RESEARCH REPORT
ANIMAL SCIENCE

Title: Determining the optimal dietary lysine:energy ratios for health challenged grow-finish pigs – NPB #16-062

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Industry Summary:
When pigs become health challenged with a virus like Porcine Reproductive and Respiratory Syndrome (PRRS), production efficiency and pig wellbeing is reduced that can have a larger economic burden on the U.S. swine industry. How to best feed and manage these health challenged pig flows is poorly understood. Interestingly, the optimum dietary requirements for energy and protein as well as amino acids have not been determined for such health challenged pigs. Therefore, two experiments were conducted to evaluate the effect of increasing SID Lys:ME (g SID Lys per Mcal ME) on growth performance during a PRRSV challenge. In Exp. 1, 379 barrows (51.3 ± 0.3 kg BW) were allotted to one of six diets (1.87 to 3.41 Lys:ME) for a 35-d growth study. In Exp. 2, 389 barrows (29.2 ± 0.23 kg BW) were allotted to one of six diets (2.39 to 3.91 Lys:ME) for a 49-d growth study. These isocaloric diets represented 80 to 130% of NRC SID Lys requirement. After the 35 to 49-d growth study, all pigs were fed a common diet until they reached a target market weight of ~127 kg. Our results from this project showed:

- There were no difference in PRRS serology due to altered Lys:ME diets.
- Breakpoint analysis showed that the optimal Lys:ME for ADG and G:F was increased up to 136% and 130%, respectively, in PRRSV infected 50 kg BW pigs (Exp. 1) compared to healthy controls depending on the breakpoint model used (one slope verses quadratic).
- In 25 kg BW pigs (Exp. 2) the optimal Lys:ME for ADG increased up to 107% as determined by breakpoint analysis; however, optimal Lys:ME for G:F was decreased up to 25% in PRRSV infected pigs.
- In the 50 kg pigs, the predicted requirement for ADG and G:F in PRRSV pigs using a quadratic model were above the highest Lys:ME diet. This was similar for G:F in control pigs in the 25 kg BW pigs. Therefore, further studies should be conducted to more accurately determine the Lys:ME requirement.

- No difference in carcass characteristics were reported.
- Overall, increasing Lys:ME 110-130% above the NRC (2012) requirement increased growth performance and feed efficiency in PRRSV infected pigs, and the response was similar between natural and experimental PRRSV infection.

Keywords: Lysine, Energy, PRRS

Scientific Abstract: Porcine reproductive and respiratory virus (PRRSV) significantly reduces pig performance. The AA requirements and Lys:ME of health challenged pigs for optimum performance are poorly understood. Two experiments were conducted to evaluate the effect of increasing SID Lys:ME (g SID Lys per Mcal ME) on growth performance during a PRRSV challenge. In Exp. 1, 379 barrows (51.3 ± 0.3 kg BW) were allotted to one of six diets (1.87 to 3.41 Lys:ME) for a 35-d growth study. In Exp. 2, 389 barrows (29.2 ± 0.23 kg BW) were allotted to one of six diets (2.39 to 3.91 Lys:ME) for a 49-d growth study. These isocaloric diets represented 80 to 130% of NRC SID Lys requirement. For each Exp., pigs were randomly allocated to two barns of 24 pens each with 7-9 pigs/pen (4 pens/diet/health status). On day 0, one barn was inoculated with live PRRSV, one barn sham inoculated (control), and all pigs were started on experimental diets. Pen growth performance and feed intake were recorded weekly and G:F calculated. Breakpoint analysis was used to determine the Lys:ME ratio that maximized ADG and G:F over the 35 or 49-d test periods for Exp. 1 and 2, respectively. In Exp. 1 increasing Lys:ME increased ADG (quadratic $P = 0.01$) and G:F (linear and quadratic $P = 0.04$) in control pigs over 35-d. In PRRSV pigs, ADG and G:F increased linearly with increasing Lys:ME ($P < 0.01$). The Lys:ME for optimum ADG and G:F during PRRSV challenge was 2.83 and 3.17, respectively, compared to 2.24 and 2.83, respectively, in control pigs using a one-slope broken-line model. In Exp. 2 control pigs became naturally infected after 21 dpi. Prior to infection, ADG and G:F increased with increasing Lys:ME in control and PRRSV pigs (linear and quadratic $P < 0.05$) with optimum ADG and G:F achieved at 3.02 and 2.92, respectively, in PRRSV pigs compared to 2.82 and 3.22 Lys:ME, respectively, in control pigs. Over the 49-d period, increasing Lys:ME improved ADG ($P<0.01$, linear and quadratic) and G:F (linear $P<0.01$) in naturally infected pigs. The response was similar in experimental infection for ADG ($P<0.01$, linear and quadratic) and G:F (linear $P=0.01$). The optimum ratio for ADG (2.86 vs. 3.12 Lys:ME) and G:F (3.18 vs. 3.08 Lys:ME) was similar between natural and experimental infection. In summary, increasing Lys:ME ratio by 110 to 120% improved performance and feed efficiency during a PRRSV challenge. This response was similar in experimental and natural PRRSV infections.

Introduction: Nutritional requirements have been well established for healthy pigs; however, requirements for pigs facing health challenges are largely unexplored, particularly AA requirements and AA requirements in relation to energy. It has been established that pig performance and lean tissue accretion rates are decreased due to different pathogens (Escobar et al., 2004; Curry et al., 2017; Schweer et al., 2017b); however, it is not known if this is a result of decreased feed intake. Additionally, this may be due to a repartitioning of nutrients, specifically AA. Lysine is the first limiting AA for healthy pigs fed corn-soybean meal diets; however, AA pertinent to the immune system and its activation differ from that

of growth (Reeds et al., 1994; Le Floc'h et al., 2004). Therefore, aromatic and nonessential AA become more important for an immune response, and Lys being less important.

Interestingly, Lys requirements (g/d basis) are reduced in immune stimulated pigs compared to control pigs (Williams et al., 1997b, c). This is due to a greater capacity for proteinaceous tissue accretion in healthy pigs as partial efficiency for Lys utilization is not different due to health status (Williams et al., 1997a). Similarly, Met+Cys requirement (g/d basis) is reduced in a repeated lipopolysaccharide (**LPS**) injection model (Rakhshandeh et al., 2014); however, the optimal Met:Met+Cys ratio for whole-body protein deposition increases during repeated LPS injection (Litvak et al., 2013). In addition, adequate energy is important for a proper immune response. Diets deficient in protein and energy can lead to reduced growth during parasite infection (Pedersen et al., 2002). Although porcine reproductive and respiratory syndrome virus (**PRRSV**) is one of the most economically significant diseases to the swine industry, research on its impact on nutritional requirements is minimal. Our group has reported that basal endogenous losses of many AA are not different and when corrected for these endogenous losses, standardized ileal digestibilities (**SID**) of AA are not different (Schweer et al., 2017a).

Therefore, the objective of these studies was to evaluate the effects of graded levels of g SID Lys per Mcal ME (**Lys:ME**) on pig performance during a health challenge in the growing phase. This will allow for the optimal Lys:ME to be defined for PRRSV challenged pigs.

Objectives: In traditional swine operations, feed costs make up 60% of production costs. When pigs become health challenged, production efficiency is reduced and therefore reduces pig wellbeing and profitability for producers. Optimum dietary requirements for energy and protein as well as amino acids have been determined for healthy pigs (NRC, 2012); however, these same requirements have not been established for health challenged pigs. Therefore, our objectives are to determine and compare optimal dietary lysine:energy ratios in healthy and PRRSV-Mycoplasma hyopneumoniae co-challenged growing pigs. We aim to:

a. To determine if increasing dietary lysine, thereby increasing amino acids, improves grow-finish growth performance and feed efficiency under a common dual health challenge regularly seen in the industry.

b. To determine if increasing grower pig dietary lysine:energy ratio during health challenges improves subsequent carcass measures at market weight.

