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

Isoleucine titration studies were selected from literature (1990 – 2017) in which only the dietary ILE content was varied by means of addition of graded levels of dietary synthetic ILE. Furthermore, only those titration studies were selected in which dietary digestible ILE 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-ILE (%) < R) then BWG or FCR = L + U × (R – SID-ILE)^2;
Else BWG or FCR = L + U × 0;
Where:
L = plateau value for BWG or FCR
R = break-point value for SID-ILE (%)
U = slope value, representing the increase in BWG or decrease in FCR per unit increase in dietary SID-ILE.

As ILE requirements are normally expressed as a percentage of lysine (LYS) requirement the estimated SID-ILE requirements of the individual ILE titration trials were expressed as a percentage of SID-LYS level as well. The SID-LYS level was in all cases the SID-LYS level used in the ILE titration studies as the SID-LYS levels in the ILE titration studies were in all cases lower than the calculated requirement SID-LYS levels according to regression formulas F.5 and F.9 for, respectively, BWG and FCR in the CVB documentation report nr. 62.

3 Results and Discussion

In Table 1 a summary of the total dataset is given. The dataset consisted of 6 studies with in total 8 titration trials and 50 observations.

Table 1. Summary of the total dataset

	N	Mean	Std Dev	Minimum	Maximum
ME Recalculated (kcal/kg)	50	3163	159.7	3037	3571
ME Publication (kcal/kg)	50	3203	77.7	3150	3400
CP Recalculated (%)	50	18	2.2	16	23
CP Publication (%)	50	18	2.4	15	23
Year	50	2004	6.1	1992	2012
Starting age (d)	50	18	10.9	1	30
Duration (d)	50	15	3.5	12	21
finishing age (d)	50	33	9.7	21	43
Mean age (d)	50	16	4.8	11	22
BWG (g/d)	50	58.5	25.73	14.8	102.3
FCR	50	1.847	0.3966	1.395	3.620

In Appendix A for each titration trial the relationship between dietary SID-ILE supply and FCR and between dietary SID-ILE and BWG is presented graphically together with the estimated SID-ILE 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 Tavernari et al. 2012), the estimated SID-ILE requirement for BWG was substantially lower than would be expected from a visual interpretation of the curve. This overestimation of the SID-ILE requirement in trial 1 could be avoided by removing the last observation leaving still some 5 observations on which the curve fitting could be carried out. Removing the observation with the highest SID-ILE content resulted in a higher estimated SID-ILE requirement which more closely agreed with the SID-ILE requirement as would be judged from a visual interpretation of the relationship between SID-ILE supply and BWG and between SID-ILE supply and FCR as shown in Appendix A in trial 1a and 1b. 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 highest SID-ILE level was removed before estimation of the SID-ILE requirement is represented with the letter ‘b’. For all other trials all observations were used for the estimation of SID-ILE requirements for both BWG and FCR.

Furthermore, for 1 titration trial for FCR it was not possible to estimate a reliable or unique SID-ILE requirement. The estimated SID-ILE:SID-LYS requirement ratios for BWG and FCR were not significantly related to sex, age, dietary protein concentration, and dietary ME.

The estimated SID-ILE:LYS requirement ratios for BWG and FCR are presented in Table 2.

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

Publication	trial	SID-ILE:SID-LYS ratio	
		BWG	FCR
Tavernari et al. (2012)	1b	62	62
Tavernari et al. (2012)	2	64	74
Barbour et al. (1992)	3	58	70
Mack et al. (1999)	4	55	
Kidd et al. (2004)	5	57	58
Kidd et al. (2004	6	66	68
Hale et al. (2004)	7	65	59
Baker et al. (2002)	8	56	54
Average		60	63
Std. Dev.		4.5	7.3

Substantial differences in estimated optimal SID-ILE: SID:LYS ratios for BWG and FCR between titration trial 5 and 6 were observed that were carried out in the same study of Kidd et al. (2004). The authors, however, came to digestible ILE requirement estimates that differed substantially less from each other. In the study of Kidd et al. (2004) the requirement of digestible ILE for BWG and FCR was estimated using a quadratic model instead of using a broken-line model as was done in this study and this possibly explains the differences in outcomes.

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-ILE 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-ILE:SID-LYS levels.

