

Immune system activation effect on lysine requirements of pigs

ACTIVATION of the immune system is a natural biological response that occurs after an animal has been exposed to a pathogenic (such as bacterial or viral) or non-pathogenic (such as an endotoxin) antigen.

First, the presence of an antigen results in the release of cytokines — such as interleukin-1, interleukin-6 and tumor necrosis factor — that activate the immune system (Klasing and Korver, 1997). These cytokines also alter the animal's metabolic state by depressing feed intake as well as partitioning nutrients away from tissue deposition and towards immune activity.

Several studies in this area have utilized the chick as a model to evaluate the impact of cytokines on immune system activation (ISA) and metabolic status. The data consistently show that ISA induces a depression in feed intake and growth rate.

The poultry data would suggest that 70% of the growth depression response from cytokine exposure is a function of reduced feed intake and that the remaining 30% results from changes in the animal's metabolism (Klasing, 1987).

Researchers were able to demonstrate that cytokine injections both depress protein synthesis (Jepson et al., 1986) and increase protein degradation (Klasing et al., 1987), which, together, would result in lower body protein accretion. The decrease in protein deposition would then suggest that the animal's dietary requirement for amino acids, such as lysine, may have changed.

Williams et al. (1997a,b,c) published a series of papers about multiple experiments they conducted focused on how pigs reacted to different dietary concentrations of lysine based on different rearing conditions that were designed to create different levels of ISA.

The researchers demonstrated that the two different rearing systems used could differentiate pigs into low immune activation (LIA) and high immune activation (HIA), as determined by the absence/presence of antibodies for multiple pathogens as well as a separation in the ratio of T lymphocytes (CD4+:CD8+).

Similar to the poultry work, the researchers observed a reduction in feed intake and bodyweight gain ($P < 0.01$) both from 13 to 60 lb. and 60 to 247 lb.

Bottom Line

with
NICK SHELTON*



in pigs with HIA compared to LIA. They also demonstrated that pigs with LIA required a higher dietary lysine concentration to optimize both bodyweight gain and gain:feed compared to pigs with HIA. For example, from 13 to 60 lb., pigs with LIA responded with improvements in gain:feed until the total lysine concentration reached 1.50%, while pigs with high HIA responded with improvements until 1.20% of dietary lysine (immune status x lysine interaction; $P < 0.01$).

Williams et al. also conducted nitrogen

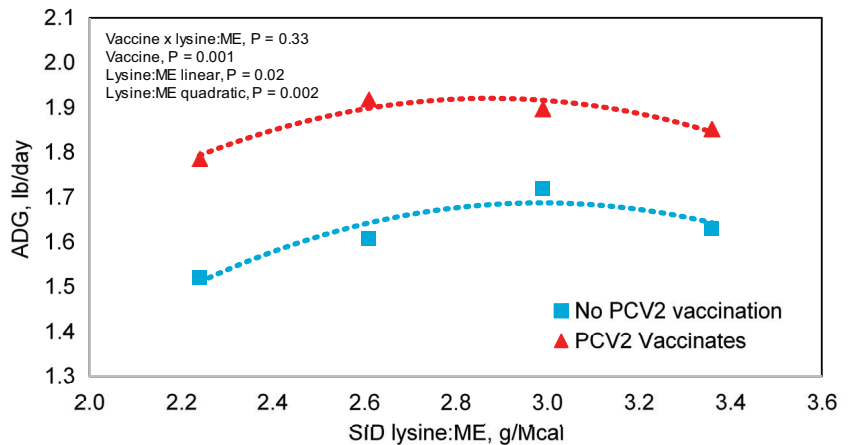
balance studies and observed no differences in the partial efficiency of lysine utilization in pigs with either LIA or HIA. Thus, this signifies that greater dietary lysine for pigs with LIA versus HIA is necessary to meet the increased body protein accretion and is not due to any differences in the efficiency of utilization.

Overall, these studies would suggest that pigs with HIA have 0.15-0.30% lower total dietary lysine requirements or 2-5 g less daily lysine intake compared to pigs with LIA.

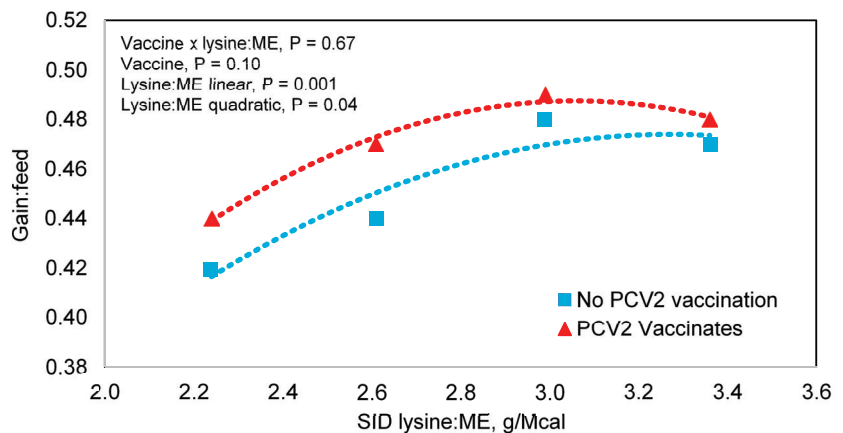
Commercial trials

Shelton et al. (2012) conducted another series of experiments that focused on how ISA could alter the response to dietary lysine in a commercial envi-

1. Impact of PCV2 vaccination and SID lysine:ME on ADG of 85-130 lb. gilts



2. Impact of PCV2 vaccination and SID lysine:ME on gain:feed of 85-130 lb. gilts



*Dr. Nick Shelton is a nutritionist with NutriQuest LLC.

ronment. In these studies, the authors utilized a natural exposure to porcine circovirus-type (PCV) disease challenge to both non-vaccinated and PCV2-vaccinated pigs as their method of immune activation.

