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Effects of Dietary Standardized Ileal Digestible Valine:Lysine Ratio on 14 to 22 lb Nursery Pigs

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Abstract

A total of 280 nursery pigs (PIC 327 × 1050; initially 14.4 lb BW) were used in a 28-d growth trial to evaluate the effects of increasing dietary standardized ileal digestible (SID) Valine:Lysine (Val:Lys) ratio on nursery pig growth performance. Pigs were weaned at approximately 21 d of age and allotted to pens according to BW and gender. A common starter diet was fed for 5 d, and then pens were allotted to 1 of 7 dietary treatments in a randomized complete block design according to BW. Experimental diets were fed for 14 d, which included SID valine concentrations of 50, 57, 63, 68, 73, 78, and 85% of Lys. Then pigs were fed a common Phase 3 diet for 14 d.

From d 0 to 14, when experimental diets were fed, ADG, ADFI, and F/G improved (quadratic, $P < 0.036$) as SID Val:Lys ratio increased. For ADG, the best-fitting model was the broken line linear (BLL). This model resulted in a maximum ADG to be achieved when feeding a minimum of 62.9% SID Val:Lys ratio. For ADFI, the quadratic polynomial (QP) was the best fitting model, predicting maximum feed intake at 73.7% SID Val:Lys ratio and 99% of maximum performance achieved with 68.0% SID Val:Lys ratio. For feed efficiency, modeled as G:F, the best-fitting model was the QP, estimating maximum G:F at 71.7% SID Val:Lys ratio. In conclusion, this experiment demonstrated that the SID valine requirement for 14 to 22 lb nursery pigs ranged from 62.9 to 73.7% of Lys depending on the response criteria modeled.

Keywords

valine, growth, nursery pigs, swine

Cover Page Footnote

Appreciation is expressed to Ajinomoto Heartland, Inc. (Chicago, IL) for partial financial support.

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K-STATE Research and Extension

Swine Day 2016

Effects of Dietary Standardized Ileal Digestible Valine:Lysine Ratio on 14 to 22 lb Nursery Pigs[1]

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Summary

A total of 280 nursery pigs (PIC 327 × 1050; initially 14.4 lb BW) were used in a 28-d growth trial to evaluate the effects of increasing dietary standardized ileal digestible (SID) Valine:Lysine (Val:Lys) ratio on nursery pig growth performance. Pigs were weaned at approximately 21 d of age and allotted to pens according to BW and gender. A common starter diet was fed for 5 d, and then pens were allotted to 1 of 7 dietary treatments in a randomized complete block design according to BW. Experimental diets were fed for 14 d, which included SID valine concentrations of 50, 57, 63, 68, 73, 78, and 85% of Lys. Then pigs were fed a common Phase 3 diet for 14 d.

From d 0 to 14, when experimental diets were fed, ADG, ADFI, and F/G improved (quadratic, $P < 0.036$) as SID Val:Lys ratio increased. For ADG, the best-fitting model was the broken line linear (BLL). This model resulted in a maximum ADG to be achieved when feeding a minimum of 62.9% SID Val:Lys ratio. For ADFI, the quadratic polynomial (QP) was the best fitting model, predicting maximum feed intake at 73.7% SID Val:Lys ratio and 99% of maximum performance achieved with 68.0% SID Val:Lys ratio. For feed efficiency, modeled as G:F, the best-fitting model was the QP, estimating maximum G:F at 71.7% SID Val:Lys ratio. In conclusion, this experiment demonstrated that the SID valine requirement for 14 to 22 lb nursery pigs ranged from 62.9 to 73.7% of Lys depending on the response criteria modeled.

Key words: valine, growth, nursery pigs, swine

Introduction

Inclusion of dietary crystalline amino acids is a common practice in the swine industry. This is done to meet specific amino acid requirements while reducing feed cost and environmental impact. Additionally, amino acids are often expressed in relation to lysine to develop the most efficient diet formulations. A previous experiment conducted

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at Kansas State University validated that the lysine requirement for 15 to 25 lb pigs was 1.45% SID lysine. Therefore, our next step was to determine the appropriate SID Val:Lys ratio for pigs in this weight range.