Materials & Methods:

Animals and facilities

All procedures adhered to the ethical and humane use of animals for research and was approved by the Iowa State University Institutional Animal Care and Use Committee (IACUC# 8-16-8330-S).

Two experiments were conducted to determine the ideal SID Lys:ME ratio (g SID Lys per Mcal ME) for grow-finish barrows (purebred Maschhoffs proprietary line Duroc sires by

commercial Yorkshire-Landrace F1 females) during a pathogen challenge. Pigs were positive for Mycoplasma hyopneumoniae, thus only a PRRS virus challenge was conducted. In both experiments, pigs were split across two identical barns, of which, one was maintained as a healthy control and the other inoculated with a live strain of PRRSV (ORF 1-18-4). Pigs in the PRRSV barn were inoculated on days post inoculation (**dpi**) 0 with 2 mL of live PRRSV (ORF 1-18-4; 1 mL intramuscular and 1 mL intranasal) while the control barn received a sham inoculation. Pigs were allowed unrestricted access to feed and water. During the challenge period pigs were fed one of six experimental diets; body weight and feed disappearance was measured weekly to determine ADG, ADFI, and to calculate feed conversion. Experimental diets were corn-soybean meal based, and were formulated to be isocaloric and meet or exceed the nutritional requirements of 50-100 kg and 25-50 kg pigs in Exp. 1 and 2, respectively (NRC, 2012). There was a stepwise increase in Lys:ME ratio and ratios of Lys to Thr, Trp, Met, Ile, and Val held constant. The dietary Lys:ME levels were achieved by increasing soybean meal. These diets correlated to 80, 90, 100, 110, 120, and 130% of NRC (2012) Lys requirement in the Maschhoffs system.

In Exp. 1, 379 barrows (51.3 ± 0.32 kg BW) were randomly allotted to one of six dietary treatments with 4 pens per treatment per health status and 7-8 pigs per pen. Pigs were given a 14-d acclimation period where all pigs were fed a common diet. At the time of PRRSV inoculation, pigs were started on experimental diets (Table 1), and performance was measured for 35-d. Diets were formulated to contain 1.87, 2.18, 2.49, 2.80, 3.11, and 3.41 Lys:ME ratio. Weekly after PRRSV inoculation, two pigs per pen were bled for PRRSV PCR and ELISA. After the experimental period all pigs were fed a common multi-phase diet until pigs reached market BW (approximately 127 kg BW), at which time, pigs were slaughtered, and carcass data collected from the slaughter plant (JBS, Marshalltown, IA). Shipping and pre-slaughter handling were the same for control and PRRSV pigs.

In Exp. 2, 389 barrows (29.2 ± 0.23 kg BW) were randomly allotted to one of six dietary treatments formulated to contain 2.33, 2.63, 2.94, 3.24, 3.55, and 3.85 Lys:ME (Table 2). Each treatment had 4 pens per treatment per health status with 7-9 pigs per pen. After a 10-d acclimation on a common diet, pigs were inoculated with PRRSV and started on experimental diets for a 49-d growth study. Between 21 and 28 dpi, the control barn became naturally infected with PRRSV. The PRRSV strain was not different from the control barn. In Exp. 2, carcass data was unable to be obtained from the slaughter plant.

Diet analysis

Proximate and AA analysis of diets in both experiments were carried out in commercial laboratories (Midwest Labs, Omaha, NE; Ajinomoto Heartland, Inc., Eddyville, IA). Samples were analyzed for AA (method 994.12 and 999.13) and N (method 990.03) according to AOAC (2007) methods, and CP was calculated (N × 6.25). Energy was determined based on internal calculations.

Blood collection and analysis

In both experiments, blood samples were collected from the jugular vein in vacutainer serum tubes (10 mL; BD Vacutainer, Franklin Lakes, NJ) while pigs were snare restrained. In Exp. 1, two pigs per pen were bled weekly during the 35-d challenge period. In Exp. 2, 6 pigs/room (12 pigs/barn) were randomly selected and bled weekly during the 49-d

challenge period. Blood from these pigs was pooled within room. Serum was allowed to clot then separated by centrifugation (2,000 × *g*, 15 min at 4°C), aliquoted and submitted to the Iowa State Veterinary Diagnostic Laboratory for analysis of PRRSV real-time RT-PCR and serology. Analysis for PRRSV was performed using commercial reagents (VetMAX™ NA and EU PRRSV real-time RT-PCR, Thermo Fisher Scientific, Waltham, MA), and a commercial ELISA kit (HerdCheck® PRRS X3, IDEXX Laboratories, Inc., Westbrook, ME) was used to detect anti-PRRSV antibody per manufacturers instruction.

Statistics

Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Car, NC) for linear and quadratic effects of increasing SID Lys:ME. Pen served as the experimental unit in both experiments. Data were considered significant if $P \leq 0.05$ and a trend if $P \leq 0.10$. For both experiments, one-slope straight broken-line and quadratic broken-line analysis as described by Robbins et al. (2006) were used to determine estimates of Lys:ME requirement for ADG and G:F. Breakpoint analysis was determined separately for control and PRRSV infected pigs and compared. In Exp. 1, breakpoint analysis was performed on performance over the 35-d experimental period. In Exp. 2, breakpoint anlaysis was performed on performance from 0-21 dpi, when control pigs were negative for PRRSV. In Exp. 2, breakpoint analysis was also performed over the 49-d experimental period to determine if Lys:ME requirements are similar between pigs naturally and experimentally infected with PRRSV.

Results:

Diet analysis

Experimental diets were formulated to contain 1.87, 2.18, 2.49, 2.80, 3.11, and 3.41 and 2.33, 2.63, 2.94, 3.24, 3.55, and 3.85 g SID Lys per Mcal ME in Exp. 1 and 2, respectively (Table 1 and 2, respectively). Proximate and AA analysis of diet determined that experimental diets were formulated similarly to calculated values. Ratio of Lys to Thr, Met, Trp, Ile and Val remained constant across all diets. As expected, dietary energy was not different, and CP increased as soybean meal inclusion increased.

Serology

Prior to experimental inoculation with PRRSV, all pigs in both experiments were negative for PRRS virus and antibody. As expected, control pigs remained negative for PRRS virus and antibody throughout the 35-d experimental period in Exp. 1. No diet or diet × dpi interactions were detected for PRRSV PCR Ct value or Log_{10} PRRSV genomic content (Table 3). Similarly, no differences were detected for PRRSV antibody ($P > 0.10$). Expectedly, PRRSV Ct value and Log_{10} genomic content decreased over time while PRRSV antibody increased causing a main effect of dpi ($P < 0.001$).

As there were no differences in PRRS viremia or antibody attributed to diet in Exp. 1, pigs in Exp. 2 were randomly bled to determine infection with PRRSV or lack thereof in control pigs. In Exp. 2 prior to 21 dpi, control pigs remained PRRSV negative. Between 21 and 28 dpi, control pigs became naturally infected with the same PRRSV isolate used for experimental infection (ORF 1-18-4).

Experiment 1

Prior to feeding experimental diets and inoculation, growth performance and feed efficiency were not different in control or PRRSV pigs (Table 4). Over the 35-d test period, control pig ADG increased as Lys:ME increased (quadratic, $P = 0.013$). Gain:feed increased (linear, $P = 0.039$; quadratic, $P = 0.037$) as Lys:ME increased. Feed intake was not different over the 35-d test period in control pigs. In the post-challenge period, when all pigs were on a common diet, there were no performance differences ($P > 0.10$, data not shown). Pig growth and feed intake from 0 dpi to market (76-d period) was not different ($P > 0.10$); however, G:F increased up to 3.11 Lys:ME resulting in a significant quadratic effect ($P = 0.040$). Over the 35-d period, PRRSV pig ADG and G:F increased linearly with increasing Lys:ME ($P = 0.001$ and $P = 0.002$, respectively), and ADFI tended to increase (linear, $P = 0.068$). Similar to control pigs, there was no difference after 35 dpi, when all pigs were on a common diet (data not shown). From inoculation to market (78 ± 2 d), ADG increased linearly with increasing Lys:ME ($P = 0.011$); however, ADFI and G:F were not different ($P > 0.10$).

