Non-essential amino acids affect nitrogen retention in pigs

C.M. Camiré[1,2], M.O. Wellington[3], J.C. Panisson[1], L.A. Rodrigues[1,2], A.K. Shoveller[4], D.A. Columbus[1,2]

Carley Camiré

Dan Columbus

SUMMARY

Low-protein diets supplemented with essential amino acids (EAA) can improve growth and performance. However, the dietary amount of non-essential amino acids (NEAA) may be a limiting factor in these diets. This may ultimately affect the efficient utilization of the dietary EAA for maximum nitrogen (N) retention and growth. Appropriate quantities of EAA and total N may be provided using the EAA-N to total N ratio (E:T). The present study showed that, generally, N retention increased linearly with increasing dietary lysine (Lys), but N retention was higher in the low E:T group. A higher Lys requirement was observed in the low E:T group compared to the high E:T fed group, contrary to the study hypothesis. The results from the present study indicate that NEAA or N becomes limiting in high E:T diets but not in low E:T diets, and more EAA are required in low E:T diets to maximize N retention. In conclusion, the E:T ratio should be an important consideration in formulating low-protein diets for pigs to ensure optimal and efficient utilization of the EAA provided in the diet.

INTRODUCTION

Reducing nitrogen (N) excretion in pig production is important for sustainable animal agriculture and swine production. The use of low protein diets supplemented with essential amino acids (EAA) has been used as a concept to improve feed efficiency while reducing N excretion and maintaining growth performance. However, the total amount of N in the diet is important to maintain optimal performance. Low protein diets generally have reduced amounts of non-essential amino acids (NEAA). In general, NEAA requirements have not been considered in diet formulations as it has been assumed that pigs can synthesize enough NEAA to meet their needs. However, a source of N is required for the endogenous synthesis of NEAA, and EAA may be used to provide N in N-deficient low-protein diets. This would reduce EAA availability and utilization efficiency for N retention and may result in increased EAA requirements in low-protein diets.

"Non-essential amino acid requirements have not been considered in diet formulation as it has been assumed that pigs can synthesize enough to meet their needs. "

The ideal protein concept focuses on meeting the EAA requirements of the pig, with little consideration given to NEAA requirements, even though they supply almost half of the total dietary N required. Consequently, the ratio between EAA-N and total N (E:T) has been suggested to depict the relationship between EAA and NEAA on an N basis. The ratio considers the appropriate amount of N coming from both EAA and NEAA sources, which may have implications on the efficiency of using EAA for N retention. It has been reported that there should be a minimum amount of NEAA supplemented in diets to improve N retention. An optimum E:T ratio of 0.48 for achieving maximum N retention was previously determined in pigs. While a number of studies have examined this ratio, there has been a lack of consistency in how this ratio has been calculated. Various factors can impact the E:T value calculation, such as total EAA, including excess above requirement, the selection of AA considered EAA and which sources of N (i.e., AA or non-protein N) are included in the NEAA-N fraction. In previous research the total N fraction only included N from NEAA and excess EAA. More recent advances in our understanding of N have shown that non-protein N can contribute to both EAA and NEAA supply in the pig and non-protein N can be used as efficiently as NEAA supplementation in NEAA-deficient diets. Thus, in the present study, we calculated the E:T ratio as the amount of EAA-N as the SID fraction up to the recommended requirement (NRC, 2012) and total dietary N as indicated by crude protein content. Consequently, our ratio represents the amount of balanced EAA (including Arg) available for protein synthesis and the total amount of N available for the synthesis of NEAA.

The objective of the present study was to determine the effect of the E:T ratio on lysine (Lys) requirement in growing pigs for maximum N retention. We hypothesized that the Lys requirement would be higher in pigs fed a diet with a high E:T ratio compared to those fed a lower ratio.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9
2 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8
3 Trouw Nutrition Innovation R&D, Veerstraat 38, 5831JN, Boxmeer, Netherlands
4 Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, N1G 1Y2

EXPERIMENTAL PROCEDURES

An N-balance study was conducted at the Prairie Swine Centre to determine the lysine (Lys) requirement for maximum nitrogen retention when pigs are fed diets with a low (0.33) or high (0.36) E:T ratio. A total of 80 growing barrows (21.5 kg initial BW; SD = 0.89 kg), individually housed in metabolism crates, were randomly assigned to 1 of 10 dietary treatments (n = 8) in 8 blocks in a 2 × 5 factorial arrangement. Diets consisted of a low ratio (LR; 16.8% crude protein; E:T of 0.33) or a high ratio (HR; 15.5% crude protein; E:T of 0.36) with graded levels of Lys (0.82%, 0.92%, 1.02%, 1.12%, and 1.22% standardized ileal digestible [SID]) fed at 2.8 × maintenance metabolizable energy requirements. Ratios were formulated to be deficient in dietary N (HR) or to contain supplemental N as intact protein (LR). After a 7-d dietary adaptation, a 4-d N-balance collection was conducted. Blood samples were obtained on d2 of the collection period for plasma urea nitrogen (PUN) analysis.