The NRC (2012)[4] estimates that the valine requirement for approximately 15 to 25 lb pigs is 63.7% SID Val:Lys, while Nemechek et. al (2014)[5] determined that 65% SID Val:Lys was necessary for optimal growth of 15 to 25 lb pigs. However, pigs in this experiment were fed at the Lys requirement for ADG, which may underestimate the Val:Lys requirement. Therefore, the objective of this study was to determine the SID Val:Lys requirement for nursery pigs weighing approximately 14 to 22 lb when fed marginally below their dietary lysine requirement.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The trial was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Corn, soybean meal, and whey were analyzed for amino acid content prior to diet formulation (Ajinomoto Heartland, Chicago, IL).

A total of 280 nursery pigs (PIC 327 × 1050; 14.4 lb BW) were used in a 28-d experiment. There were 8 replicate pens per treatment and 5 pigs per pen. Pigs were weaned at approximately 21 d of age and allotted to pens according to BW and gender. A common Phase 1 starter diet was fed 5 d post-weaning. On d 5 after weaning, pens were allotted to 1 of 7 dietary treatments by BW in a randomized complete block design. The 7 dietary treatments were formulated to contain SID Val at 50, 57, 63, 68, 73, 78, and 85% of Lys. Treatment diets were fed for 14 d followed by a common Phase 3 diet fed for 14 d. Both the experimental and common diets were fed in meal form.

Pigs were weighed and feed disappearance was measured on d 0, 7, 14, 21, and 28. Each pen (4 × 5 ft) contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. Samples of treatment diets were collected upon manufacturing at the feed mill. Proximate analysis was conducted on composite samples (Ward Laboratories, Inc., Kearney, NE). In addition, experimental diet samples were submitted for amino acid analysis (Ajinomoto Heartland, Chicago, IL).

Data were analyzed as a randomized complete block design using PROC GLIMMIX in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and initial BW as a covariate. Results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$. The effect of SID Val:Lys ratio dose response on ADG, ADFI, and feed efficiency (modeled as gain to feed ratio; G:F) during the experimental period (d 0 to 14) were fit using PROC GLIMMIX and PROC NLMIXED accord-

[4] NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC.

[5] Nemechek, J. E.; Tokach, M. D.; Dritz, S. S.; Goodband, R. D.; DeRouchey, J. M. 2014. Evaluation of standardized ileal digestible valine:lysine, total lysine:crude protein, and replacing fish meal, meat and bone meal, and poultry byproduct meal with crystalline amino acids on growth performance of nursery pigs from seven to twelve kilograms. Journal of Animal Science. 2014.92:1548–1561.

ing to procedures of Gonçalves et al. (2016).[6] For ADFI, block was removed from the model as it did not contribute to model fit. Dose response models evaluated were quadratic (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. Bayesian Information Criterion (BIC) was used to determine best fit, with a lower number indicating an improved fit. A decrease in BIC greater than 2.0 among models for a particular response criterion was considered an improved fit.

Results and Discussion

The calculated experimental diet (Table 1) composition was similar to analyzed values (Table 2). Additionally, amino acid analysis matched intended levels, with lysine remaining constant while valine increased in a step-wise manner.

From d 0 to 14, when experimental diets were fed, ADG, ADFI, and F/G improved (quadratic, $P < 0.036$) as SID Val:Lys ratio increased (Table 3). During the common Phase (d 14 to 28), ADFI increased and F/G became poorer (linear, $P < 0.028$) in pigs previously fed diets containing increasing SID Val:Lys ratio. During the overall period (d 0 to 28), ADG marginally improved (quadratic, $P = 0.089$), while ADFI increased (linear, $P = 0.006$) and F/G was marginally poorer (linear, $P = 0.094$) as SID Val:Lys ratio increased. Similarly, BW was increased (quadratic, $P = 0.001$) on d 14 and marginally increased (linear, $P = 0.057$) with increasing SID Lys on d 28.