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

Ratio	Rec. CVB AFD ratio	FCR				BWG			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
M+C:LYS	73	83	7.9	69	91	83	7.9	69	91
THR:LYS	65	69	5.0	58	73	69	5.0	58	73
TRP:LYS	16	17	1.4	15	19	17	1.4	15	19
ARG:LYS	105	113	7.0	103	122	113	7.0	103	122
VAL:LYS	80	87	7.5	77	102	87	7.5	77	102

There were two studies that contained two titration trials whereas the other four studies contained only one titration trial. This may result in average calculated SID-ILE:LYS requirement ratios for BWG and FCR that are strongly influenced by the two studies containing two titration trials. In order to weigh the estimated SID-ILE:LYS ratios from each study equally it is possible to take into account the effect of study. However, 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-ILE:LYS ratios for BWG and FCR were the same as the average values of 60% for BWG and 63% for FCR as shown in Table 2.

4 Conclusions

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

SID-ILE:LYS for BWG = 60%
SID-ILE:LYS for FCR = 63%

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.

Barbour, G. and J. D. Latshaw. 1992. Isoleucine requirement of broiler chicks as affected by the concentrations of leucine and valine in practical diets. British Poultry Science 33(3):561-568.

Hale, L. L., S. J. Barber, A. Corzo, and M. T. Kidd. 2004. Isoleucine needs of thirty- to forty-two-day-old female chickens: Growth and carcass responses. Poultry Science 83(12):1986-1991.

Kidd, M. T., D. J. Burnham, and B. J. Kerr. 2004. Dietary isoleucine responses in male broiler chickens. British Poultry Science 45(1):67-75.

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.

Tavernari, F. C., G. R. Lelis, P. R. O. Carneiro, R. A. Vieira, R. C. Polveiro, J. A. P. Luengas, H. S. Rostagno, and L. F. T. Albino. 2012. Effect of different digestible isoleucine/lysine ratios for broiler chickens. Revista Brasileira de Zootecnia 41(7):1699-1705.

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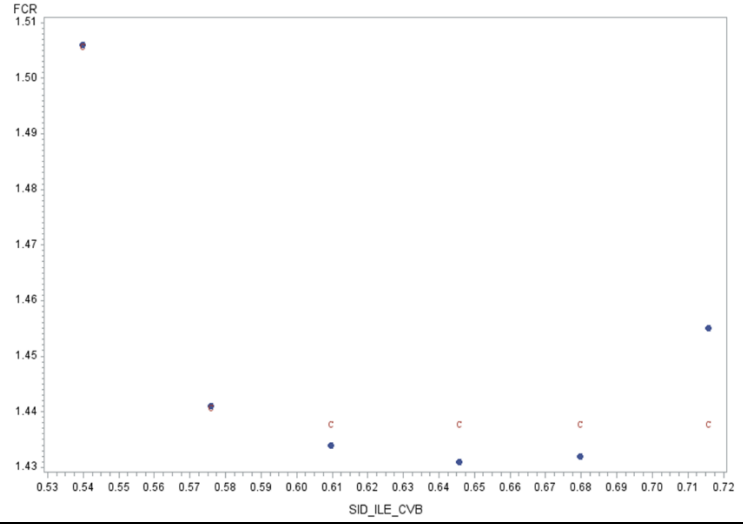
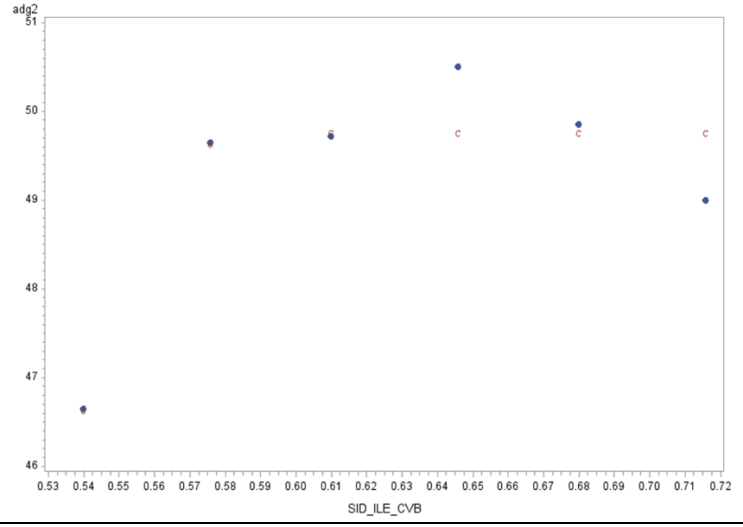
Blok and Dekker. 2017. Table ‘Standardized ileal digestibility of amino acids in feedstuffs for poultry’. CVB Documentation report nr. 61.