RESULTS AND DISCUSSION

Nitrogen intake was greater in the LR-fed pigs than in the HR-fed pigs, whereas N intake generally increased with increasing dietary Lys content ($P < 0.05$). The apparent total tract digestibility (ATTD) of N was higher in the HR-fed pigs compared to the LR-fed pigs (83.1 vs 81.6 %; $P < 0.01$) but was not affected by dietary Lys. Fecal and urinary N output were lower in pigs fed the HR diets ($P < 0.01$), and urinary N output was decreased with increasing Lys content ($P < 0.01$).

Nitrogen retention increased linearly, and PUN decreased with increasing Lys ($P < 0.01$). A significant interaction between ratio and Lys ($P < 0.01$) was observed for N retention ($P = 0.01$). The linear broken-line breakpoint model estimated SID Lys required to maximize N retention of pigs fed HR diets at 1.08% ($R2 = 0.61$) at maximum N retention of 17.8 g/d (Figure 1A) and LR diets at 1.21% SID Lys ($R2 = 0.80$) at maximum N retention of 19.3 g/d (Figure 1B). We also determined Lys requirement to minimize PUN concentration. The estimated Lys requirement was 1.12% SID Lys in the HR-fed pigs ($R2 = 0.14$) at 6.37 mg/dL PUN. In the LR-fed pigs an estimated Lys requirement was observed at 1.17% SID Lys ($R2 = 0.23$) at 4.03 mg/dL PUN.

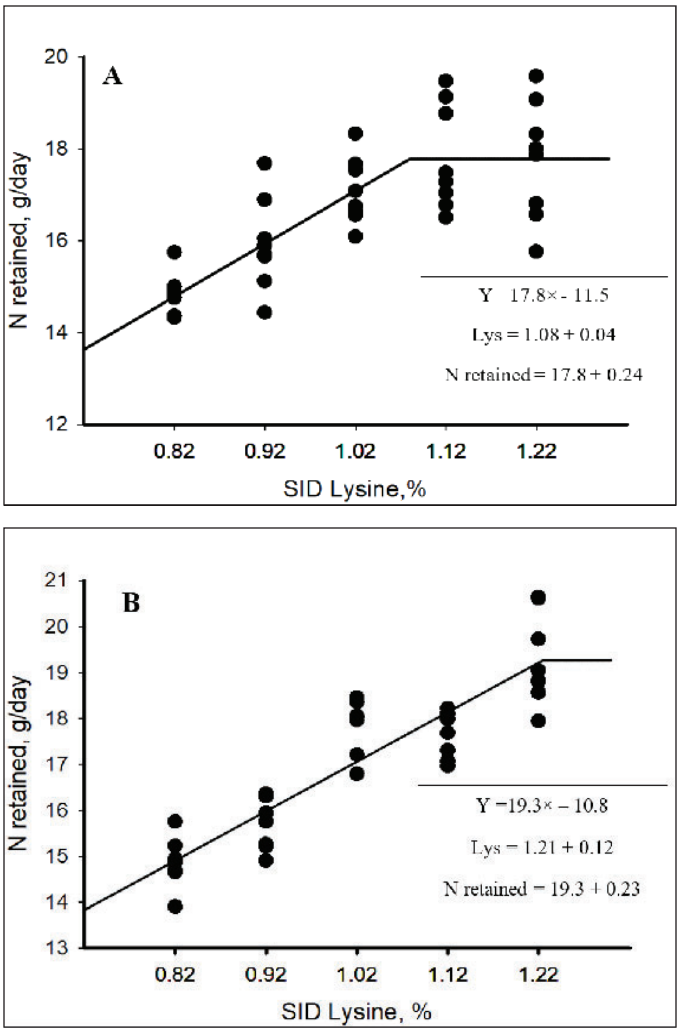

Figure 1. The linear broken-line model analyses estimate of nitrogen retention (NR; g/d) in pigs fed high essential amino acid-nitrogen: total nitrogen ratio (HR; 0.36; A) or low ratio (LR; 0.33; B) diets. The analyses indicate a breakpoint was achieved at 1.08 SID Lys, % at maximum NR at 17.8 g/d for pigs fed the HR diets (Fig 1A). The breakpoint was achieved in pigs fed the LR diet at 1.21 SID Lys, % at maximum NR 19.3 g/d (Fig.1B).

IMPLICATIONS

The Lys requirement was demonstrated to be higher than current NRC (2012) requirements for both LR-and-HR-fed pigs and greater in LR vs. HR diets. The results from the present study indicate that NEAA or N is limiting in HR diets and supplementation with N as intact protein (LR diets) improves N retention, resulting in greater Lys to maximize N retention. In conclusion, the E:T ratio should be considered in formulating diets for pigs to ensure optimal and efficient utilization of the EAA provided in the diet.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the Government of Saskatchewan and Government of Saskatchewan under the Canadian Agricultural Partnership via the Agriculture Development Fund and CJ Bio. 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.