Heterogeneous variance was used for ADG models and homogeneous variance was used for ADFI and feed efficiency models. For ADG (Figure 1), the BLL was the best fit and the maximum ADG was obtained with a minimum of 62.9% SID Val:Lys ratio (95% CI: [52.2, 73.7%]). For ADFI, (Figure 2) the QP [-0.5740219 + 0.039020944×(Val:Lys) – 0.000264771×(Val:Lys)^2] was the best fitting model, predicting maximum feed intake at 73.7% SID Val:Lys ratio and 99% of maximum performance achieved with 68.0% SID Val:Lys ratio. Feed efficiency (Figure 3), modeled as G:F, found that the best fit was the QP [0.010294 + 0.017526×(Val:Lys) – 0.000122×(Val:Lys)^2]. This model reported a maximum G:F at 71.7% SID Val:Lys ratio and 99% of maximum performance achieved with 64.4% SID Val:Lys.

As previously stated, Nemechek et al. (2014) determined that 65% SID Val:Lys ratio was necessary for optimal growth in pigs of similar weight range to those used in this study. This coincides with the current trial, however multiple models in our trial provide a range of estimated requirements depending on model and response criteria. Using similar modeling techniques, Gonçalves et al. (2015)[7] determined that the ideal SID Val:Lys ratio for pigs weighing 55 to 100 lb was 71.0% for feed efficiency and 74.0% for ADG. Although this result is for heavier pigs, it is very similar to the feed efficiency result determined in the present study. In conclusion, this experiment demonstrated that

[6] Gonçalves, M., N. Bello, S. Dritz, M. Tokach, J. DeRouchey, J. Woodworth, and R. Goodband. 2016. An update on modeling dose–response relationships: Accounting for correlated data structure and heterogeneous error variance in linear and nonlinear mixed models. Journal of Animal Science. 94(5): 1940-1950.

[7] Gonçalves, M. A.; Jacquez, J.; Tokach, M. D.; Dritz, S. S.; Touchette, K. J.; DeRouchey, J. M.; Woodworth, J. C.; and Goodband, R. D. (2015). Effects of Standardized Ileal Digestible Valine:Lysine Ratio on the Growth Performance and Economics of Finishing Pigs from 55 to 100 lb. Kansas State University Swine Day 2015. Kansas Agricultural Experiment Station Research Reports. Vol. 1: Iss. 7.

the SID Val:Lys ratio requirement for approximately 14 to 22 lb nursery pigs ranged from 62.9 to 73.7% depending on the response criteria modeled.

Table 1. Diet composition (as-fed basis)[1]

	Formulated % SID Val:Lys Ratio		
Item	50	85	Common phase
Ingredient, %			
Corn	62.97	62.50	63.77
Soybean meal (48% CP)	22.07	22.11	32.86
Dried whey	10.00	10.00	--
Limestone	1.00	1.00	0.98
Monocalcium phosphate (22% P)	1.65	1.65	1.10
Sodium chloride	0.30	0.30	0.35
L-Lys-HCl	0.63	0.63	0.3
DL-Met	0.27	0.27	0.12
L-Thr	0.29	0.29	0.12
L-Trp	0.08	0.08	--
L-Val	0.00	0.44	--
L-Ile	0.10	0.10	--
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Zinc oxide	0.25	0.25	--
Total	100.00	100.00	100.00
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.24	1.24	1.22
Ile:Lys	57	57	63
Leu:Lys	110	110	129
Met:Lys	40	40	33
Met and Cys:Lys	60	60	57
Thr:Lys	66	66	63
Trp:Lys	20.1	20.1	18.7
Val:Lys	50	85	69
Total Lys, %	1.36	1.36	1.37
ME, kcal/lb	1,492	1,496	1,484
NE, kcal/lb	1,101	1,092	1,092
SID Lys:ME, g/Mcal	3.75	3.74	3.73
SID Lys:NE, g/Mcal	5.09	5.08	5.16
CP, %	17.6	17.9	21.4
Ca, %	0.82	0.82	0.70
P, %	0.73	0.73	0.64
Available P, %	0.49	0.49	0.41