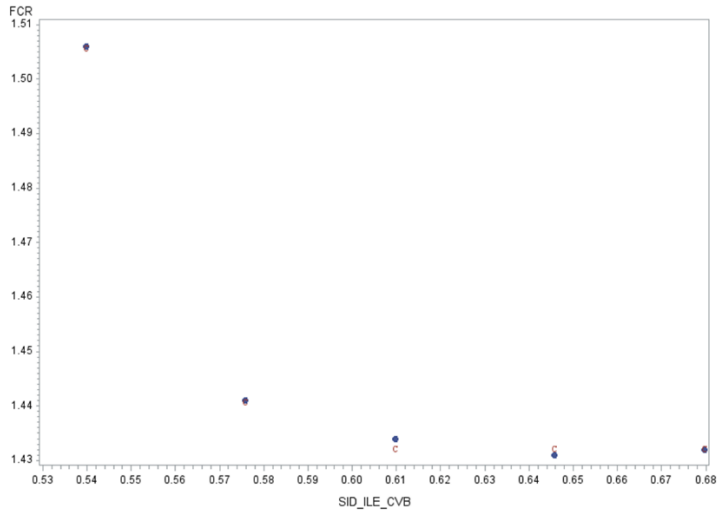
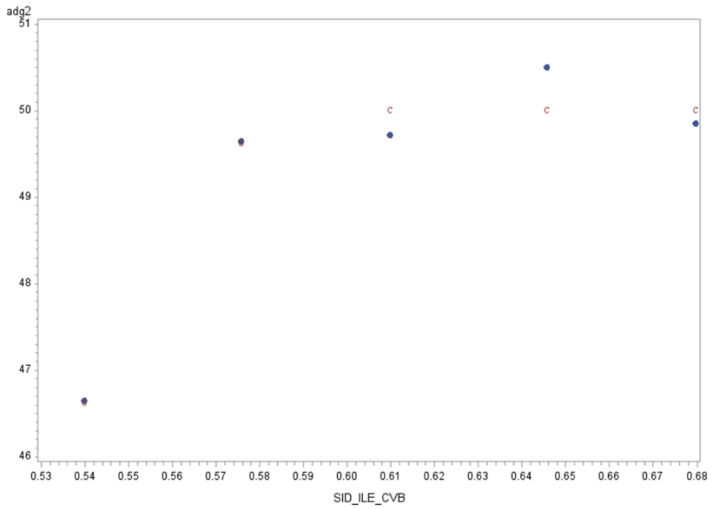
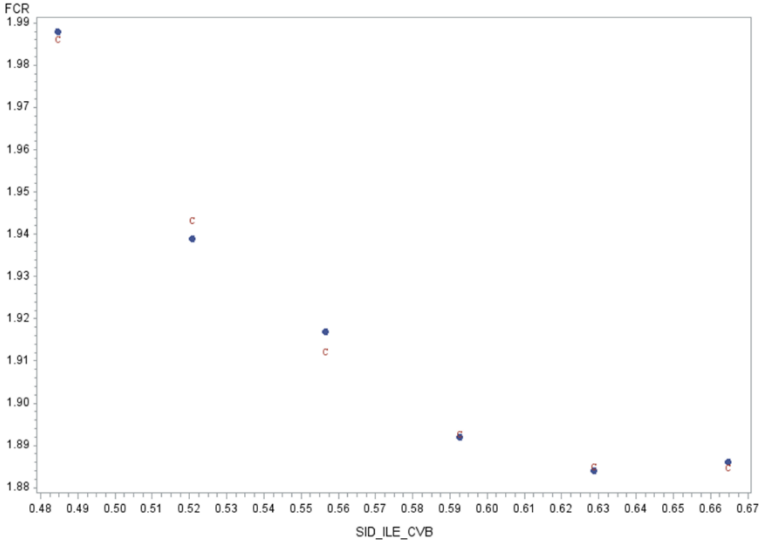
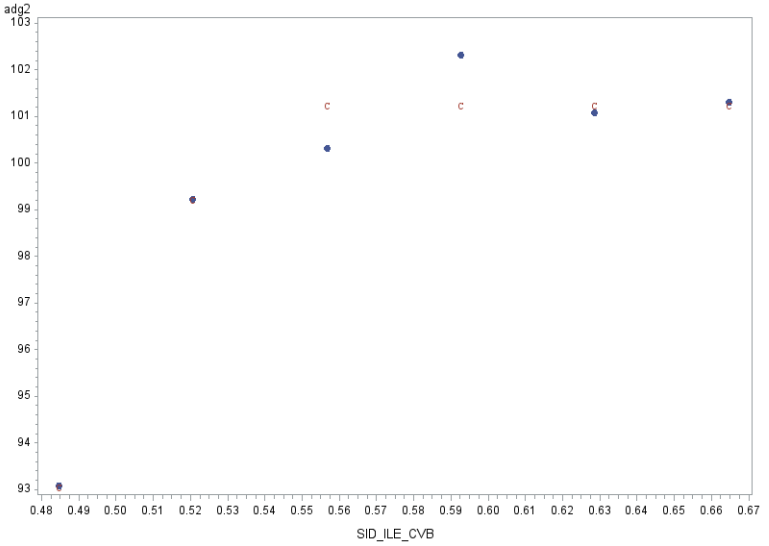
Spek, J.W. 2018. Standardized ileal digestible lysine requirement for broilers. CVB Documentation report nr. 62.