Breakpoint analysis was used to determine the optimal Lys:ME ratio to maximize growth and feed efficiency in control and PRRSV pigs. It was determined that optimal ADG in control pigs was achieved at 2.24 and 2.38 Lys:ME using a one-slope and quadratic broken-line model, respectively. Optimal G:F was achieved at 2.83 and 2.95 Lys:ME in a one-slope and quadratic broken-line model, respectively. In PRRSV infected pigs, optimal ADG and G:F were achieved at 2.83 and 3.17 Lys:ME, respectively, using a one-slope broken-line model. When using a quadratic broken-line model the optimal ADG and G:F were predicted to be 4.71 and 4.22 Lys:ME, respectively; however, these values are outside of the maximum 3.41 Lys:ME diet tested, and should be studied further.

Carcass composition was evaluated when pigs reached approximately 128 kg BW (Table 5). All control pigs were marketed at 76 dpi and there was no difference in final BW ($P > 0.10$). There was a quadratic effect ($P = 0.016$) of Lys:ME on fat depth where fat depth decreased from 1.87 to 2.80 Lys:ME and increased from 2.80 to 3.41 Lys:ME. Concurrently, there was a linear tendency ($P = 0.060$) for lean percentage to increase as Lys:ME increased. Hot carcass weight (HCW) and dress percentage were not impacted by increasing Lys:ME in control pigs. In PRRSV infected pigs, fat depth increased linearly ($P = 0.045$) and lean depth showed a strong tendency ($P = 0.059$) to decrease with increasing Lys:ME. Days to market decreased from 80 to 77 days as Lys:ME increased (linear, $P = 0.004$).

Experiment 2

In Exp. 2, control pigs became infected with PRRSV after 21 dpi, therefore, data was analyzed as two separate challenge periods. The first challenge period, 0-21 dpi, represents when control pigs were not infected with PRRSV. The second period, 0-49 dpi, is to determine the impact of a natural PRRSV infection compared to an experimental infection.

Prior to experimental infection at 0 dpi, control pig performance and feed efficiency were not different (Table 6). During the first challenge period, when control pigs were uninfected, control pig ADG (linear $P < 0.001$, quadratic $P = 0.020$) and G:F (linear $P < 0.001$) increased as Lys:ME increased. Feed intake increased from 2.33 to 3.24 Lys:ME and then decreased, resulting in a quadratic effect (P = 0.039). Wjhen breakpoint analysis was performed on 21-d performance, optimal ADG and G:F was achieved at 2.82 and 3.22

Lys:ME, respectively, in a one-slope broken-line model. In a quadratic broken-line model, optimal ADG was attained at 3.32 Lys:ME. Optimal G:F was predicted at 4.22 Lys:ME; however, this was outside the range of the experimental diets tested. Although PRRSV pigs were on a common diet prior to experimental infection, ADG and G:F increased linearly ($P < 0.01$); however, differences in ADG and G:F prior to infection did not significantly impact performance in other experimental periods. In PRRSV pigs, 21-d ADG, ADFI and G:F increased linearly with increasing Lys:ME ($P \leq 0.001$, all parameters), and ADG and G:F also demonstrated a quadratic effect ($P = 0.043$ and $P = 0.006$, respectively). Breakpoint analysis determined optimal ADG and G:F at 3.02 and 2.92, respectively, in a one-slope broken-line model and 3.41 and 3.22, respectively, in a quadratic broken-line model.

In Exp. 2, control pigs became infected with PRRSV after 21 dpi, therefore, performance and feed efficiency were evaluated from 0-49 dpi to determine the effect of natural versus experimental infection. In pigs naturally infected with PRRSV, ADG increased linearly from 2.33 to 3.24 with increasing Lys:ME resulting in both linear and quadratic effects ($P < 0.001$ and $P = 0.003$, respectively). Also, in naturally infected pigs, ADFI increased quadratically ($P = 0.029$) with peak at 3.24 Lys:ME and G:F increased linearly ($P < 0.001$) and with Lys:ME. From 0 dpi to market (approximately 100 d), ADG increased as Lys:ME increased, causing an increase in final BW (linear $P < 0.02$, quadratic $P < 0.01$, both parameters). Overall feed intake increased in a quadratic manner ($P = 0.032$). Breakpoint analysis determined 2.85 and 3.41 Lys:ME for optimal ADG using one-slope and quadratic broken-line models, respectively. Optimal G:F was achieved at 3.18 and 3.85 Lys:ME in one-slope and quadratic broken-line models, respectively.

Pigs experimentally infected with PRRSV demonstrated a similar response to increasing Lys:ME, with ADG and ADFI having a linear ($P < 0.001$, both parameters) and quadratic ($P = 0.007$ and $P = 0.037$, respectively) response, while G:F responded linearly to increasing Lys:ME ($P = 0.011$). Overall, final BW and ADG increased linearly with Lys:ME (linear $P \leq 0.002$, both parameters). Feed intake increased from 2.33 to 3.24 Lys:ME then decreased, leading to a linear ($P < 0.001$) and quadratic effect ($P = 0.048$). Optimal ADG was achieved at 3.12 and 3.47 Lys:ME using one-slope and quadratic broken-line breakpoint analysis, respectively. Optimal G:F was achieved at 3.08 and 3.52 Lys:ME using one-slope and quadratic broken-line models, respectively.

Discussion:

In healthy pigs, Lys is the first limiting AA for growth, and recommendations for Lys requirements have been established (NRC, 2012). Interestingly, when pigs are housed in unsanitary conditions, the Lys requirement for growth is reduced (Williams et al., 1997b, c) which is attributed to a reduced capacity for protein accretion (Williams et al., 1997a); however, efficiency of Lys utilization is not different between healthy and immune stimulated pigs, therefore, reduced feed intake, and Lys intake, is likely the cause of reduced tissue accretion. In a similar model, van der Meer et al. (2016) reported an improvement in feed efficiency when Met, Thr and Trp were increased 20% relative to Lys. In contrast, when the immune system is stimulated using LPS, pigs Met+Cys requirement is reduced (Rakhshandeh et al., 2014) but Met:Met+Cys increases for protein deposition (Litvak et al., 2013). These data suggest that AA requirements for pigs facing an immune insult may be different from that of healthy pigs, therefore, we conducted two experiments

to determine how increasing Lys:ME impacted growth performance in healthy and PRRSV challenge pigs.

Soybean meal was primarily used to increase Lys concentration in the diet. Feeding increased levels to PRRSV infected pigs may have potential benefits for viral clearance (Rochell et al., 2015). In Exp. 1, we reported no difference in viral titers, PRRSV genomic content or antibody response attributed to dietary treatment which is consistent with a previous study from our group (end. Loss paper). Increased dietary soybean meal has also been shown to increase performance in pigs facing a live inflammatory (Boyd et al., 2010) or PRRSV challenge (Rochell et al., 2015) or have been previously exposed to PRRSV (Shelton et al., 2011). In agreement with these reports, pigs infected with PRRSV in the current study showed linear improvements in ADG and G:F as Lys:ME, and therefore soybean meal, increased suggesting a potential role of soybean meal. In contrast, previous data from our group suggests no benefit of increased soybean meal in pigs dual-challenged with *Mycoplasma hyopneumoniae* and PRRSV (O'Connell et al., 2016).

In agreement with Li et al. (2012), fat thickness was impacted by Lys:ME in control pigs. In the current study there was a clear quadratic effect while Li et al. demonstrated both a linear and quadratic effect. Interestingly, when comparing fat thickness in control and PRRSV pigs, there is an opposite effect of Lys:ME, where fat thickness decreased from 1.87 to 2.80 Lys:ME in control pigs and then increased up to 3.41 Lys:ME. In PRRSV pigs, fat depth increased linearly with increasing Lys:ME. Our group has shown that fat accretion is decreased in PRRSV infected pigs (Schweer et al., 2017b), therefore, increasing the AA profile of the diet during a PRRSV challenge period may aid the pig in maintaining energy levels and therefore body fat.

