Inclusion of non-protein nitrogen on lysine requirement for maximum nitrogen retention

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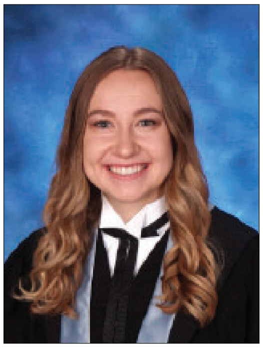

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SUMMARY

Low protein diets have improved nutrient utilization while maintaining animal performance. However, these diets may be limiting in nitrogen (N) content to meet non-essential amino acid (NEAA) requirements, potentially altering essential amino acid (EAA) utilization and requirements. Inclusion of a source of non-protein nitrogen (NPN) may be beneficial for improving EAA utilization for lean gain. An N-balance study was conducted to determine the lysine requirement for maximum nitrogen retention (NR) when pigs are fed diets without and with the inclusion of NPN in the form of ammonium phosphate (AP). Lysine and N content had an effect ($P < 0.05$) on fecal and urinary N output, digestibility, and plasma urea nitrogen (PUN), including an increase in NR and decrease in urinary N output with inclusion of NPN and increasing Lys ($P < 0.01$). A decrease in PUN was observed with increasing Lys ($P < 0.05$). The linear breakpoint model indicated NR was maximized at 1.00% SID Lys (15.6 g/d NR; $R^2 = 0.68$) in pigs fed no AP and at 1.09% SID Lys (16.4 g/d NR; $R^2 = 0.61$) in AP-fed pigs. These results indicate that diets deficient in dietary N reduce NR and Lys requirement, which were in turn increased with NPN supplementation. Future research should continue to assess the impact NPN inclusion has on low-protein diets that are limiting in NEAA-N.

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INTRODUCTION

The current practice in swine production is to feed low protein (LP) diets, amino acid supplemented diets. These diets are formulated to meet essential amino acid (EAA) requirements according to the ideal protein concept, which allows for a reduction in total dietary protein. There are several benefits to this, such as lowering diet cost and reducing nitrogen (N) excretion. While these benefits are important for industry, there are issues with LP diets. For example, animals require both EAA and non-essential amino acids (NEAA) to ensure proper growth and productivity, and LP diets assume pigs can produce sufficient levels of NEAA to meet their requirements. As the endogenous synthesis of NEAA requires N, dietary N may be a limiting factor in LP diets. When there is a decrease in dietary supply of NEAA-N, the necessary N may be sourced from the catabolism of EAA, impacting efficiency of EAA utilization for lean gain. Consequently, both EAA and NEAA, or a source of N for the synthesis of NEAA, should be provided. A practical method to optimize both EAA and NEAA sources is to consider the essential amino acid-nitrogen:total nitrogen (E:T) ratio, as this ratio gives an indication of sufficiency of both EAA and NEAA. Nitrogen retention (NR) is affected by E:T, with reduced efficiency observed at extreme ratios.

It has been previously shown that non-protein nitrogen (NPN) may be used as a direct source of N in LP diets, for the endogenous synthesis of NEAA. A positive response has been observed in swine when NPN is included in diets that are deficient in NEAA-N. Previous research demonstrated feeding ammonia-N is as effective as feeding synthetic AA or intact protein to growing pigs that are undersupplied in NEAA-N, in terms of maintaining growth performance. The objective of the present study was to determine the effect of including NPN on lysine (Lys) requirement for NR in growing pigs. It was hypothesized that the Lys requirement for NR would be increased when a source of NPN was included in a diet deficient in NEAA-N compared to an unsupplemented diet.

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EXPERIMENTAL PROCEDURES

An N-balance study was conducted to determine the lysine requirement for maximum NR when pigs are fed diets without and with the inclusion of NPN in the form of ammonium phosphate (AP). A total of 90 growing barrows with an initial body weight of 20.4 ± 0.46 kg were individually housed in metabolism crates and randomly assigned to 1 of 10 dietary treatments (n = 9 pigs/treatment) in 9 blocks in a 2 × 5 factorial design. Diets contained no ammonium phosphate (NAP; E:T of 0.36, considered to be deficient in N) or were supplemented with 1.7% ammonium phosphate (AP; E:T of 0.33) with graded levels of dietary lysine (Lys; 0.8%, 0.9%, 1.0%, 1.1% and 1.2% standardized ileal digestible [SID]), fed at 2.8 × maintenance metabolizable energy requirements in 2 equal meals each day. A 4-d N-balance collection period was conducted following a 7-d dietary adaptation period. Jugular blood samples were taken on d 2 of the collection period to measure plasma urea N (PUN).

RESULTS AND DISCUSSION

Nitrogen intake was greater in the AP-fed pigs when compared to the NAP-fed pigs and generally increased with increasing Lys content ($P < 0.01$). There was no impact of inclusion of NPN on fecal N output, but Lys content close to NRC requirements reduced fecal N output ($P < 0.05$). Urinary N output decreased and NR (g/d) increased with NPN supplementation and increasing Lys content ($P < 0.01$). Apparent total tract digestibility was greater in the pigs fed NPN ($P < 0.05$). Nitrogen retained as % of intake increased with increasing Lys content ($P < 0.01$), and was greater in NAP-fed pigs ($P < 0.05$).