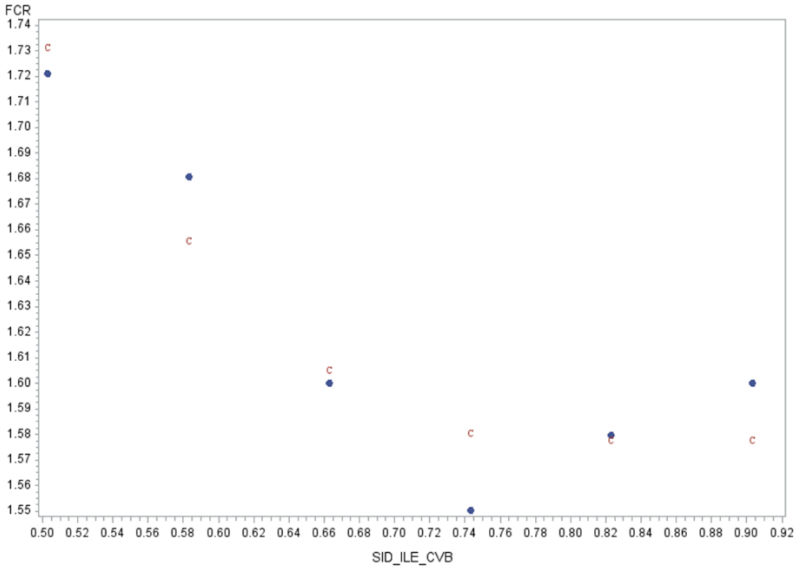
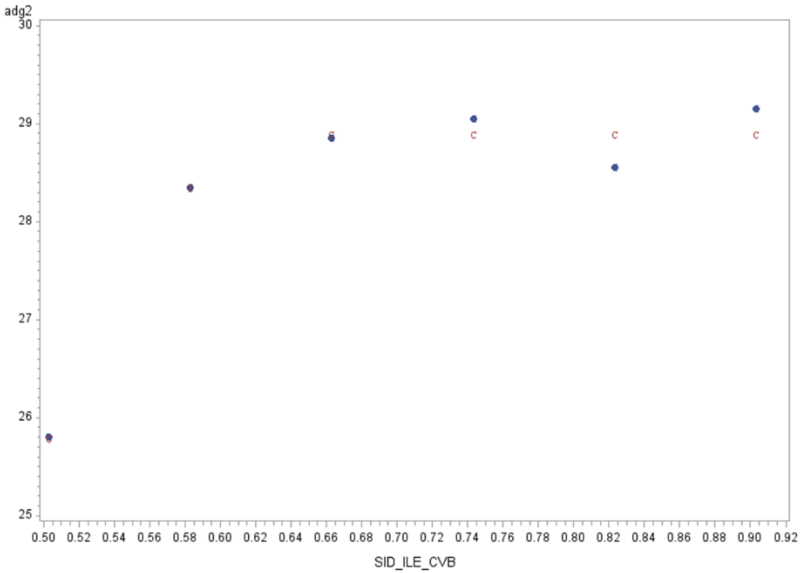
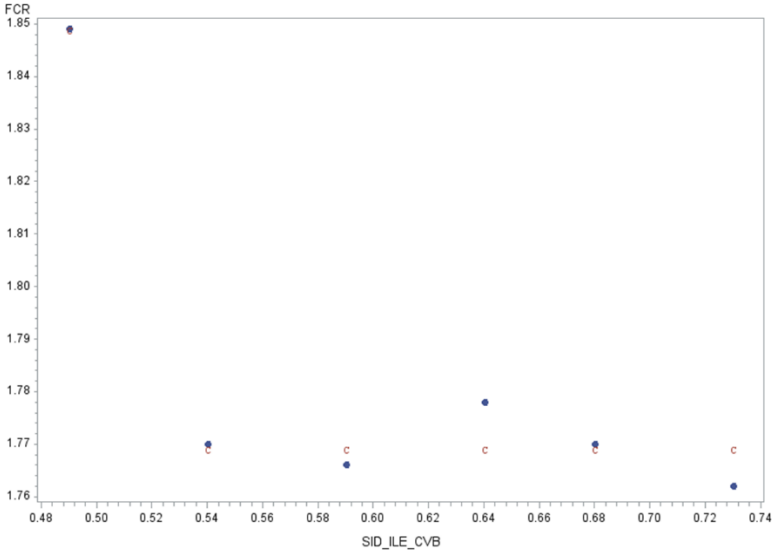
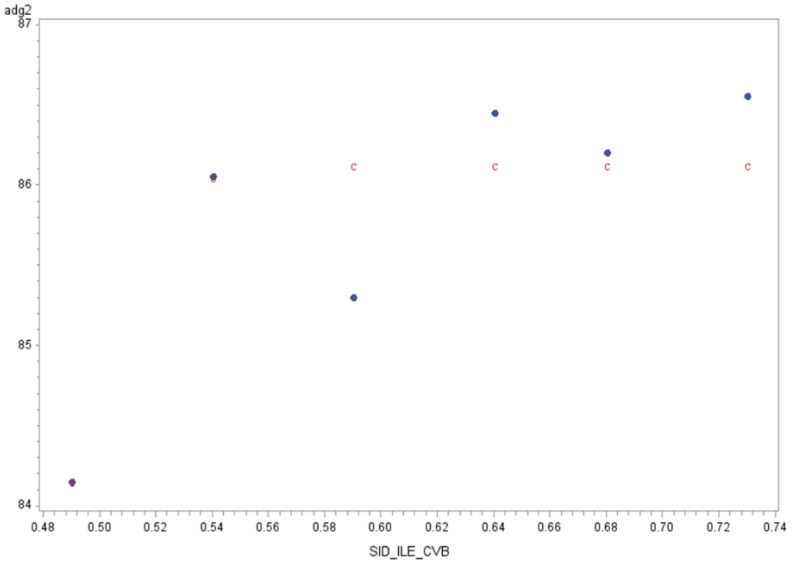
Veldkamp, T., J.W. van Riel, R.A. Dekker, S. Khalaji, V. Khaksar, H. Hashemipour, M.M. van Krimpen, and M.C. Blok. 2016. Estimating requirement values for apparent faecal digestible and standardised ileal digestible isoleucine in broilers by a meta-analysis approach.