To the author's knowledge, this is the first set of experiments to determine the Lys:ME requirements for optimal ADG and G:F in pigs challenged with PRRSV. Compared to healthy cohorts in Exp. 1, PRRSV increased Lys:ME requirement for ADG by 21 to 36% depending on the statistical model used; however, the quadratic model predicted Lys:ME requirement to be 3.71 Lys:ME which is above the 3.41 Lys:ME tested in the study suggesting that the requirement could be higher than the test diets. Similarly, PRRSV increased the Lys:ME for optimal G:F by 11 to 30%. Similar to the predicted quadratic requirement for ADG, the G:F prediction was above the 3.41 Lys:ME diet and, therefore, the requirement may be higher than the tested diets. In Exp. 2, and in agreement with Exp. 1, optimal ADG was achieved at 3 to 7% higher in PRRSV pigs compared to healthy controls. Interestingly, PRRSV decreased Lys:ME requirement to achieve optimal G:F by 9 to 25%; however, optimal G:F in control pigs using a quadratic model predicted a requirement above the diets tested. Because control pigs in Exp. 2 became infected with PRRSV, the optimal Lys:ME was able to be determined for natural versus experimental PRRSV infection. Interestingly, optimal ADG and G:F was achieved at slightly higher Lys:ME levels in naturally infected pigs compared to experimentally infected cohorts. These data contrast with the classic papers by Williams et al. (1997a, b, c) that determined Lys requirements to be less in immune stimulated pigs compared to healthy pigs; however, Lys efficiency was not different between the groups suggesting growth differences to be related to feed intake and Lys intake. A similar response occurs in broilers challenged with LPS, where Lys utilization by muscle does not change but Lys utilization by the immune system increases 6-fold (Klasing and Calvert, 1999). As mentioned, soybean meal was used to increase

dietary Lys, therefore, intake of other AA is likely increased. Acute-phase protein synthesis requires a large portion of aromatic AA (Reeds et al., 1994). Also, increased Met and Met+Cys can be beneficial to protein deposition in LPS challenged pigs (Litvak et al., 2013; Rakhshandeh et al., 2014). Altogether, increased intake of these AA and others can reduce the need for lean tissue catabolism and preserve lean tissue and therefore growth.

Conclusion

In summary, increased Lys:ME during a 35-d or 21-d PRRSV challenge in 50 and 25 kg pigs, respectively, increases ADG and G:F. There was no difference in immune response, as determined by PRRS viremia or antibody response, and no difference in carcass characteristics. When breakpoint analysis was performed in Exp. 1, optimal Lys:ME for ADG and G:F was increased up to 136% and 130%, respectively, in PRRSV infected pigs compared to healthy controls. In Exp. 2, optimal Lys:ME for ADG increased up to 7%; however, optimal Lys:ME for G:F was decreased up to 25% in PRRSV infected pigs. In Exp. 1, the predicted requirement for ADG and G:F in PRRSV pigs using a quadratic model were above the highest Lys:ME diet. This was similar for G:F in control pigs in Exp. 2, therefore, further studies should be conducted to more accurately determine the Lys:ME requirement. In Exp. 2, it was also determined that Lys:ME for optimal ADG and G:F between pigs naturally and experimentally infected with PRRSV was not different. Altogether, increasing Lys:ME above the NRC requirement increased performance and feed efficiency in PRRSV infected pigs, and the response was similar between natural and experimental PRRSV infection.

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Table 1. Experiment 1 diet composition, as fed basis

Ingredients, %	SID Lys:ME (g/Mcal)					
	1.87	2.18	2.49	2.80	3.11	3.41
Corn	87.16	84.13	81.07	77.74	73.95	70.29
Soybean meal, 48% CP	9.75	12.75	15.74	19.10	22.92	26.61
Limestone	1.00	1.01	1.02	1.02	1.02	1.03
Monocalcium phosphate, 21%	1.13	1.07	1.05	0.94	0.86	0.79
Salt	0.51	0.51	0.51	0.51	0.51	0.51
L-Lysine·HCl	0.27	0.31	0.34	0.37	0.38	0.39
Commercial VTM[1]	0.11	0.11	0.11	0.11	0.11	0.11
L-Threonine	0.05	0.06	0.08	0.10	0.10	0.11
DL-Methionine	0.02	0.05	0.08	0.11	0.13	0.15
Optiphos 1000	-	-	-	0.004	0.006	0.009
Calculated composition						
DM, %	85.6	85.7	85.8	85.9	86.0	86.1
CP, %	11.4	12.6	13.9	15.2	16.8	18.3
ME, Mcal/kg	3.28	3.27	3.27	3.27	3.27	3.26
SID AA						
Lys	0.61	0.71	0.81	0.92	1.02	1.11
Thr:Lys	0.60	0.60	0.60	0.60	0.60	0.60
Met:Lys	0.30	0.32	0.33	0.34	0.35	0.35
Met+Cys:Lys	0.57	0.57	0.57	0.57	0.57	0.57
Trp:Lys	0.16	0.16	0.16	0.16	0.17	0.17
Ile:Lys	0.58	0.58	0.57	0.57	0.58	0.59
Val:Lys	0.71	0.68	0.66	0.65	0.65	0.65
SID Lys:ME, g/Mcal	1.87	2.18	2.49	2.80	3.11	3.41
Total Lys, %	0.70	0.80	0.91	1.02	1.13	1.23
Analyzed composition						
DM, %	85.8	85.8	85.9	87.3	87.1	87.0
CP, %	13.6	15.3	16.3	18.4	20.3	22.8
ME, kcal/kg	3.53	3.55	3.53	3.46	3.44	3.40
Thr:Lys	0.61	0.63	0.61	0.62	0.67	0.59
Met:Lys	0.28	0.29	0.29	0.31	0.33	0.28
Met+Cys:Lys	0.58	0.58	0.55	0.57	0.59	0.50
Trp:Lys	0.15	0.16	0.16	0.16	0.19	0.17
Ile:Lys	0.57	0.56	0.64	0.65	0.68	0.56
Val:Lys	0.71	0.68	0.72	0.72	0.74	0.63
Total Lys:ME, g/Mcal	2.14	2.45	2.73	3.00	3.36	3.70
Total Lys, %	0.76	0.87	0.96	1.04	1.14	1.27

[1]VTM=Vitamin-trace mineral premix, which supplied per kilogram of diet: vitamin A, 8,820 IU; vitamin D_3, 1,653 IU; vitamin E, 33.1 IU; vitamin K, 4.4 mg; riboflavin, 6.6 mg; niacin, 38.9 mg; pantothenic acid, 22.1 mg; vitamin B_{12}, 0.04 mg; I, 1.1 mg as potassium iodide; Se, 0.30 mg sodium selenite; Zn, 60.6 mg as zinc oxide; Fe, 36.4 mg as ferrous sulfate; Mn, 12.1 mg as manganous oxide; and Cu, 3.6 mg as copper sulfate.

