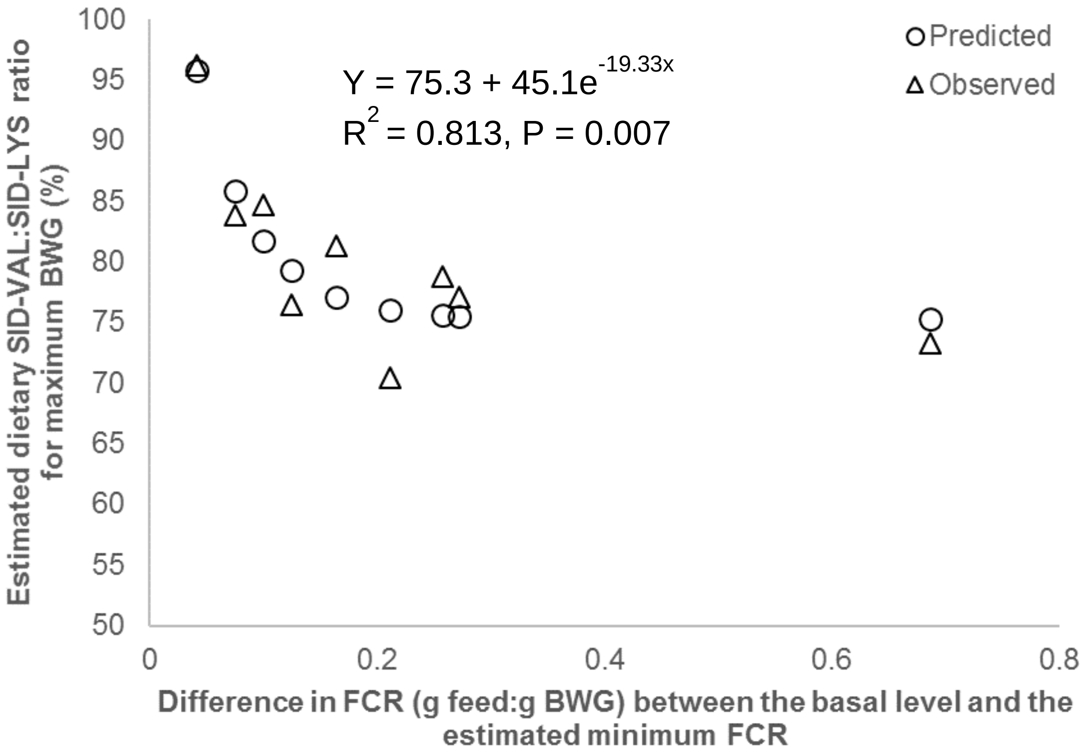

Figure 4. Relationship between the difference in FCR between the basal diet and the estimated minimum FCR and the estimated SID-VAL:SID-LYS requirement ratio for maximum BWG.

It was found that variation in estimated SID-VAL:LYS ratios was not significantly related to sex, age and dietary energy and protein. It is concluded that part of the variation in estimated SID-VAL:LYS ratios is related to the choice of the basal level of SID-VAL in the diet (the lower the basal level, the higher the difference between FCR at the basal level and the estimated plateau level for FCR and the lower the estimated SID-VAL:LYS requirement ratio).

It is therefore difficult to decide what the optimal dietary SID-VAL:LYS ratio is. Because of this difficulty it might be most prudent to base the dietary SID-VAL:LYS requirement ratio recommendation on the complete dataset of VAL titration trials (excluding the results of Berres et al. (2011) and correcting for a (random) study effect. This results in the following recommendations:

SID-VAL:LYS for BWG = 77.3±2.11 % (estimate ± Std. Err.)
SID-VAL:LYS for FCR = 72.9±1.95 % (estimate ± Std. Err.)

4 Conclusions

Based on the results of this study it is concluded that it is most prudent to base dietary SID-VAL:LYS requirement ratios on the complete dataset of SID-VAL trials and correct for a (random) study effect. This results in the following SID-VAL:LYS requirements:

SID-VAL:LYS for BWG = 77%
SID-VAL:LYS for FCR = 73%

List of studies included in the meta-analysis

Baker, D. H., A. B. Batal, T. M. Parr, N. R. Augspurger, and C. M. Parsons. 2002. Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks posthatch. Poultry Science 81(4):485-494.