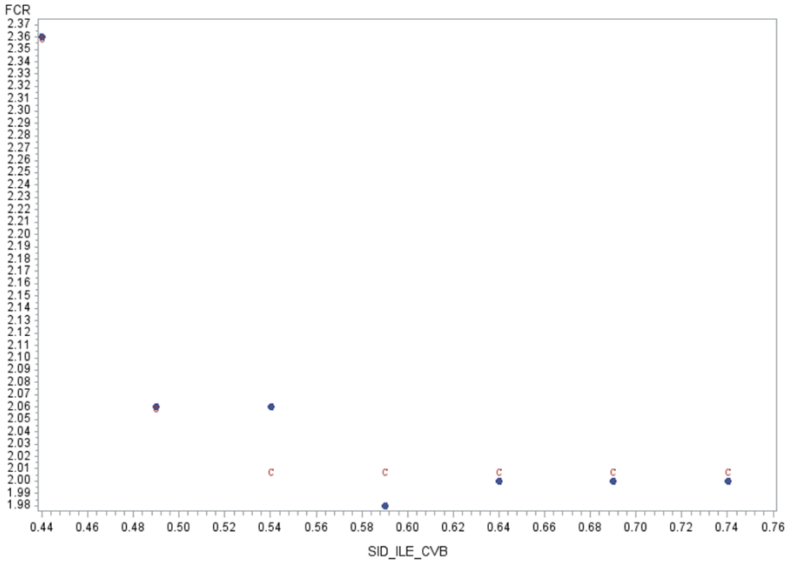
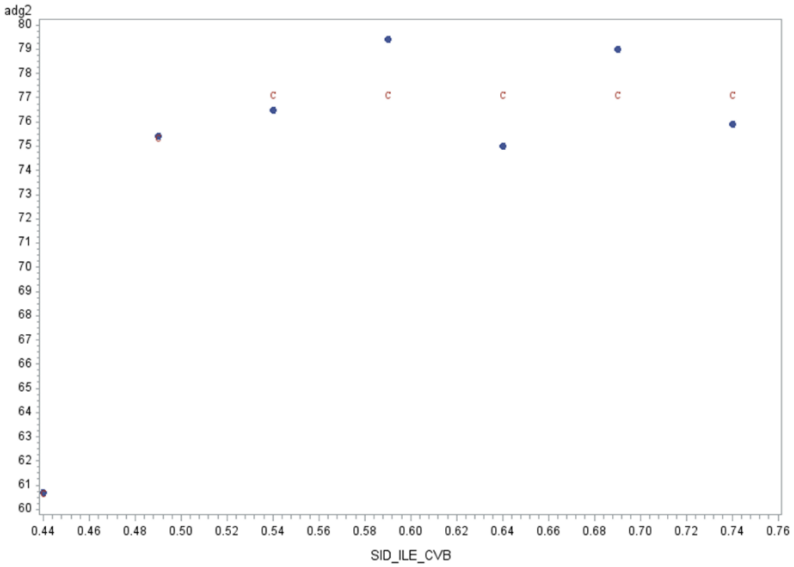
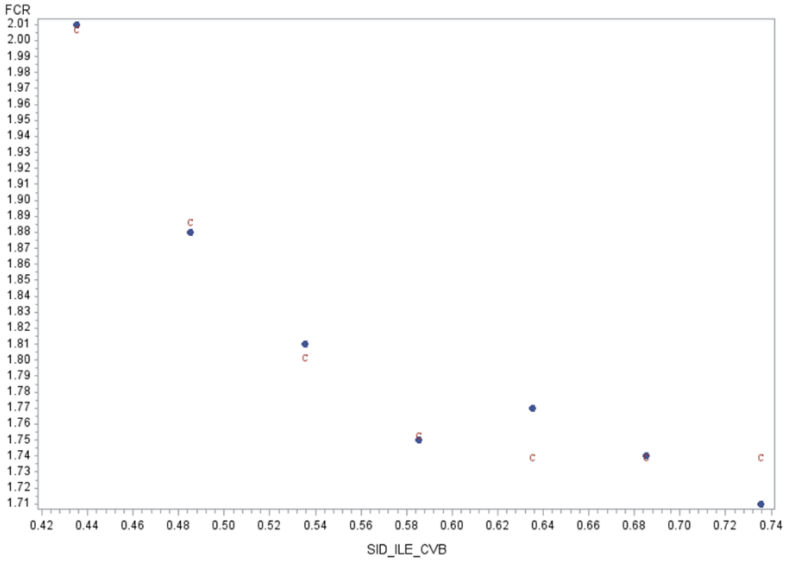
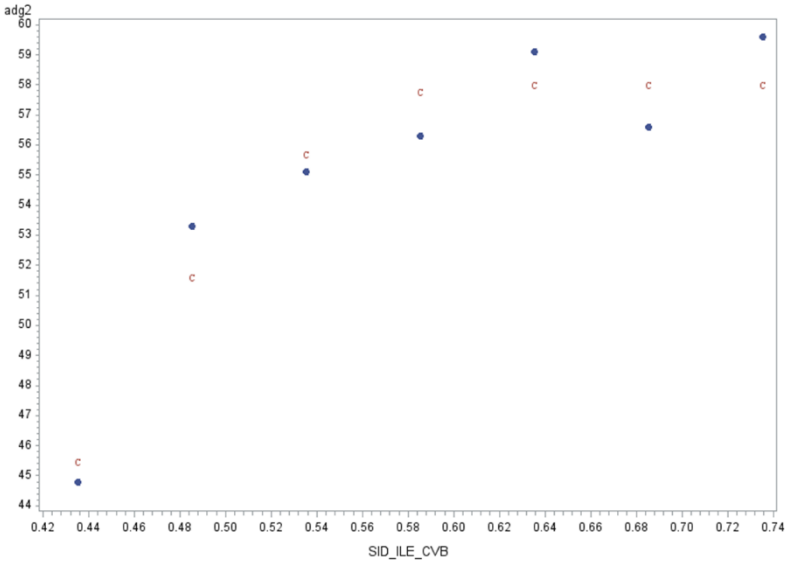
Appendix A. Relationship between dietary SID-ILE supply and performance parameters FCR and BWG for the various titration trials.