Table 2. Experiment 2 diet composition, as fed basis

Ingredients, %	SID Lys:ME (g/Mcal)					
	2.33	2.63	2.94	3.24	3.55	3.85
Corn	82.16	79.11	75.59	71.87	68.02	64.29
Soybean meal, 48% CP	14.55	17.52	21.08	24.84	28.73	32.49
Limestone	0.96	0.98	0.98	0.99	0.99	1.00
Monocalcium phosphate, 21%	1.01	0.99	0.89	0.80	0.72	0.64
Salt	0.51	0.51	0.51	0.51	0.51	0.51
L-Lysine·HCl	0.32	0.35	0.37	0.38	0.39	0.40
Beef tallow	0.25	0.25	0.25	0.25	0.25	0.25
Commercial VTM[1]	0.11	0.11	0.11	0.11	0.11	0.11
L-Threonine	0.07	0.09	0.10	0.10	0.11	0.12
DL-Methionine	0.06	0.09	0.12	0.14	0.16	0.18
Optiphos 1000	0.0	0.0	0.008	0.008	0.009	0.012
Calculated composition						
DM, %	86.2	86.3	86.3	86.4	86.5	86.6
CP, %	13.0	14.2	15.6	17.2	18.7	20.2
ME, Mcal/kg	3.29	3.29	3.29	3.29	3.29	3.29
SID AA						
Lys	0.77	0.86	0.97	1.07	1.17	1.27
Thr:Lys	0.60	0.60	0.60	0.60	0.60	0.60
Met:Lys	0.32	0.33	0.34	0.34	0.35	0.35
Met+Cys:Lys	0.57	0.57	0.57	0.57	0.57	0.57
Trp:Lys	0.16	0.16	0.16	0.17	0.17	0.17
Ile:Lys	0.58	0.58	0.58	0.59	0.59	0.60
Val:Lys	0.67	0.66	0.65	0.65	0.65	0.65
SID Lys:ME, g/Mcal	2.33	2.63	2.94	3.24	3.55	3.85
Lys, Total %	0.86	0.97	1.08	1.18	1.29	1.40
Analyzed composition						
DM, %	86.3	86.1	86.5	86.6	86.5	86.8
CP, %	14.1	15.7	16.1	17.9	20.2	20.8
ME, kcal/kg	3.64	3.48	3.44	3.40	3.35	3.31
Thr:Lys	0.57	0.61	0.64	0.61	0.62	0.61
Met:Lys	0.26	0.31	0.32	0.32	0.30	0.30
Met+Cys:Lys	0.49	0.57	0.56	0.55	0.53	0.53
Trp:Lys	0.15	0.18	0.18	0.17	0.18	0.17
Ile:Lys	0.53	0.64	0.64	0.59	0.61	0.62
Val:Lys	0.63	0.71	0.70	0.64	0.66	0.66
Total Lys:ME, g/Mcal	2.77	2.87	3.10	3.57	4.12	4.36
Lys, Total %	1.00	1.00	1.07	1.21	1.38	1.44

[1]VTM=Vitamin-trace mineral premix, which supplied per kilogram of diet: vitamin A, 8,820 IU; vitamin D_3, 1,653 IU; vitamin E, 33.1 IU; vitamin K, 4.4 mg; riboflavin, 6.6 mg; niacin, 38.9 mg; pantothenic acid, 22.1 mg; vitamin B_{12}, 0.04 mg; I, 1.1 mg as potassium iodide; Se, 0.30 mg sodium selenite; Zn, 60.6 mg as zinc oxide; Fe, 36.4 mg as ferrous sulfate; Mn, 12.1 mg as manganous oxide; and Cu, 3.6 mg as copper sulfate.

Table 3. Effect of standardized ileal digestible (SID) Lys:ME ratio on PRRS viremia and antibody, Exp. 1.

Parameter[1]	SID Lys:ME (g/Mcal)							*P-value*[2]		
	1.87	2.18	2.49	2.80	3.11	3.41	SEM	*Diet*	*dpi*	*Diet×dpi*
PRRSV Ct value[3]										
dpi7	21.9	21.5	23.5	23.0	21.9	22.0	1.28	0.124	<0.001	0.951
dpi14	32.8	27.3	30.0	31.4	28.8	32.3				
dpi21	33.7	32.7	33.7	33.9	32.7	33.3				
dpi28	37.0	34.2	37.0	36.8	36.6	36.5				
dpi35	37.0	35.5	35.5	37.0	36.2	37.0				
Genomic PRRSV/mL[4]										
dpi7	7.33	7.30	6.99	7.01	7.34	7.31	0.71	0.407	<0.001	0.946
dpi14	3.36	4.92	4.92	4.49	4.60	4.24				
dpi21	2.40	3.41	3.11	3.76	4.12	3.93				
dpi28	0.00	2.26	0.00	0.78	0.82	0.88				
dpi35	0.00	1.15	1.00	0.00	0.96	0.00				
PRRSV S/P ratio[5]										
dpi7	0.07	0.15	0.04	0.04	0.09	0.04	0.12	0.929	<0.001	0.676
dpi14	2.22	2.12	2.24	1.90	2.08	2.10				
dpi21	2.28	2.29	2.30	2.13	2.18	2.24				
dpi28	2.02	2.24	2.25	2.21	2.13	2.19				
dpi35	2.19	2.25	2.19	2.13	2.07	2.10				

[1]n=4 pens/treatment
[2]main effect of diet, day post inoculation (dpi) and diet × dpi interaction
[3]Cycle threshold (Ct), Ct ≥37.0 denotes PRRS negative
[4]Log_{10} transformation of PRRSV genomic content/mL
[5]PRRSX3 antibody sample to positive (S/P) ratio, <0.40 denotes PRRS negative

Table 4. Effect of standardized ileal digestible (SID) Lys:ME on growth performance in healthy and PRRSV infected growing pigs, Exp. 1.

	SID Lys:ME (g/Mcal)						SEM	*P-value*[2]	
Parameter[1]	1.87	2.18	2.49	2.80	3.11	3.41		*Linear*	*Quadratic*
Pre-challenge[3]									
Control Start BW, kg	36.4	36.4	36.4	36.3	36.4	36.4	0.80	0.962	0.989
Control ADG, kg	1.02	0.94	0.97	1.01	0.93	1.00	0.03	0.832	0.383
Control ADFI, kg	1.82	1.79	1.81	1.78	1.75	1.87	0.05	0.893	0.260
Control G:F	0.558	0.525	0.535	0.570	0.533	0.540	0.013	0.784	0.933
PRRS Start BW, kg	36.8	36.7	37.0	37.0	36.9	37.0	0.76	0.811	0.928
PRRS ADG, kg	1.03	0.99	1.05	1.08	1.08	1.01	0.03	0.372	0.148
PRRS ADFI, kg	1.88	1.71	1.86	1.88	1.88	1.86	0.04	0.278	0.669
PRRS G:F	0.548	0.578	0.565	0.575	0.570	0.548	0.015	0.922	0.110
Challenge[4]									
Control									
Start BW, kg	50.6	49.6	50.0	50.5	49.4	50.4	1.09	0.914	0.675
ADG, kg	1.05	1.11	1.14	1.12	1.13	1.11	0.02	0.069	0.013
ADFI, kg	2.79	2.91	2.85	2.83	2.71	2.87	0.06	0.695	0.891
G:F	0.375	0.383	0.403	0.395	0.418	0.388	0.009	0.039	0.037
PRRSV									
Start BW, kg	52.2	51.6	52.7	53.3	52.9	52.2	0.89	0.563	0.454
ADG, kg	0.70	0.74	0.76	0.86	0.84	0.86	0.04	0.001	0.396
ADFI, kg	2.05	1.99	2.16	2.13	2.12	2.13	0.05	0.068	0.374
G:F	0.343	0.370	0.353	0.408	0.395	0.403	0.014	0.002	0.536
Overall[5]									
Control									
End BW, kg	128.0	130.2	131.5	130.9	130.4	130.4	2.04	0.481	0.336
ADG, kg	1.02	1.06	1.07	1.06	1.07	1.05	0.02	0.387	0.129
ADFI, kg	2.95	3.08	3.00	2.98	2.91	3.04	0.05	0.849	0.955
G:F	0.345	0.343	0.358	0.355	0.368	0.345	0.005	0.128	0.040
PRRSV									
End BW, kg	128.4	129.4	128.5	129.0	128.6	129.7	0.93	0.569	0.788
ADG, kg	0.95	0.97	0.98	0.98	0.99	1.02	0.02	0.011	0.841
ADFI, kg	2.40	2.34	2.46	2.45	2.42	2.47	0.06	0.240	0.964
G:F	0.398	0.415	0.398	0.398	0.410	0.413	0.010	0.500	0.643

[1]n=4 pens/treatment
[2]linear and quadratic orthogonal contrast
[3]Pre-challenge adaptation period (-14-0 days post inoculation (dpi)), all pigs on common diet
[4]Challenge period (0-35 dpi), pigs fed experimental diets
[5]Overall challenge period (0 dpi – market; control = 76 d, PRRS = 78 ± 2 d)

Table 5. Effect of standardized ileal digestible (SID) Lys:ME ratio on carcass characteristics in control and PRRSV infected pigs, Exp. 1.