Berres, J., S. L. Vieira, A. Favero, D. M. Freitas, J. E. M. Peña, and E. T. Nogueira. 2011. Digestible valine requirements in high protein diets for broilers from twenty-one to forty-two days of age. Animal Feed Science and Technology 165(1-2):120-124.

Corzo, A., W. A. Dozier Iii, and M. T. Kidd. 2008. Valine nutrient recommendations for Ross x Ross 308 broilers. Poultry Science 87(2):335-338.

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.

Ospina-Rojas, I. C., A. E. Murakami, C. R. A. Duarte, G. R. Nascimento, E. R. M. Garcia, M. I. Sakamoto, and R. V. Nunes. 2017. Leucine and valine supplementation of low-protein diets for broiler chickens from 21 to 42 days of age. Poultry Science 96(4):914-922.

Tavernari, F. C., G. R. Lelis, R. A. Vieira, H. S. Rostagno, L. F. T. Albino, and A. R. Oliveira Neto. 2013. Valine needs in starting and growing cobb (500) broilers. Poultry Science 92(1):151-157.

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 n. 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 valine in broilers by a meta-analysis approach.

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

On the x-axis of the Figures the dietary VAL 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.

<table>
<tr><th>Trial</th><th>FCR</th><th>BWG</th></tr>
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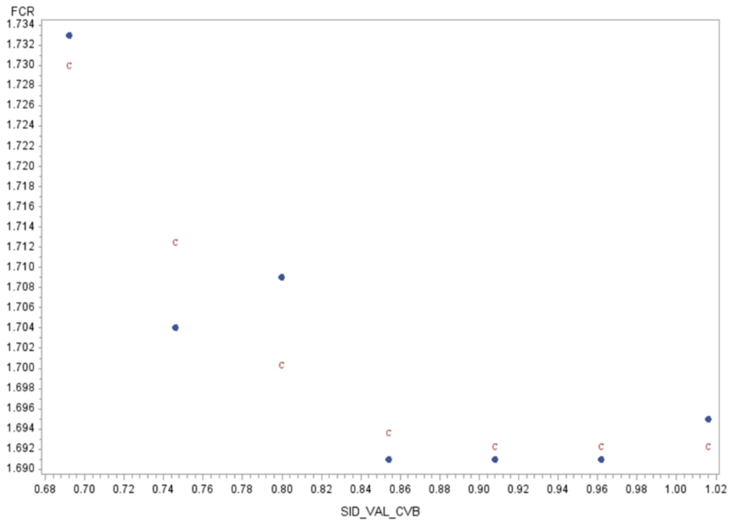
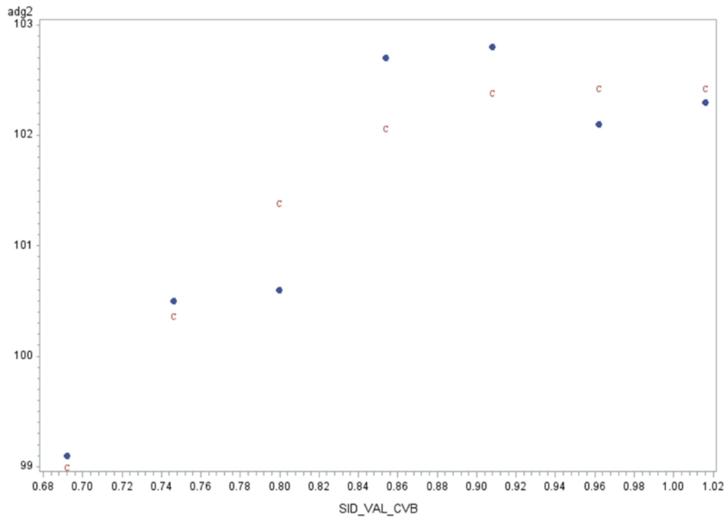
Berres et al. (2011)