It is also important to note that all pigs in these trials had been exposed to porcine reproductive and respiratory syndrome virus (PRRSv) in a controlled fashion by injecting them with serum containing PRRSv as part of the farms' standard production protocol roughly five to six weeks before the initiation of the first two trials.

The authors then titrated four increasing levels of standardized ileal digestible (SID) lysine to metabolizable energy (ME) in four separate trials (two separate bodyweight ranges in both gilt and barrow barns). In both of the early-finishing studies, PCV2-vaccinated pigs had greater ($P < 0.001$) average daily gain (ADG) and average daily feed intake as well as a trend ($P < 0.10$) for improved gain:feed over the non-vaccinated pigs.

Prior to and during both of the early-finishing studies, clinical evidence of PCV disease was evident in the non-vaccinates. This, combined with the growth and feed intake responses, would suggest that a health challenge occurred, generating different levels of ISA between the PCV2 and non-vaccinated groups.

No interactive effects were observed ($P > 0.18$) between vaccination status and SID lysine:ME in either early-finishing study.

Figures 1 and 2 provide a visual of the ADG and gain:feed responses in the gilt trial, respectively. It can be noticed that, based on the trend line of the response, the optimal SID lysine:ME in both non-vaccinates and PCV2-vaccinated pigs appears to be approximately 3.00 g/Mcal, matching the third incremental SID lysine:ME treatment.

These two studies suggest that the pigs' optimal level of SID lysine:ME was not altered by the increase in immune challenge. One of the major symptoms associated with PCV disease is muscle wasting, so it might seem logical that this particular disease would have a stronger effect on body protein metabolism and decrease the dietary requirement for lysine more than some other disease; however, that was not an observation from this study.

The two late-finishing trials also showed no interactive effects ($P > 0.36$) between SID lysine:ME and vaccination status, although at this point, the authors were no longer seeing a decrease in growth or intake between the vaccinate groups and observed minimal clinical signs of PCV disease. This would suggest that the latter two trials may have been conducted after the non-vaccinat-



Photo: Shutterstock

ed pigs had returned to baseline levels of immune activity.

So, the logical question is why the pigs with lower immune activation responded to higher levels of lysine in the Williams et al. (1997 a,b,c) trials but not in trials by Shelton et al. (2012). The likely explanation is that in the Williams trials, there was a large difference in ISA between the relative treatment groups compared to the other trials.

Pigs' exposure to PRRSv in the Shelton trials would have initiated some immune stimulation in vaccinate groups and may have narrowed the range in ISA differences. The severity of a health challenge may dictate whether or not a group or flow of pigs will respond to lysine levels for maximum lean gain or if their requirement is lowered.

The next issue that needs to be addressed then would be whether the ratios to lysine for all additional amino acids are still valid under various health challenges.

The Bottom Line

ISA, while certainly necessary to combat health challenges, has a detrimental effect on growth rate and feed intake and reduces the potential for body protein accretion in growing pigs. Fortifying the diet with additional dietary lysine will not combat the feed intake reduction associated with a health challenge, because the animals' underlying metabolism is the rate-limiting factor, and over-compensating dietary lysine would only unnecessarily increase feed costs.

Depending on the severity of the health challenge, research would suggest that the lysine requirement as a percentage of the diet for grow/finish pigs is similar to high-health pigs or slightly lower for

maximizing performance.

References

- Jepson, M.M., J.M. Pell, P.C. Bates and D.J. Millward. 1986. The effects of endotoxaemia on protein metabolism in skeletal muscle and liver of fed and fasted rats. *Biochem. J.* 235:329-339.
- Klasing, K.C. 1987. Avian interleukin-1: Immunological and physiological functions. In: *Proceedings of 36th Western Poultry Disease Conference*, Davis, Cal. p. 82.
- Klasing, K.C., and D.R. Korver. 1997. Leukocytic cytokines regulate growth rate and composition following activation of the immune system. *J. Anim. Sci.* 75:58-67.
- Klasing, K.C., D.E. Laurin, R.K. Peng and D.M. Frey. 1987. Immunologically mediated growth depression in chicks: Influence of feed intake, corticosterone and interleukin-1. *J. Nutr.* 117:1629-1637.
- Shelton, N.W., M.D. Tokach, S.S. Dritz, R.D. Goodband, J.L. Nelssen, J.M. DeRouchey and J.L. Ustry. 2012. Effects of porcine circo virus type 2 vaccine and increasing standardized digestible lysine:metabolizable energy ratio on growth performance and carcass composition of growing and finishing pigs. *J. Anim. Sci.* 90:361-372.
- Williams, N.H., T.S. Stahly and D.R. Zimmerman. 1997a. Effect of level of chronic immune system activation on rate, efficiency and composition of growth and lysine needs of pigs fed from 6 to 27 kg. *J. Anim. Sci.* 75:2463-2471.
- Williams, N.H., T.S. Stahly and D.R. Zimmerman. 1997b. Effect of level of chronic immune system activation on body nitrogen retention, partial efficiency of lysine utilization and lysine needs of pigs. *J. Anim. Sci.* 75:2472-2480.
- Williams, N.H., T.S. Stahly and D.R. Zimmerman. 1997c. Effect of level of chronic immune system activation on the growth and dietary lysine needs of pigs fed from 6 to 112 kg. *J. Anim. Sci.* 75:2481-2496. ■