Two-phase breakpoint analysis determined a Lys requirement of 1.00% SID Lys at 15.6 g/d NR in NAP-fed pigs ($R^2 = 0.68$) and 1.09% SID Lys at 16.4 g/d NR in AP-fed pigs ($R^2 = 0.61$; Figure 1). Two-phase breakpoint analysis also determined a Lys requirement of 1.00% SID Lys at 69.9% NR as % of intake in NAP-fed pigs ($R^2 = 0.64$) and 1.12% at 68.6% NR as % of intake in AP-fed pigs ($R^2 = 0.72$).

Plasma urea N tended to decrease with increasing Lys content ($P < 0.01$). The quadratic breakpoint was determined to be 1.14% SID Lys at 2.67 mg/dL in NAP-fed pigs, while the linear model analyses indicated a breakpoint of 1.12% SID Lys at 1.91 mg/dL in the AP-fed pigs.

Efficiency of Lys utilization for NR (g/d) was not impacted by NPN inclusion. Inclusion of NPN increased the marginal efficiency of utilizing SID lysine (K_{lysine}; $P < 0.01$), whereas marginal efficiency of utilizing SID N was reduced by NPN inclusion ($K_{nitrogen}$; $P < 0.0001$) for protein synthesis. These parameters were also impacted by Lys content, where $K_{nitrogen}$ was increased with Lys content and K_{lysine} was reduced at higher Lys content ($P < 0.0001$; Table 3.3).

IMPLICATIONS

These results indicate that diets deficient in dietary N reduce NR and Lys requirement. Nitrogen retention in g/d was increased with NPN supplementation, likely a result of sufficient dietary N. The higher E:T ratio diets were shown to be limiting in NEAA or N, and indicate that the E:T ratio should be considered during diet formulation as a tool to improve N utilization. Lastly, ammonia-N in the form of AP has been shown to be an acceptable form of N for the improvement of N utilization efficiency in diets lacking NEAA-N, including low protein diets. Future research should continue to assess the impact NPN inclusion has on LP diets that are limiting in NEAA-N, while considering the E:T ratio.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the Government of Saskatchewan and the Government of Canada under the Canadian Agricultural Partnership via the Agriculture Development Fund, Gowans Feed Consulting, Mitacs and CJ Bio America. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

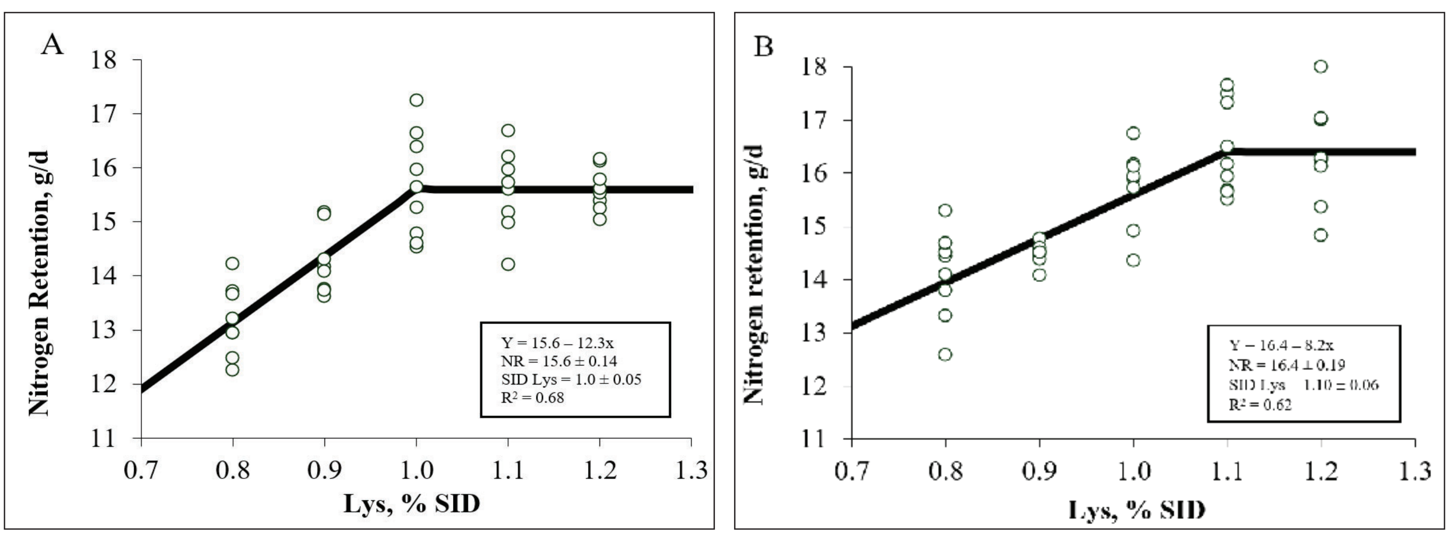

Figure 1. The two-phase breakpoint analyses estimates for nitrogen retention (NR; g/d) in pigs fed no ammonium phosphate (NAP; A) and ammonium phosphate (AP; B). The analyses indicated a breakpoint of 1.00% with maximum NR at 15.6 g/d in pigs fed the NAP diet. A breakpoint of 1.09% with maximum NR at 16.4 g/d was achieved in pigs fed the AP diet.