Optimal SID-VAL FCR (%): 0.893

Optimal SID-VAL BWG (%): 0.932</td><td>
</td><td>
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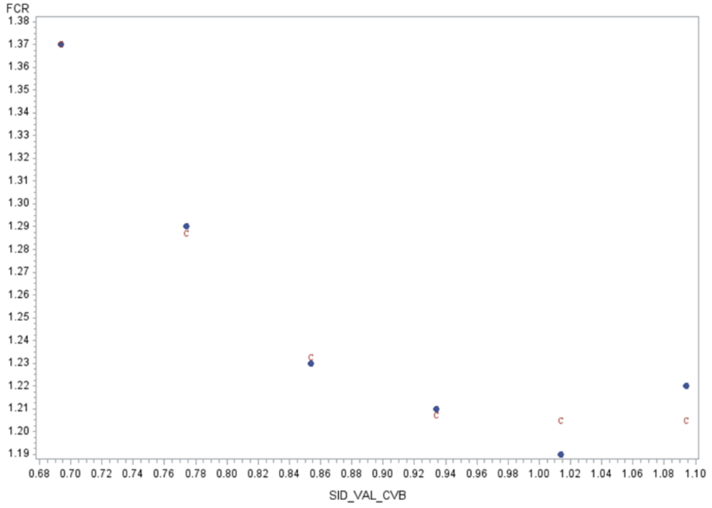
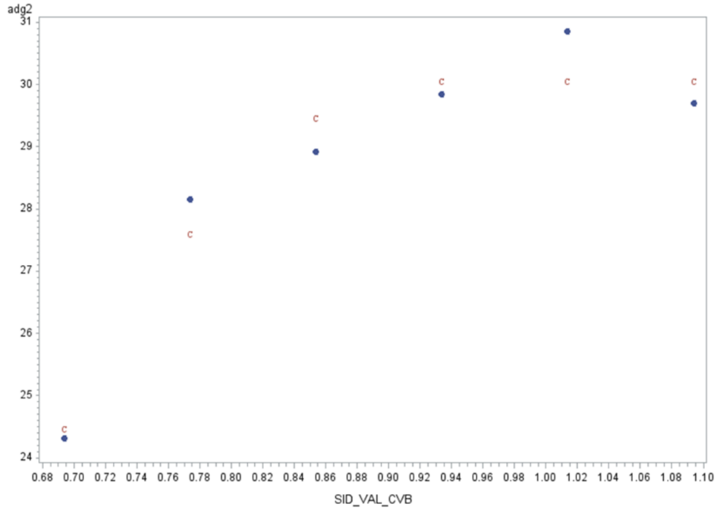