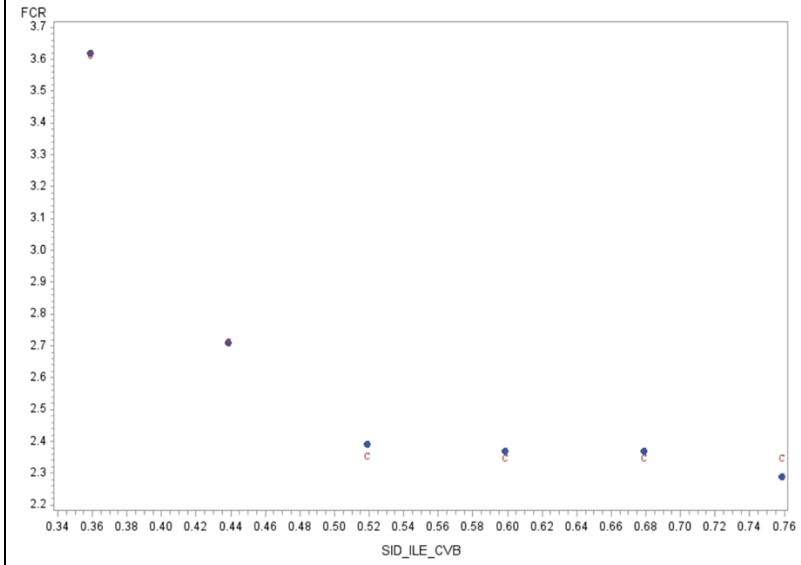
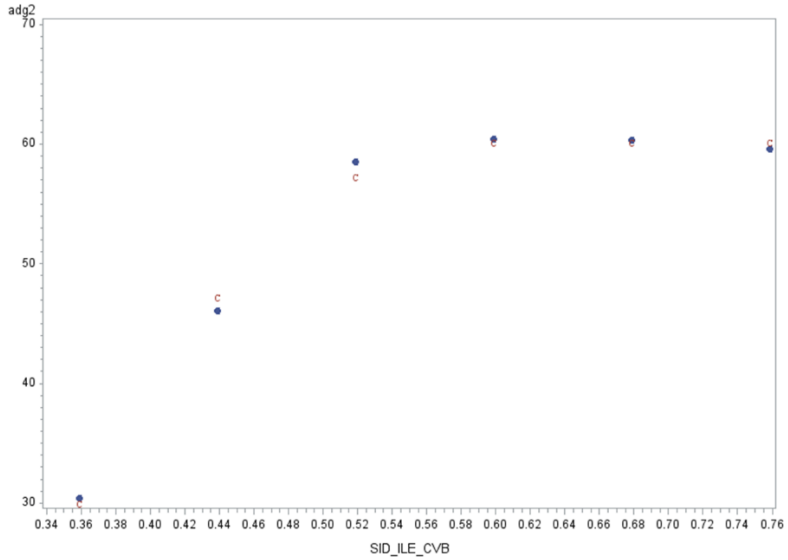
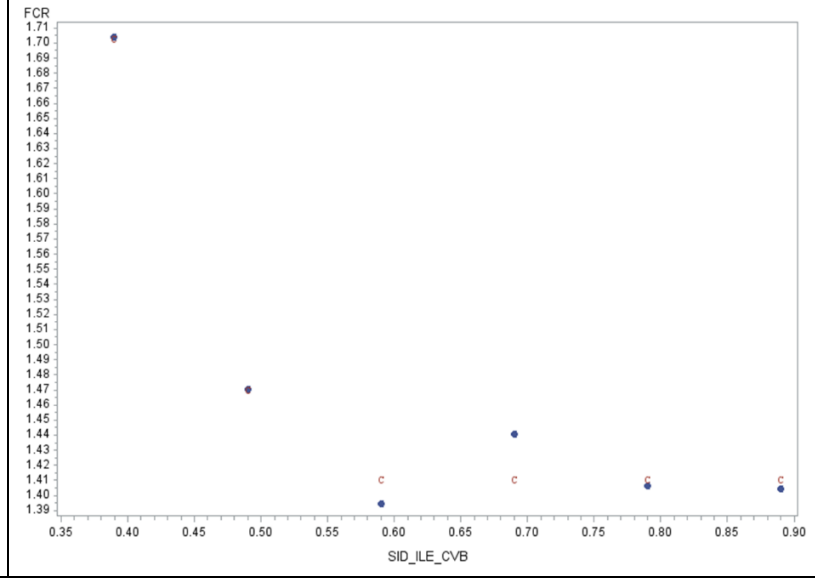
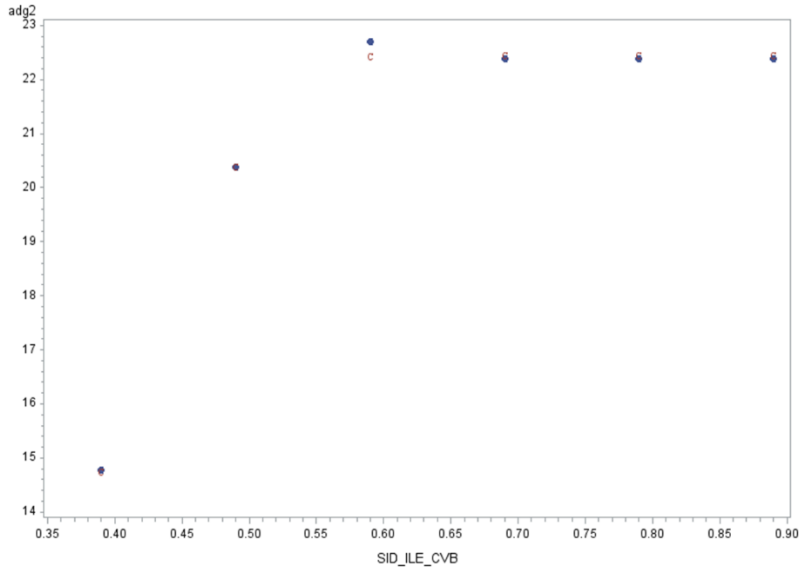
On the x-axis of the Figures the dietary ILE concentration (%) is given and on the y-axis of the Figures the FCR (left hand Figures) and BWG (right hand figures) are given. The closed circles are the observed values and the 'c' symbols are the fitted values. The letter 'a' behind the trial number (shown 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 highest dietary SID-ILE 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. Tavernari et al. (2012) Trial 1 Optimal SID-ILE FCR (%): 0.585 Optimal SID-ILE BWG (%): 0.585		

