12-2012

Improved nutrient digestibility and retention partially explains feed efficiency gains in pigs selected for low residual feed intake

A. J. Harris
Iowa State University

John F. Patience
Iowa State University, jfp@iastate.edu

Steven M. Lonergan
Iowa State University, slonerga@iastate.edu

Jack C. M. Dekkers
Iowa State University, jdekkers@iastate.edu

Nicholas K. Gabler
Iowa State University, ngabler@iastate.edu

Improved nutrient digestibility and retention partially explains feed efficiency gains in pigs selected for low residual feed intake

Abstract

Residual feed intake (RFI) is a unique measure of feed efficiency (FE) and an alternative to traditional measures. The RFI is defined as the difference between the actual feed intake of a pig and its expected feed intake based on a given amount of growth and backfat. Therefore, selecting pigs with a low RFI (LRFI) results in a more feed-efficient animal for a given rate of growth. Our objective was to determine the extent to which apparent total tract digestibility of nutrients and energy use and retention may explain FE differences between pigs divergently selected for LRFI or high RFI (HRFI). After 7 generations of selection, 12 HRFI and 12 LRFI pigs (62 ± 3 kg BW) were randomly assigned to metabolism crates. Pigs had free access to a standard diet based on corn (*Zea mays*) and soybean (*Glycine max*) meal containing 0.4% TiO_2, an exogenous digestibility marker. After a 7-d acclimation, total urine and feces were collected for 72 h. Nutrient and energy digestibility, P digestibility, and N balance were then measured and calculated to determine differences between the RFI lines. As expected, ADFI was lower (2.0 vs. 2.6 kg; $P < 0.01$), ADG did not differ, and FE was higher in the LRFI ($P < 0.001$) compared to the HRFI pigs. The digestibility values for DM (87.3 vs. 85.9%), N (88.3 vs. 86.1%), and GE (86.9 vs. 85.4%) were higher ($P \leq 0.003$) in the LRFI vs. HRFI pigs, respectively. The DE (16.59 vs. 16.32 MJ/kg DM) and ME (15.98 vs. 15.72 MJ/kg DM) values were also greater ($P < 0.001$) in LRFI pigs. When correcting for ADFI, P digestibility did not differ between the lines. However, the LRFI pigs tended to have improved N retention ($P = 0.08$) compared to HRFI pigs (36.9 vs. 32.1 g/d). In conclusion, the higher energy and nutrient digestibility, use, and retention may partially explain the superior FE seen in pigs selected for LRFI.

Keywords

Swine Feed Efficiency, feed efficiency, nutrient digestibility, pig, residual feed intake

Disciplines

Agriculture | Animal Sciences | Meat Science

Comments

This article is from *Journal of Animal Science* 91 (2012): 164–166, doi:10.2527/jas.53855.

JOURNAL OF ANIMAL SCIENCE
The Premier Journal and Leading Source of New Knowledge and Perspective in Animal Science

Improved nutrient digestibility and retention partially explains feed efficiency gains in pigs selected for low residual feed intake

A. J. Harris, J. F. Patience, S. M. Lonergan, C. J.M. Dekkers and N. K. Gabler

J ANIM SCI 2012, 90:164-166.
doi: 10.2527/jas.53855

Improved nutrient digestibility and retention partially explains feed efficiency gains in pigs selected for low residual feed intake[1]

A. J. Harris, J. F. Patience, S. M. Lonergan, J. C. M. Dekkers, and N. K. Gabler[2]

Department of Animal Science, Iowa State University, Ames, IA 50011

ABSTRACT: Residual feed intake (RFI) is a unique measure of feed efficiency (FE) and an alternative to traditional measures. The RFI is defined as the difference between the actual feed intake of a pig and its expected feed intake based on a given amount of growth and backfat. Therefore, selecting pigs with a low RFI (LRFI) results in a more feed-efficient animal for a given rate of growth. Our objective was to determine the extent to which apparent total tract digestibility of nutrients and energy use and retention may explain FE differences between pigs divergently selected for LRFI or high RFI (HRFI). After 7 generations of selection, 12 HRFI and 12 LRFI pigs (62 ± 3 kg BW) were randomly assigned to metabolism crates. Pigs had free access to a standard diet based on corn (*Zea mays*) and soybean (*Glycine max*) meal containing 0.4% TiO_2, an exogenous digestibility marker. After a 7-d acclimation, total urine and feces were collected for 72 h. Nutrient and energy digestibility, P digestibility, and N balance were then measured and calculated to determine differences between the RFI lines. As expected, ADFI was lower (2.0 vs. 2.6 kg; $P < 0.01$), ADG did not differ, and FE was higher in the LRFI ($P < 0.001$) compared to the HRFI pigs. The digestibility values for DM (87.3 vs. 85.9%), N (88.3 vs. 86.1%), and GE (86.9 vs. 85.4%) were higher ($P \leq 0.003$) in the LRFI vs. HRFI pigs, respectively. The DE (16.59 vs. 16.32 MJ/kg DM) and ME (15.98 vs. 15.72 MJ/kg DM) values were also greater ($P < 0.001$) in LRFI pigs. When correcting for ADFI, P digestibility did not differ between the lines. However, the LRFI pigs tended to have improved N retention ($P = 0.08$) compared to HRFI pigs (36.9 vs. 32.1 g/d). In conclusion, the higher energy and nutrient digestibility, use, and retention may partially explain the superior FE seen in pigs selected for LRFI.