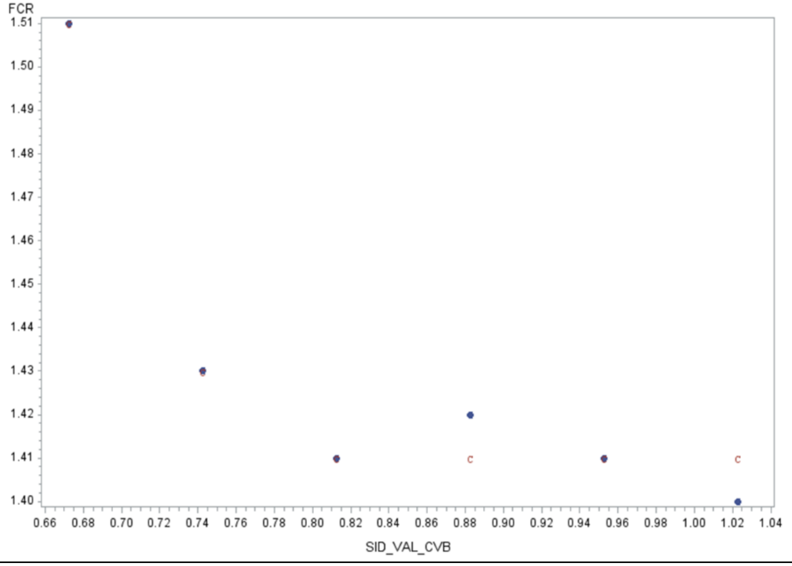
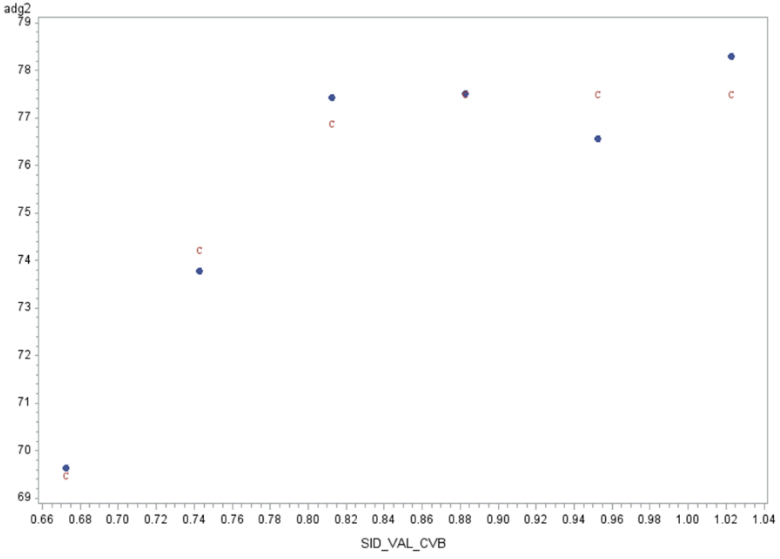
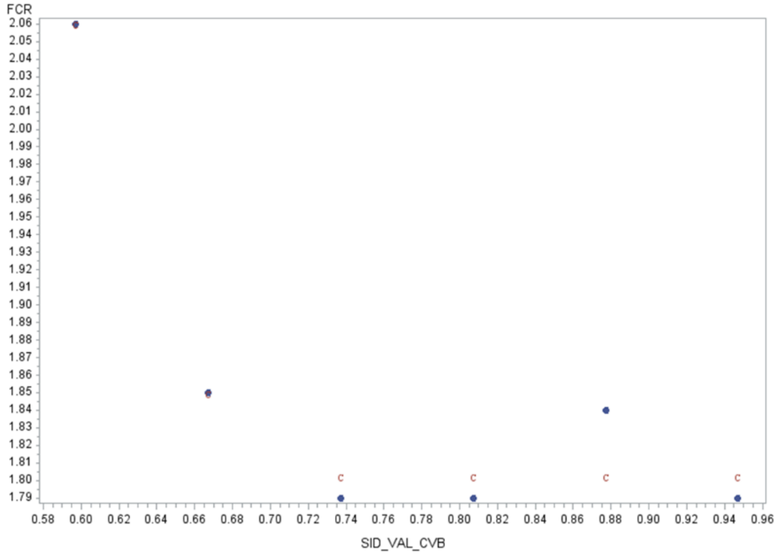
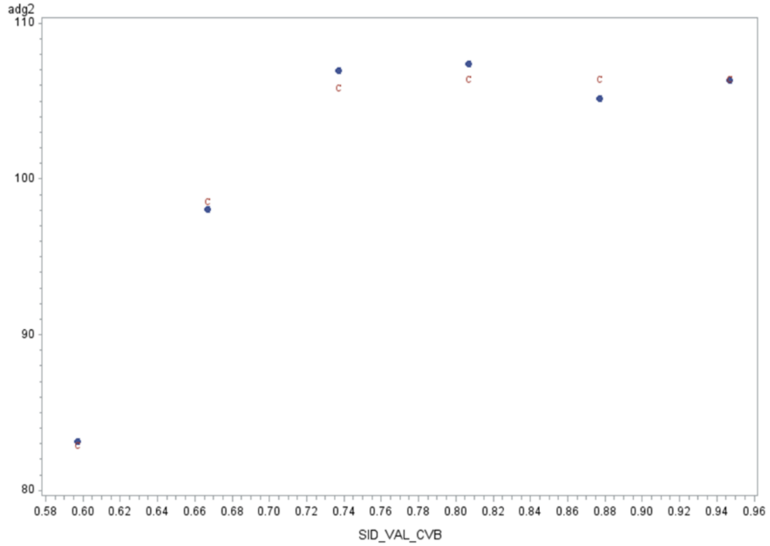
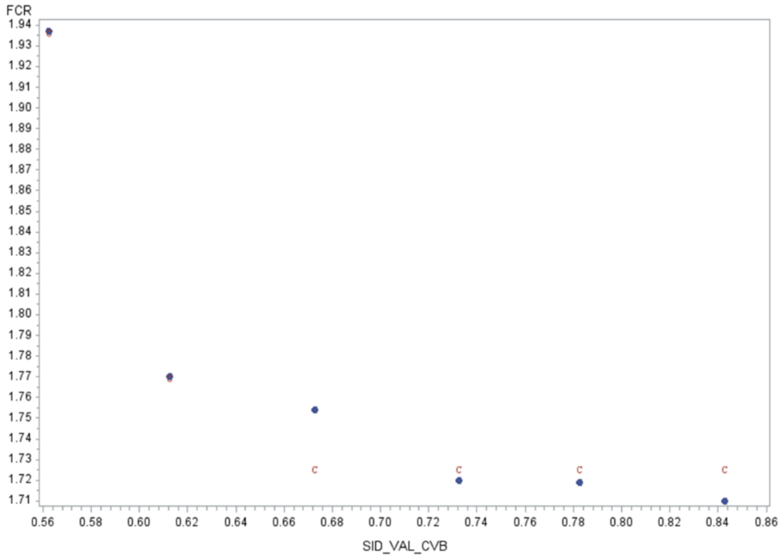