1b. Tavernari et al. (2012) Trial 1 Optimal SID-ILE FCR (%): 0.595 Optimal SID-ILE BWG (%): 0.594		
2. Tavernari et al. (2012) Trial 2 Optimal SID-ILE FCR (%): 0.635 Optimal SID-ILE BWG (%): 0.556		

3. Barbour et al. (1992) Optimal SID-ILE FCR (%): 0.780 Optimal SID-ILE BWG (%): 0.641		
4. Mack et al. (1999) Optimal SID-ILE FCR (%): 0.520 (no unique solution) Optimal SID-ILE BWG (%): 0.553		

5. Kidd et al. (2004) Trial 1 Optimal SID-ILE FCR (%): 0.521 Optimal SID-ILE BWG (%): 0.514		
6. Kidd et al. (2004) Trial 2 Optimal SID-ILE FCR (%): 0.629 Optimal SID-ILE BWG (%): 0.611		

7. Hale et al. (2004) Optimal SID-ILE FCR (%): 0.532 Optimal SID-ILE BWG (%): 0.591		
8. Baker et al. (2002) Optimal SID-ILE FCR (%): 0.572 Optimal SID-ILE BWG (%): 0.596		

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

SID-ILE 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 highest dietary SID-ILE 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	1.438	0.0057	0.585	0.0255	33	36.2	0.907
1b	1.432	0.0009	0.595	0.0028	25	2.5	0.999
2	1.885	0.0029	0.635	0.0119	4	0.7	0.994
3	1.578	0.0175	0.780	0.0977	2	1.4	0.898
4	1.769	0.0027	0.520	.	91	7.4	0.974
5	2.008	0.0136	0.521	0.0160	53	21.5	0.956
6	1.740	0.0123	0.629	0.0289	7	2.3	0.970
7	2.352	0.0227	0.532	0.0132	42	6.6	0.996
8	1.412	0.0101	0.572	0.0278	9	2.8	0.982

SID-ILE 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 highest dietary SID-ILE 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	49.8	0.31	0.585	0.0307	-1543	2081	0.876
1b	50.0	0.24	0.594	0.0170	-1151	717	0.962
2	101.3	0.41	0.556	0.0158	-1595	737	0.963
3	28.9	0.13	0.641	0.0265	-162	64	0.973
4	86.1	0.28	0.553	0.0633	-512	1031	0.767
5	77.2	0.87	0.514	0.0216	-2982	1750	0.938
6	58.0	0.93	0.611	0.0447	-409	220	0.923
7	60.2	0.60	0.591	0.0159	-559	80	0.996
8	22.5	0.08	0.596	0.0095	-181	17	0.998