[1] Treatments 50% and 85% SID Val:Lys were manufactured and blended at the feed mill to create the intermediate levels of 57, 63, 68, 73, and 78 % SID Val:Lys.

Table 2. Chemical analysis of diets (as-fed basis)[1]

	Formulated % SID Val:Lys ratio[2]						
Item	50	57	63	68	73	78	85
Proximate analysis, %[3]							
DM	89.84	90.16	90.37	90.24	90.35	90.06	90.24
CP	17.0	18.7	17.6	18.0	18.0	19.3	17.6
Crude fiber	2.0	1.7	1.7	1.7	1.2	2.0	1.8
Ether extract	2.6	2.2	2.2	2.4	2.2	2.3	2.2
Ash	5.25	5.58	5.26	5.08	5.17	5.14	5.14
Amino acid analysis, %[4]							
Lys	1.32	1.33	1.37	1.35	1.35	1.33	1.34
Ile	0.76	0.78	0.77	0.77	0.78	0.87	0.80
Leu	1.56	1.54	1.54	1.51	1.55	1.61	1.59
Met	0.46	0.50	0.50	0.48	0.49	0.46	0.48
Met + Cys	0.73	0.77	0.77	0.74	0.78	0.75	0.77
Thr	0.92	0.89	0.92	0.89	0.90	0.94	0.96
Trp	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Val	0.78	0.84	0.88	0.92	0.99	1.04	1.10
His	0.43	0.42	0.41	0.41	0.42	0.44	0.43
Phe	0.83	0.92	0.82	0.80	0.83	0.86	0.84

[1] Treatment diet samples were collected at the feed mill after manufacturing.
[2] Low (50% SID Val:Lys) and high (85% SID Val:Lys) diets were blended at the feed mill to create the intermediate treatments.
[3] Composite samples were submitted to Ward Laboratories (Kearney, NE) for proximate analysis.
[4] Composite samples were submitted to Ajinomoto Heartland Inc. (Chicago, IL) for amino acid analysis.

Table 3. Effects of standardized ileal digestible Val:Lys ratio on nursery pig growth performance[1]

	Formulated % SID Val:Lys[2]								Probability, $P <$	
Item	50	57	63	68	73	78	85	SEM	Linear	Quadratic
Phase 1 (d 0 to 14)[3]										
ADG, lb	0.42	0.49	0.55	0.55	0.55	0.55	0.52	0.025	0.001	0.001
ADFI, lb	0.73	0.80	0.87	0.86	0.89	0.86	0.85	0.038	0.012	0.030
F/G	1.74	1.65	1.60	1.56	1.63	1.56	1.64	0.050	0.084	0.036
Phase 2 (d 14 to 28)										
ADG, lb	1.19	1.17	1.14	1.27	1.15	1.17	1.19	0.034	0.992	0.945
ADFI, lb	1.82	1.80	1.82	1.94	1.87	1.91	1.93	0.051	0.028	0.965
F/G	1.53	1.54	1.61	1.53	1.63	1.64	1.63	0.025	0.001	0.945
Overall (d 0 to 28)										
ADG, lb	0.81	0.83	0.84	0.91	0.85	0.86	0.86	0.024	0.067	0.089
ADFI, lb	1.28	1.30	1.34	1.40	1.38	1.38	1.39	0.038	0.006	0.266
F/G	1.58	1.57	1.59	1.54	1.63	1.61	1.63	0.026	0.094	0.288
BW, lb										
d 14	20.3	21.2	22.1	22.1	22.0	22.2	21.8	0.35	0.001	0.001
d 28	36.9	37.6	37.7	39.8	38.1	38.5	38.5	0.760	0.057	0.146