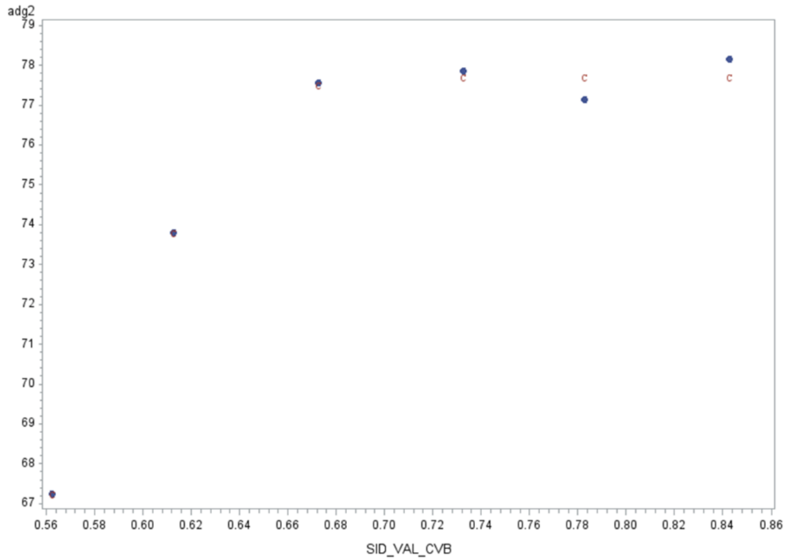
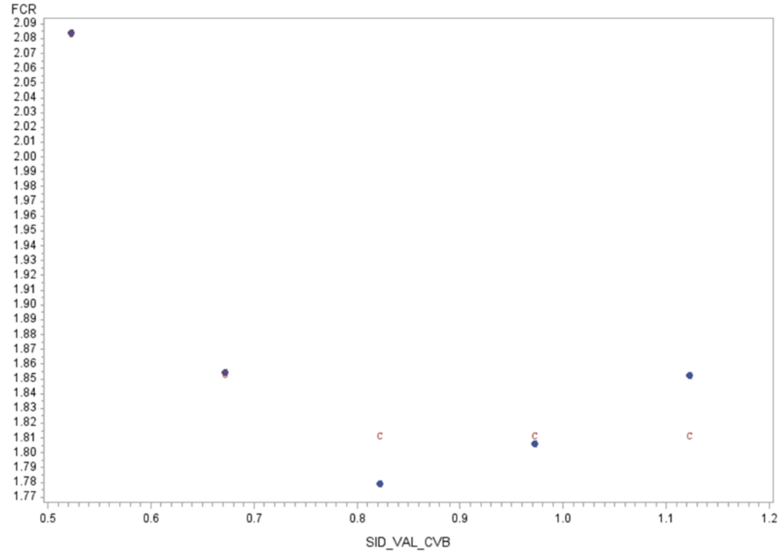
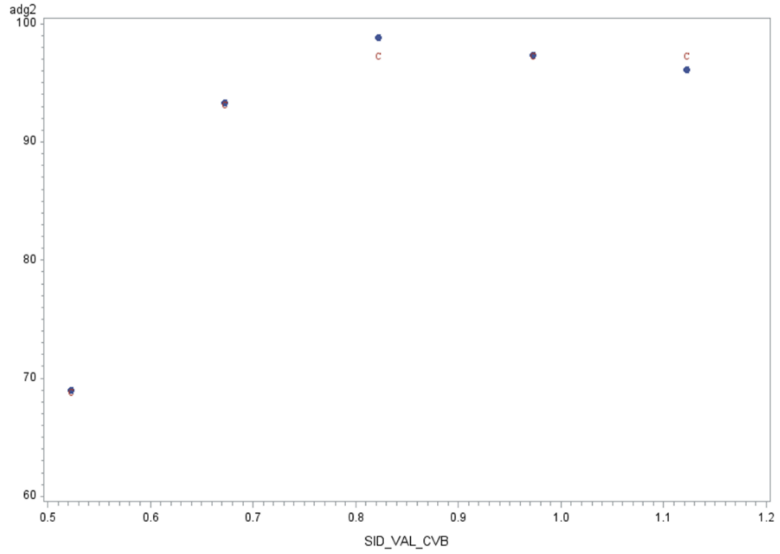
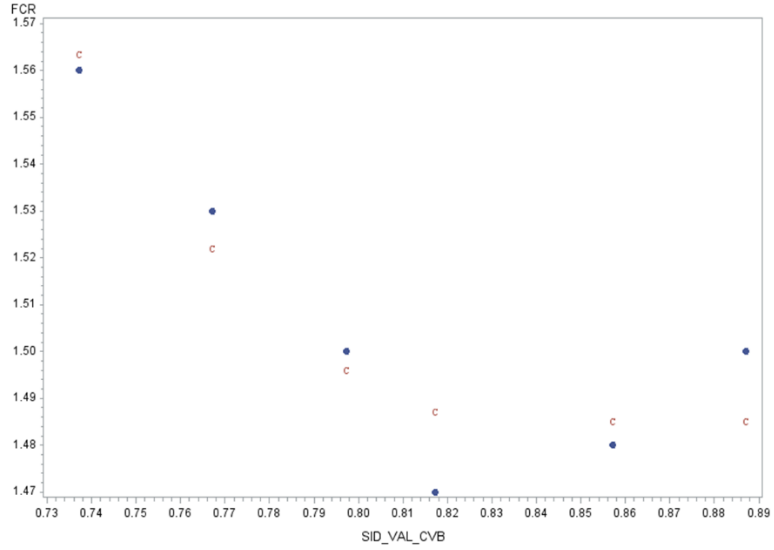
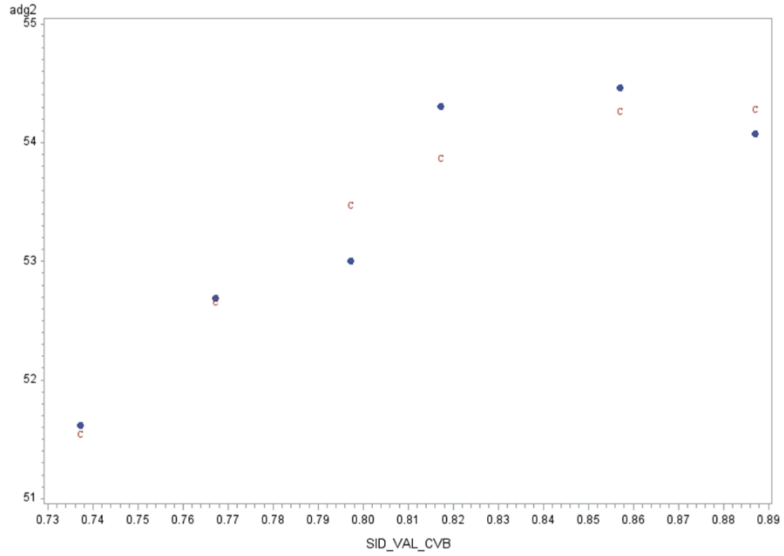
2. Corzo et al. (2008) Trial 1 Optimal SID-VAL FCR (%): 0.964 Optimal SID-VAL BWG (%): 0.931		
3. Corzo et al. (2008) Trial 2 Optimal SID-VAL FCR (%): 0.799 Optimal SID-VAL BWG (%): 0.867		