Parameter[1]	SID Lys:ME (g/Mcal)							*P-value*[2]	
	1.87	2.18	2.49	2.80	3.11	3.41	SEM	*Linear*	*Quadratic*
Control									
Live weight, kg	128.0	130.2	131.5	130.9	130.4	130.4	2.04	0.481	0.336
HCW[3], kg	97.2	100.4	99.9	97.0	98.7	97.9	1.41	0.722	0.405
Dress %	76.1	77.2	76.0	74.1	75.7	75.1	1.28	0.312	0.837
Lean %	53.4	52.0	54.1	54.9	54.2	53.7	0.79	0.205	0.355
Fat thickness, mm	20.76	20.36	20.13	18.38	20.12	20.98	0.58	0.782	0.016
Lean depth, mm	60.19	61.05	62.96	60.31	63.60	63.35	1.24	0.060	0.994
Days to market[4]	76	76	76	76	76	76	-	-	-
PRRSV									
Live weight, kg	128.4	129.3	128.5	129.0	128.6	129.6	0.93	0.581	0.800
HCW[3], kg	97.4	94.7	98.0	96.5	97.7	96.8	1.72	0.755	0.975
Dress %	75.8	73.2	76.2	74.8	75.9	74.7	1.27	0.920	0.918
Lean %	52.5	54.9	54.0	53.7	53.1	53.3	0.96	0.867	0.272
Fat depth, mm	19.71	18.96	20.43	20.57	21.28	21.09	0.78	0.045	0.968
Lean depth, mm	64.70	63.48	63.09	61.91	60.46	60.93	1.72	0.059	0.791
Days to market	80	80	78	78	77	77	0.88	0.004	0.627

[1]n=4 pen/treatment
[2]linear and quadratic orthogonal contrasts
[3]HCW = hot carcass weight
[4]All control pigs marketed at 76 d after start of experimental diets

Table 6. Effect of increasing standardized ileal digestible (SID) Lys:ME on growth performance in healthy and PRRSV infected pigs and natural and experimental PRRSV infection, Exp. 2.

Parameter[1]	SID Lys:ME (g/Mcal)							*P-value*	
	2.33	2.63	2.94	3.24	3.55	3.85	SEM	*Linear*	*Quadratic*
Pre-challenge (-14-0 dpi)[4]									
Control									
Start BW, kg	23.0	23.1	23.1	22.9	22.8	22.4	0.46	0.299	0.396
ADG, kg	0.48	0.58	0.52	0.46	0.52	0.48	0.04	0.521	0.631
ADFI, kg	1.24	1.36	1.29	1.26	1.33	1.25	0.04	0.886	0.260
G:F	0.39	0.42	0.40	0.36	0.39	0.39	0.03	0.564	0.968
PRRSV									
Start BW, kg	23.3	23.5	23.7	23.9	23.5	22.9	0.57	0.684	0.248
ADG, kg	0.59	0.53	0.58	0.66	0.64	0.62	0.02	0.008	0.808
ADFI, kg	1.43	1.30	1.35	1.41	1.35	1.31	0.04	0.264	0.943
G:F	0.41	0.41	0.44	0.46	0.47	0.47	0.01	<0.001	0.600
Challenge1 (0-21 dpi)[5]									
Control									
Start BW, kg	28.2	29.5	28.8	27.9	28.6	27.7	0.71	0.283	0.405
ADG, kg	0.65	0.81	0.87	0.92	0.92	0.92	0.05	<0.001	0.020
ADFI, kg	1.57	1.87	1.76	1.86	1.74	1.72	0.08	0.489	0.039
G:F	0.42	0.43	0.49	0.50	0.53	0.54	0.01	<0.001	0.123
PRRSV									
Start BW, kg	29.7	29.1	30.0	31.1	30.5	29.7	0.73	0.413	0.323
ADG, kg	0.19	0.26	0.43	0.45	0.39	0.49	0.04	<0.001	0.043
ADFI, kg	0.71	0.74	0.90	0.96	0.88	0.98	0.06	0.001	0.262
G:F	0.27	0.35	0.48	0.47	0.44	0.49	0.03	<0.001	0.006
Challenge2 (0-49 dpi)									
Natural infection									
ADG, kg	0.58	0.69	0.72	0.82	0.78	0.77	0.03	<0.001	0.003
ADFI, kg	1.49	1.66	1.61	1.79	1.68	1.63	0.06	0.086	0.029
G:F	0.39	0.42	0.44	0.46	0.46	0.47	0.01	<0.001	0.143
Experimental infection									
ADG, kg	0.55	0.58	0.72	0.78	0.73	0.75	0.03	<0.001	0.007
ADFI, kg	1.23	1.23	1.46	1.54	1.41	1.50	0.05	<0.001	0.037
G:F	0.45	0.47	0.50	0.50	0.52	0.50	0.02	0.011	0.147
Overall[8]									
Control									
End BW, kg	116.2	130.2	123.4	130.7	131.5	125.2	2.49	0.016	0.006
ADG, kg	0.88	1.01	0.95	1.03	1.03	0.98	0.02	0.002	0.003
ADFI, kg	1.66	1.85	1.78	1.97	1.85	1.80	0.07	0.12	0.032
G:F	0.53	0.55	0.54	0.52	0.56	0.54	0.02	0.529	0.812
PRRSV									
End BW, kg	121.4	120.9	129.3	129.9	129.7	132.5	2.62	0.002	0.473
ADG, kg	0.90	0.90	0.97	0.97	0.97	1.01	0.02	0.001	0.712
ADFI, kg	1.44	1.41	1.66	1.72	1.61	1.69	0.05	<0.001	0.048
G:F	0.63	0.64	0.59	0.56	0.61	0.60	0.02	0.091	0.081

[1]n=4 pens/treatment

[2]Linear and quadratic orthogonal contrast

[4]Pre-challenge adaptation period (-14-0 dpi), all pigs on common diet

[5]Challenge period 1 (0-21 dpi), pigs fed experimental diets

[6]Challenge period 2 (0-49 dpi), Control barn naturally infected with PRRSV after 21 dpi, pigs fed experimental diets

[8]Overall challenge period (0 dpi - market); control pigs naturally infected after 21 dpi, PRRSV pigs experimentally infected at 0 dpi