[1] A total of 280 nursery pigs (PIC 327 × 1050, initially 14.4 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 8 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 5 d post-weaning, then placed on test. An initial (d 0) BW of 14.4 lb was used as a covariate.
[2] Low (50% SID Val:Lys ratio) and high (85% SID Val:Lys ratio) diets were blended upon manufacturing at the feed mill to create the 57, 63, 68, 73, and 78% SID Val:Lys ratio dietary treatments.
[3] Experimental diets were fed from d 0 to 14 and a common Phase 3 diet was fed from d 14 to 28.

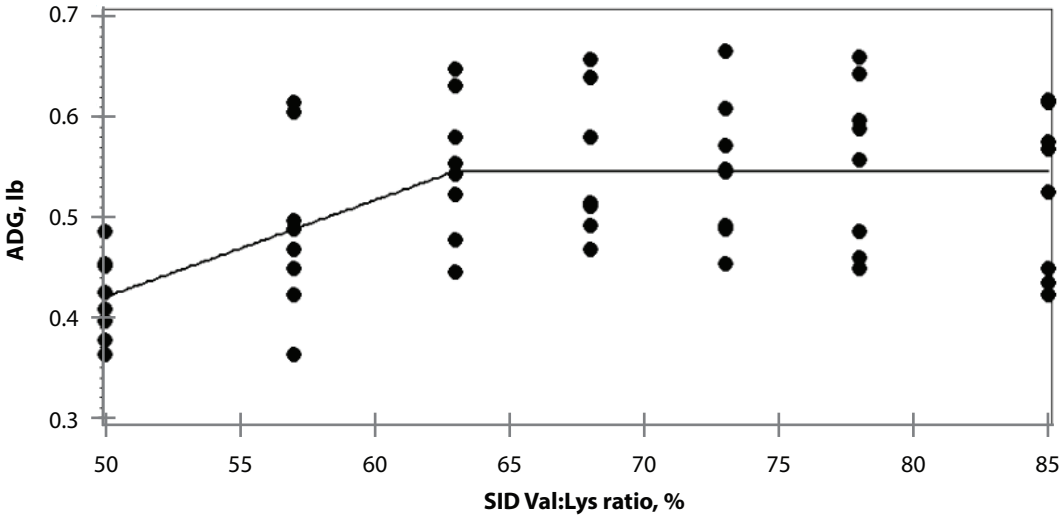

Figure 1. Estimated standardized ileal digestible Val:Lys ratio requirement to maximize ADG for nursery pigs.

ADG BLL 62.9% (95% CI: 52.2, 73.7)

A total of 280 nursery pigs (PIC 327 × 1050, initially 14.4 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 8 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 5 d post-weaning, then placed on test. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Val:Lys ratio level to maximize ADG. Bayesian Information Criterion (BIC) was used to determine the best fitting models; a lower value indicates a better fit to the data.