4. Corzo et al. (2008) Trial 3 Optimal SID-VAL FCR (%): 0.720 Optimal SID-VAL BWG (%): 0.763		
5. Mack et al. (1999) Optimal SID-VAL FCR (%): 0.655 Optimal SID-VAL BWG (%): 0.691		

6. Ospina Rojas et al. (2017) Optimal SID-VAL FCR (%): 0.769 Optimal SID-VAL BWG (%): 0.765		
7. Tavernari et al. (2013) Trial 1 Optimal SID-VAL FCR (%): 0.833 Optimal SID-VAL BWG (%): 0.868		

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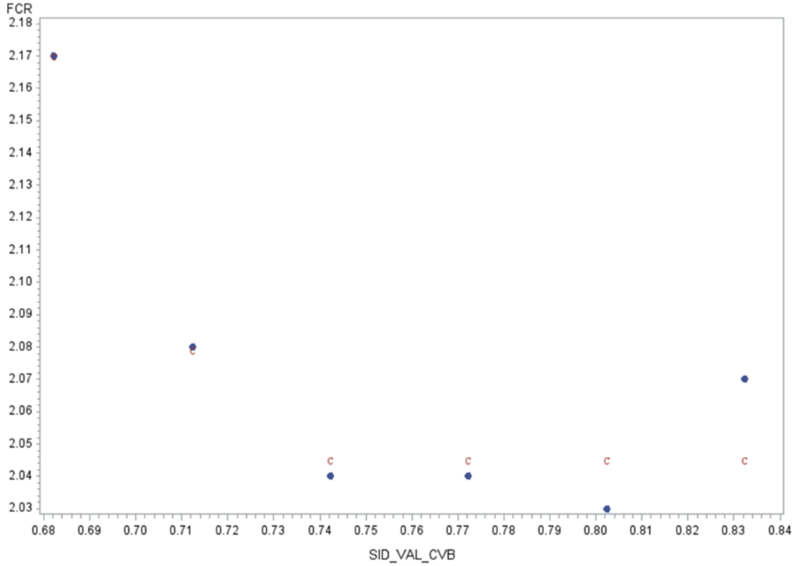
Tavernari et al. (2013)
Trial 2

Optimal SID-VAL FCR (%): 0.745

Optimal SID-VAL BWG (%): 0.742</td>
<td>
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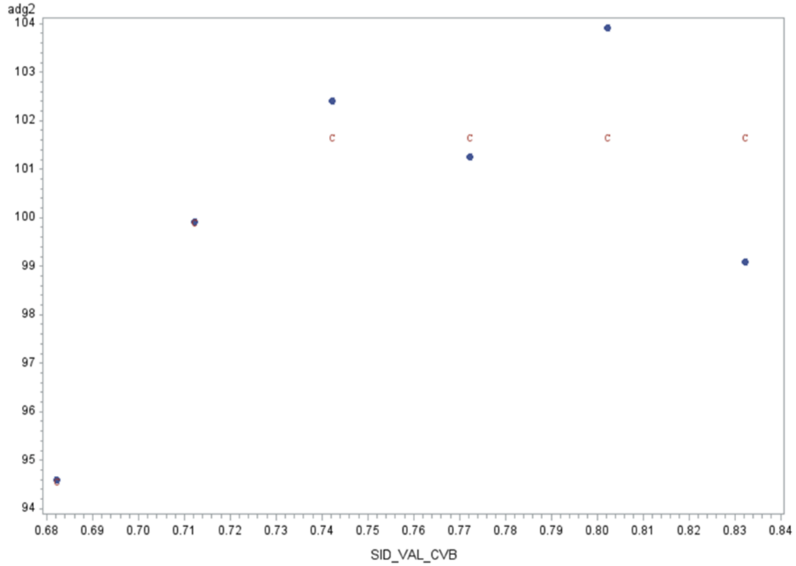
<td>
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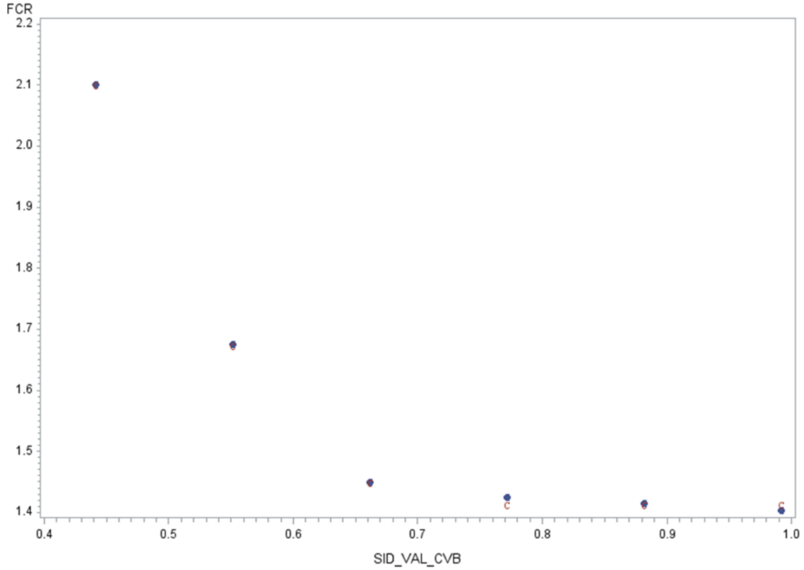
<td>9.
Baker et al. (2002)

