Swine Feed Efficiency: Influence of Amino Acids

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Introduction

Amino acids are the building blocks for protein deposition (lean muscle), important in physiological functions that influence endocrinology and gene expression, and are utilized as an expensive energy source when energy is limited or excess amino acids are present. Feed efficiency is optimized when dietary amino acids are balanced accounting for the pigs feed intake (energy consumption) and protein deposition rate (lean gain).

Rate of protein deposition is the main determinant of dietary amino acid requirements of growing pigs and is closely associated with feed efficiency and carcass quality. The requirement of dietary amino acids for protein deposition is influenced by digestion, absorption and post-absorptive metabolism; biological processes unique within a pig (health status, genotype, physiological state) and the environment of the pig (temperature, diet composition, physical environment). Thus, the optimum dietary amino acid level will vary among pigs and groups of pigs. Therefore, the relationships between amino acid intake, protein deposition, and pig growth must be considered when adjusting feeding programs within an operation.

Research Highlights for Amino Acids

Protein deposition (PD) is considered more objective and universally measured more than lean tissue growth, and may be used to characterize growth rates and growth potentials of pigs. According to NRC (2012), the typical mean PD for barrow and gilts between 55 and 275 lb body weight is approximately 0.297 lb/day (135 g/d).

A 10% increase in mean PD represents an improvement in feed efficiency of approximately 5.5% and an increase in estimated carcass lean yield of just over 3% (Table 1). These estimates assume that energy intake is constant. The data illustrates the importance of improving the genetic capacity of pig for protein deposition and of optimizing environmental conditions and feeding programs to allow the expression of that genetic potential.

Table 1. Estimated effect of a 10% improvement in whole body protein deposition on growth and carcass characteristics for pigs between 55 and 275 pounds of body weight.

Mean PD lb/day	0.297	0.327
Metabolizable Energy Intake, kcal/day	7,231	7,239
Feed Intake, lb/day	5.09	5.09
ADG, lb/day	1.89	2.00
Lipid Deposition, lb/day	0.58	0.55
F/G	2.69	2.54
Back Fat Probe, in.	0.75	0.66
Carcass Lean Content, %	49.0	50.6

Estimated based on the partitioning of energy intake for growth and prediction of carcass characteristics as outlined in NRC (2012).

Feed efficiency is compromised when amino acids are fed below or above biological requirements. For example, in 130 to 190 lb growing gilts (Table 2), 2.8 g lysine/Mcal ME was found to optimize both F/G and income over feed cost. Feed efficiency was 3 to 5% worse when feeding lower or higher lysine diets. In 220 to 270 lb finishing gilts (Table 3) 2.2 g lysine/Mcal ME optimized F/G and income over marginal feed cost. With these heavier gilts, F/G was 8.5 to 20% worse as the lysine level decreased in the diet.

Table 2. Effect of Lysine: Calorie Ratio on 130 to 190 Pound Gilts

	Lysine: Calorie (g lysine/Mcal ME)						
	1.96	2.24	2.52	2.80	3.08	3.36	
	SID Lysine, %						**Probability**
Item	0.61	0.70	0.79	0.88	0.98	1.07	**Linear (P<)**
Initial Wt, lb	132.1	131.4	131.7	131.3	131.8	131.9	0.89
ADG, lb	2.02	2.07	2.12	2.15	2.10	2.06	0.09
ADFI, lb	5.09	5.09	5.21	5.12	5.24	5.10	0.32
F/G	2.52	2.48	2.46	2.39	2.50	2.47	0.27
Off-test Wt, lb	188.1	189.4	190.9	191.8	190.3	189.4	0.0001

Total of 1163 gilts housed with 27-28 pigs/pen and 7 replications per treatment in 28-day trial. Main et al, 2002.

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Table 3. Effect of Lysine: Calorie Ratio on 220 to 270 Pound Gilts

	Lysine: Calorie (g lysine/Mcal ME)						
	1.4	1.6	1.8	2.0	2.2	2.4	
	SID Lysine, %						Probability
Item	0.43	0.50	0.56	0.63	0.69	0.76	Linear (P<)
Initial Wt, lb	221.6	221.5	222.4	222.2	222.2	221.8	0.73
ADG, lb	1.59	1.60	1.69	1.95	1.94	1.94	0.0001
ADFI, lb	5.36	5.26	5.14	5.29	5.45	5.43	0.15
F/G	3.37	3.32	3.05	2.87	2.81	2.81	0.0001
Off-test wt, lb	262.2	262.3	264.5	268.4	270.8	270.8	0.0001

Total of 1021 gilts housed with 21-25 pigs/pen and 7 replications per treatment in 25-day trial. Main et al, 2002.

The lower magnitude of the response on F/G of the lighter gilts is supported by other research. At lower body weights, protein deposition is generally not determined by the pig's genetic capacity for protein deposition, but by the intake of energy. The differences in PD and feed intake curves between genders provide the basis for developing spilt-sex feeding programs. The magnitude of the gender effect on PD curves varies among genetic lines of pigs.

Amino acids are required for maintenance and protein deposition. Endogenous gut amino acid losses, integument amino acid loss, and amino acid catabolism are main contributors to maintenance requirements. The inefficiency of utilizing available amino acid intake over and above maintenance amino acid requirements for amino acid retention in PD can be attributed to inevitable amino acid breakdown. NRC (2012) does acknowledge that amino acid maintenance requirements increase with body weight; however, slightly decrease with increased rates of protein deposition.

Feeding Programs

NRC (2012) suggested amino acid requirements are higher than NRC (1998) to reflect increases in PD and reductions in feed intake with modern genetics. Phase-feeding is used to accommodate the continuous changes in amino acid requirements of growing pigs. When feeding a diet over a given weight range, a period of amino acids fed below the requirement (potential compromise of performance) will transition to a period of feeding amino acids above the requirement (potential cost and increased N excretion). Having a number of phases (diets) can reduce the periods of being grossly above and below the requirement. Research has documented that pigs can have compensatory growth if adequate amino acid levels are provided subsequent to the deficiency period. Thus, shortages of amino acids during early periods may not influence overall feed efficiency. It is hypothesized that compensatory gain is most likely to occur during the energy intake dependent phase of PD (up to approximately 150 lb). Results indicate that the amino acid requirements per lb of PD are not altered during compensatory growth. This compensatory gain concept may be used to reduce the number of diet phases, reduce overall feed costs, and, potentially, improve pig health (by not providing high protein diets immediately after weaning).

Pratical Applications

To estimate amino acid requirements at different stages of growth, information is required about the pattern of feed intake and whole body protein deposition (PD). Protein deposition can be estimated from energy intake above maintenance energy requirements and live body weight gain. Establishing a feed budget and documenting the actual days between phases becomes a tool to monitor the growth and feed disappearance curves for a group. Efficiency is greatest when dietary amino acids are balanced to account for the pigs feed intake (energy consumption) and protein deposition rate (lean gain).

References

De Lange, C.F.M, C.L. Levesque, and B.J. Kerr. 2012. Amino acid nutrition and feed efficiency. p. 81-100 in: Feed Efficiency in Swine. Wagen ingen Academic

Main, R.G., S.S. Dritz, M.D. Tokach, R.D. Goodband, and J.L. Nelssen. 2008. Determining an optimum lysine:calorie ratio for barrows and gilts in a commercial finishing facility J. Anim Sci. 86: 2190-2207.

NRC. 2012. Nutrient Requirements of Swine. 11th rev. ed. Natl. Acad. Press, Washington, DC