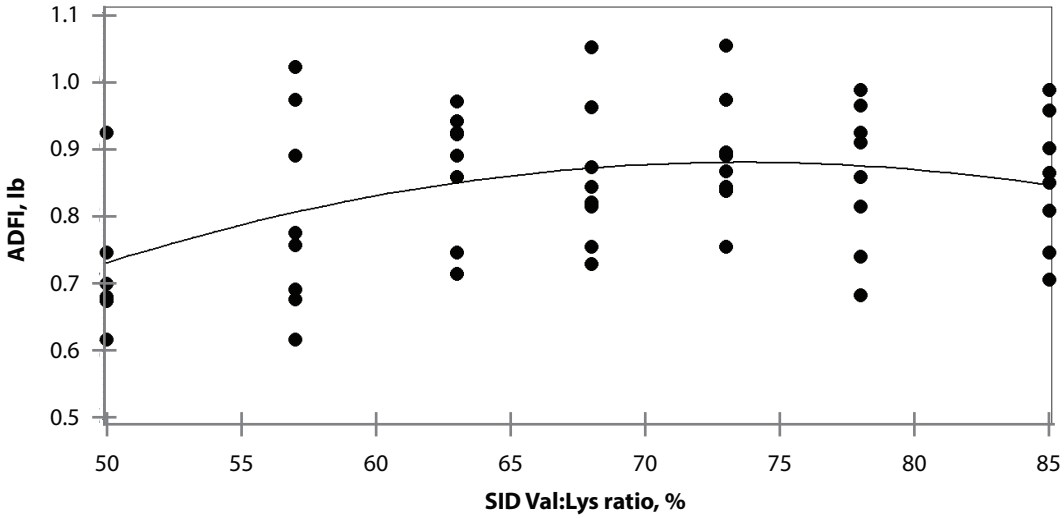

Figure 2. Estimated standardized ileal digestible Val:Lys ratio requirement to maximize ADFI for nursery pigs.

ADFI **QP** Maximum: 73.7%
99% Maximum: 68.0%
$[-0.5740219 + 0.039020944 \times (\text{Val:Lys}) - 0.000264771 \times (\text{Val:Lys})^2]$

A total of 280 nursery pigs (PIC 327 × 1050, initially 14.4 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 8 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 5 d post-weaning, then placed on test. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Val:Lys ratio level to maximize ADFI. Bayesian Information Criterion (BIC) was used to determine the best fitting models; a lower value indicates a better fit to the data.

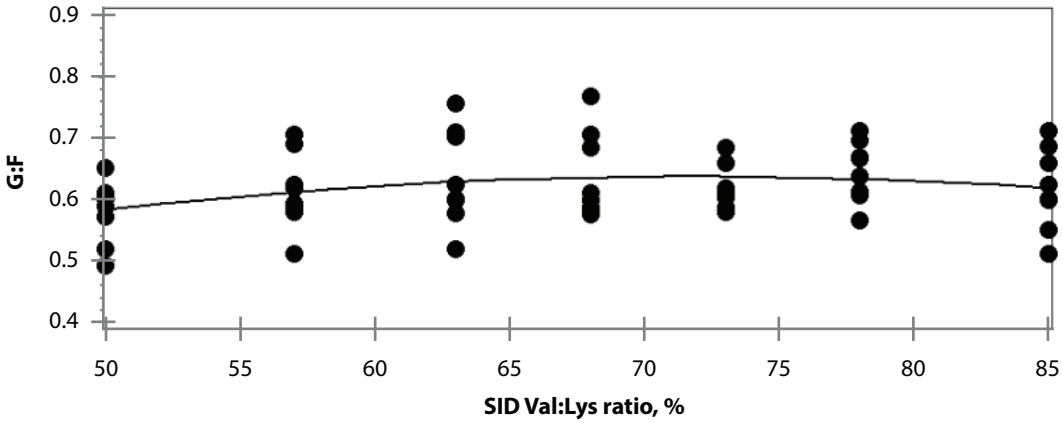

Figure 3. Estimated standardized ileal digestible Val:Lys ratio requirement to maximize G:F for nursery pigs.

G:F **QP** Maximum: 71.7%
99% Maximum: 64.6%
$[0.010294 + 0.017526 \times (\text{Val:Lys}) - 0.000122 \times (\text{Val:Lys})^2]$

A total of 280 nursery pigs (PIC 327 × 1050, initially 14.4 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 8 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 5 d post-weaning, then placed on test. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Val:Lys level to maximize G:F, as well as SID Val:Lys level to achieve 99% of maximum G:F using the QP model. Bayesian Information Criterion (BIC) was used to determine the best fitting models; a lower value indicates a better fit to the data.