Optimal SID-VAL FCR (%): 0.728

Optimal SID-VAL BWG (%): 0.783</td>
<td>
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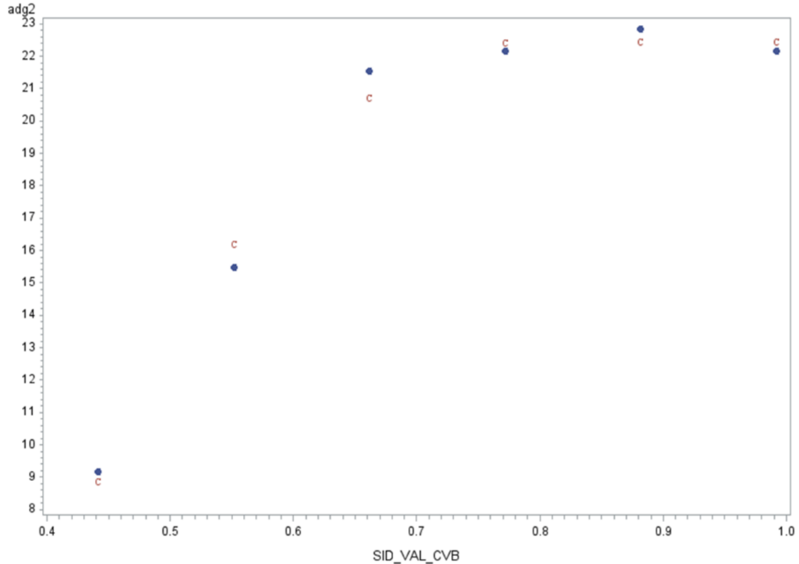
<td>
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Appendix B. SID-VAL model estimates using the quadratic broken-line model for minimum FCR and maximum BWG

SID-VAL model estimates using the quadratic broken-line model for minimum FCR.

Trial nr.	Estimate L	Std. Err. L	Estimate R	Std. Err. R	Estimate U	Std. Err. U	R^2
1	1.692	0.0037	0.893	0.0648	0.9	0.63	0.879
2	1.206	0.0080	0.964	0.0415	2.3	0.71	0.979
3	1.410	0.0041	0.799	0.0229	6.2	2.33	0.976
4	1.803	0.0125	0.720	0.0266	17.1	7.62	0.966
5	1.726	0.0097	0.655	0.0186	24.9	10.40	0.970
6	1.812	0.0213	0.769	0.0790	4.5	2.88	0.954
7	1.485	0.0097	0.833	0.0357	8.5	6.43	0.885
8	2.045	0.0090	0.745	0.0195	31.8	20.53	0.933
9	1.414	0.0051	0.728	0.0077	8.4	0.47	0.999

SID-VAL model estimates using the quadratic broken-line model for maximum BWG.

Trial nr.	Estimate L	Std. Err. L	Estimate R	Std. Err. R	Estimate U	Std. Err. U	R^2
1	102	0.4	0.932	0.0760	-59	38.9	0.885
2	30	0.4	0.931	0.0573	-99	50.1	0.946
3	78	0.5	0.867	0.0394	-213	90.3	0.963
4	107	0.6	0.763	0.0176	-852	186.4	0.991
5	78	0.2	0.691	0.0115	-637	118.6	0.994
6	97	0.8	0.765	0.0276	-485	110.8	0.994
7	54	0.3	0.868	0.0395	-160	95.6	0.918
8	102	1.0	0.742	0.0377	-1991	2624.1	0.763
9	22	0.4	0.783	0.0368	-116	26.1	0.989