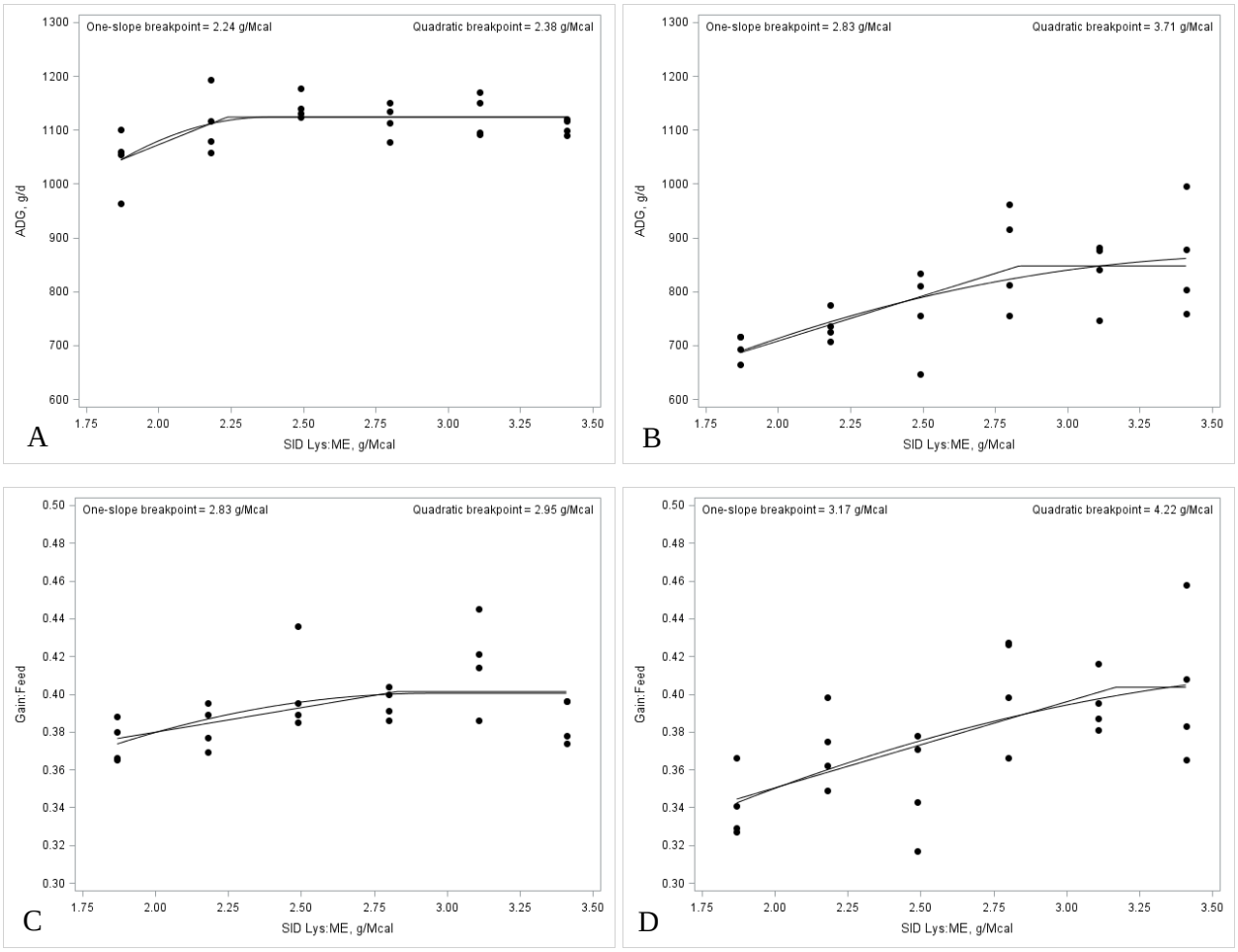

Figure 1. Data points represent treatments means from 4 pens per experimental diet per health status (Exp. 1). One-slope straight broken-line and quadratic broken-lines were fitted for maximum ADG (A-B) and G:F (C-D) expressed as a function of standardized ileal digestible (SID) Lys:ME (g SID Lys per Mcal ME) over a 35-d growth period in control (A,C) and PRRSV (B,D) infected pigs, respectively. (**A**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 2.24 g/Mcal (Y plateau = 1123.6 ADG; slope below requirement = −216.1; r^2 = 0.38). The quadratic broken-line model resulted in a SID Lys:ME requirement of 2.38 g/Mcal (Y = 1123.6 − 302.5(2.38 − g SID Lys/Mcal)^2; r^2 = 0.38). (**B**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 2.83 g/Mcal (Y plateau = 847.4 ADG; slope below requirement = −167.2; r^2 = 0.47). The quadratic broken-line model yielded a SID Lys:ME requirement of 4.71 g/Mcal (Y = ; r^2 = 0.45); however, this predicted requirement is outside the range of the diets tested. (**C**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 2.83 g/Mcal (Y plateau = 0.401 G:F; slope below requirement = -0.026; r^2 = 0.23). The quadratic broken-line model yielded a SID Lys:ME requirement of 2.95 g/Mcal (Y = ; r^2 = 0.25). (**D**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 3.17 g/Mcal (Y plateau = 0.404 G:F; slope below requirement = −0.046; r^2 = 0.41). The quadratic broken-line model projected a SID Lys:ME requirement of 4.22 g/Mcal (Y = 4.22 – 0.013(4.22 − g SID Lys/Mcal)^2; r^2 = 0.41); however, the predicted requirement is outside the range of the experimental diets.

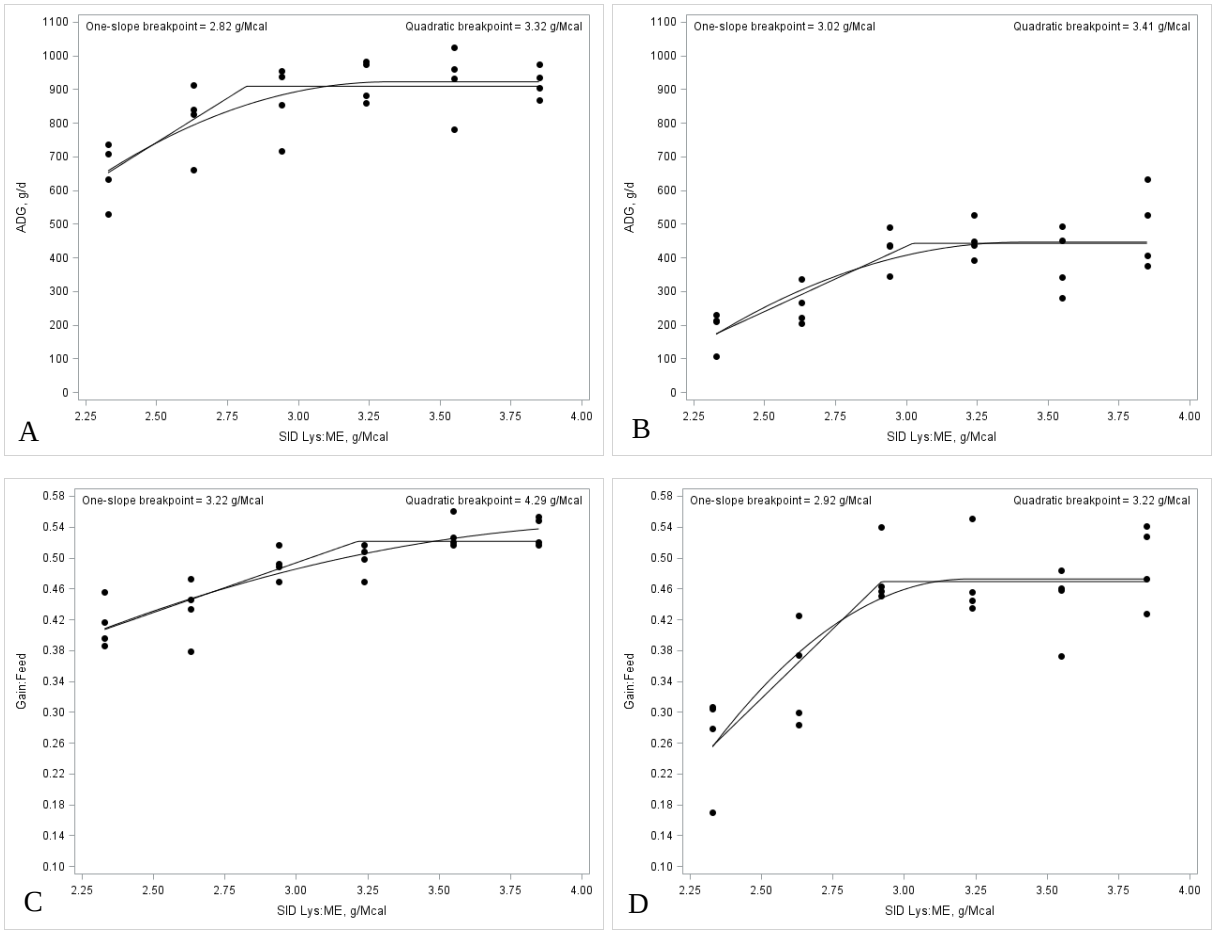

Figure 2. Data points represent treatment means from 4 pens per experimental diet per health status (Exp. 2). One-slope straight broken-line and quadratic broken-lines were fitted for maximum ADG (A-B) and G:F (C-D) expressed as a function of standardized ileal digestible (SID) Lys:ME (g SID Lys per Mcal ME) over a 21-d growth period in control (A,C) and PRRSV (B,D) infected pigs, respectively. (**A**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 2.82 g/Mcal (Y plateau = 908.8 ADG; slope below requirement = −526.7; r^2 = 0.59). The quadratic broken-line model resulted in a SID Lys:ME requirement of 3.32 g/Mcal (Y = 921.9 − 267.2(3.32 − g SID Lys/Mcal)^2; r^2 = 0.61). (**B**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 3.02 g/Mcal (Y plateau = 442.2 ADG; slope below requirement = −387.3; r^2 = 0.65). The quadratic broken-line model yielded a SID Lys:ME requirement of 3.41 g/Mcal (Y = 445.4 − 235.8(3.41 − g SID Lys/Mcal)^2; r^2 = 0.63). (**C**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 3.22 g/Mcal (Y plateau = 0.521 G:F; slope below requirement = −0.129; r^2 = 0.74). The quadratic broken-line model yielded a SID Lys:ME requirement of 4.29 g/Mcal (Y = 0.544 – 0.036(4.29 – g SID Lys/Mcal)^2; r^2 = 0.78); however, this predicted value is outside the range of the experimental diets tested. (**D**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 2.92 g/Mcal (Y plateau = 0.469 G:F; slope below requirement = −0.361; r^2 = 0.72). The quadratic broken-line model projected a SID Lys:ME requirement of 3.22 g/Mcal (Y = 0.472 – 0.272(3.22 − g SID Lys/Mcal)^2; r^2 = 0.69).

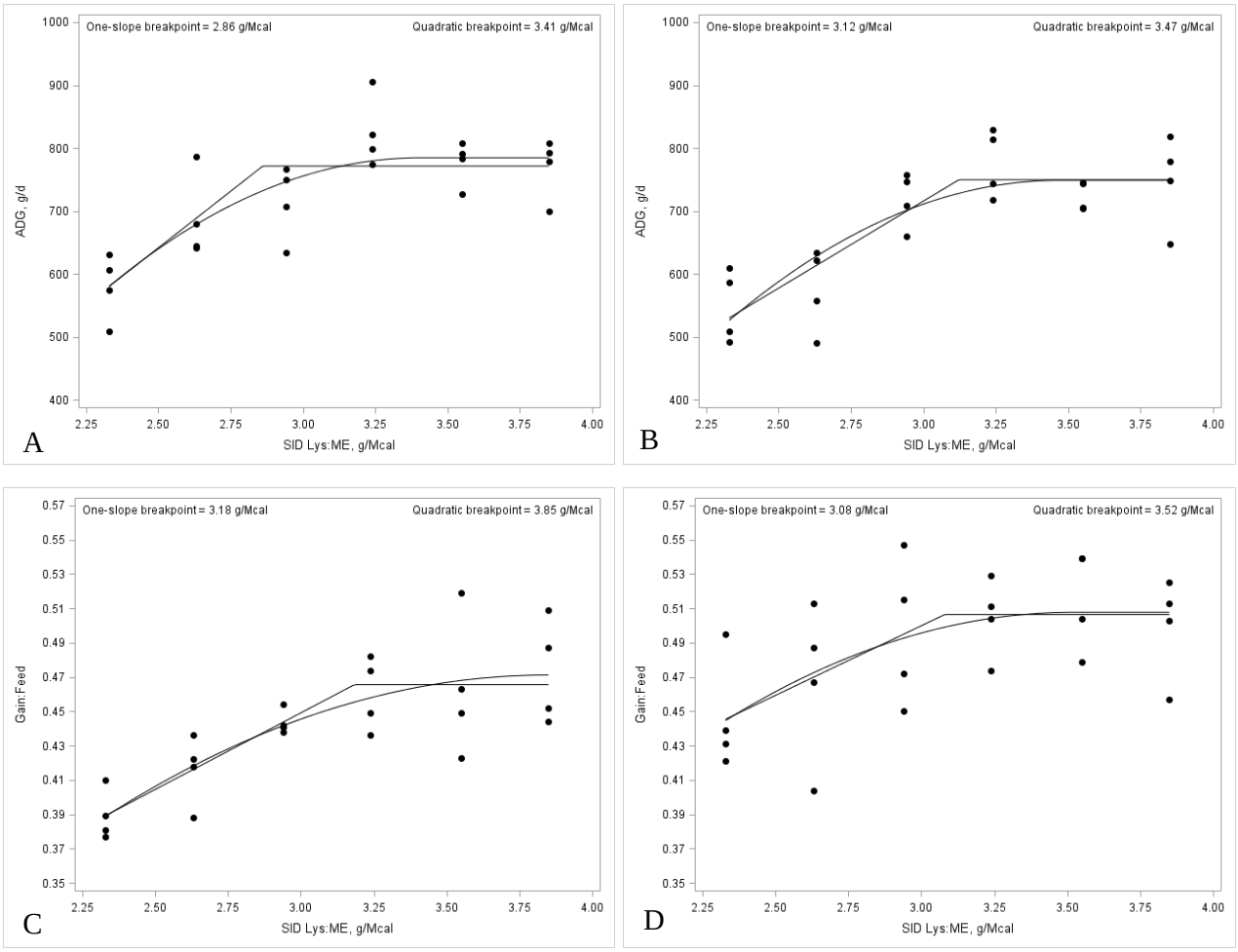

Figure 3. Data points represent treatments means from 4 pens per experimental diet per health status (Exp. 2). One-slope straight broken-line and quadratic broken-lines were fitted for maximum ADG (**A-B**) and G:F (**C-D**) expressed as a function of standardized ileal digestible (SID) Lys:ME (g SID Lys per Mcal ME) over a 49-d growth period in pigs that experienced a natural (A,C) or experimental (B,D) PRRSV infection, respectively. (**A**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 2.86 g/Mcal (Y plateau = 771.3 ADG; slope below requirement = −360.0; r^2 = 0.62). The quadratic broken-line model resulted in a SID Lys:ME requirement of 3.41 g/Mcal (Y = 784.4 – 176.4(3.41 − g SID Lys/Mcal)^2; r^2 = 0.67). (**B**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 3.12 g/Mcal (Y plateau = 749.6 ADG; slope below requirement = −276.8; r^2 = 0.71). The quadratic broken-line model yielded a SID Lys:ME requirement of 3.47 g/Mcal (Y = 748.6 – 171.3(3.47 – g SID Lys/Mcal)^2; r^2 = 0.67); however, this predicted requirement is outside the range of the diets tested. (**C**) The one-slope straight broken-line model yielded a SID Lys:ME requirement of 3.18 g/Mcal (Y plateau = 0.466 G:F; slope below requirement = -0.089; r^2 = 0.64). The quadratic broken-line model yielded a SID Lys:ME requirement of 3.85 g/Mcal (Y = 0.471 – 0.036(3.85 – g SID Lys/Mcal)^2; r^2 = 0.65). (**D**) The one-slope straight broken-line model resulted in a SID Lys:ME requirement of 3.08 g/Mcal (Y plateau = 0.506 G:F; slope below requirement = −0.081; r^2 = 0.36). The quadratic broken-line model projected a SID Lys:ME requirement of 3.52 g/Mcal (Y = 0.508 – 0.044(3.52 − g SID Lys/Mcal)^2; r^2 = 0.36).