Key words: feed efficiency, nutrient digestibility, pig, residual feed intake

J. Anim. Sci. 2012.90:164–166
doi:10.2527/jas53855

INTRODUCTION

Improving feed efficiency (**FE**) is a major objective in swine production due to the rising costs of feed and the need to enhance overall production efficiency and profitability. Genetic selection to reduce residual feed intake (**RFI**) is 1 way that producers can improve FE in their livestock (Koch et al., 1963; Cai et al., 2008). However, the main biological factors that contribute to differences in RFI have only been partially quantified in poultry (Luiting, 1990), pigs (Barea et al., 2010), and beef cattle (Herd and Arthur, 2009). These key factors include physical activity, feed intake patterns and behavior, stress, body composition, nutrient digestibility, protein turnover, and metabolism. According to Herd and Arthur (2009), nutrient digestibility in beef cattle may account for 10% of the variation associated with RFI index. Interestingly, Barea et al. (2010) found that efficiency of digestibility was not affected by selection for low RFI (**LRFI**) in Large White pigs. Therefore, our objective was to determine the extent to which nutrient digestibility and energy use explain FE differences in Yorkshire finisher pigs divergently selected for LRFI or high RFI (**HRFI**). We hypothesized that pigs selected for LRFI would have increased nutrient digestibility and retention, in particular for N, relative to the HRFI line.

MATERIALS AND METHODS

All animal procedures were approved by the Animal Care and Use Committee of Iowa State University (**ISU**). Twelve HRFI and 12 LRFI pigs from the 7th

[1]This research was supported by the Iowa Pork Producers Association and the Agriculture and Food Research Initiative Competitive Grant 2010-65206-20670 from the USDA National Institute of Food and Agriculture.

[2]Corresponding author: ngabler@iastate.edu

generation of the ISU RFI selection project, matched by age and live weight (62 ± 3 kg BW), were selected and placed into randomly assigned individual metabolism crates. Backfat and loin eye area were measured using ultrasound. Pigs had free access to a standard diet based on corn and soybean meal containing 0.4% TiO_2 (an exogenous digestibility marker) that was formulated to meet or exceed the nutrient requirements for this size of pig (NRC, 1998). The analyzed chemical composition of the diet was 17.21% CP, 4.34% ash, 5.58% ether extract (**EE**), 0.73% P, and 17.38 kJ/kg GE. Pigs had free access to water and were fed this diet for 3 wk. Thereafter, total urine and feces were collected for 72 h and daily feed intake was recorded. Nutrient and energy digestibility and N and P balance were measured and calculated to determine differences between the RFI lines as previously described (Htoo et al., 2008). Data was analyzed using the Mixed procedure of SAS (SAS Institute, Cary, NC). The N and P balance data were adjusted for a similar energy intake as a covariate. Differences were considered significant at P < 0.05 and a tendency at 0.05 < *P* < 0.10.

Table 1. Effects of divergent selection for residual feed intake on nutrient and energy digestibility and N and P balance in gilts (62 ± 3 kg BW)

Item	LRFI[1]	HRFI[1]	*P*-value
Digestibility, %			
DM	87.3 ± 0.25	85.9 ± 0.25	<0.001
N	88.3 ± 0.47	86.1 ± 0.47	0.003
P	65.0 ± 1.10	62.4 ± 1.10	0.12
GE	86.9 ± 0.25	85.4 ± 0.25	<0.001
Ether extract	64.7 ± 0.57	64.2 ± 0.57	0.56
Ash	65.7 ± 0.53	67.1 ± 0.53	0.08
Energy values, MJ/kg of DM			
DE	16.59 ± 0.048	16.32 ± 0.048	<0.001
ME	15.98 ± 0.046	15.72 ± 0.046	<0.001
N balance, g/d[2]			
Intake	63.00 ± 0.001	63.00 ± 0.001	0.57
Absorbed	55.40 ± 0.407	54.27 ± 0.407	0.12
Retained	36.91 ± 1.533	32.12 ± 1.533	0.08
P balance, g/d[2]			
Intake	16.62 ± 0.001	16.62 ± 0.001	0.30
Absorbed	10.73 ± 0.289	10.38 ± 0.289	0.49
Retained	9.43 ± 0.236	8.92 ± 0.236	0.21

[1]LRFI = low residual feed intake, n = 12; HRFI = high residual feed intake, n = 12.

[2]Adjusted for ADFI.

RESULTS AND DISCUSSION

In previous generations of pigs selected based on RFI, pigs from our LRFI line consistently have reduced carcass fat, consume less feed, and exhibit similar rates of gain to the HRFI line (Cai et al., 2008; Boddicker et al., 2011). As expected, our selection lines differed in ADFI [2.6 vs. 2.0 kg ($P < 0.001$) for HRFI vs. LRFI, respectively] while maintaining similar ADG. Therefore, FE was 35% higher ($P < 0.001$) in LRFI compared to HRFI pigs (0.46 vs. 0.34, respectively).

Digestion of nutrients and energy may explain a major portion of the genetic variation associated with FE and RFI in cattle (Herd and Arthur, 2009). In our study, divergent selection for RFI in pigs alters nutrient and energy digestibility and N and P balance (Table 1). We observed greater ($P < 0.01$) digestibility values for DM, N, and GE in our LRFI compared to the HRFI gilts. Additionally, there was a tendency ($P = 0.08$) for ash digestibility to be lower in the LRFI verses the HRFI line. The EE and P digestibility values were not affected ($P > 0.05$) by line. The DE and ME values were also augmented in the LRFI pigs vs. HRFI, respectively ($P < 0.001$). Even when adjusting for ADFI, the DE and ME values were still higher ($P \leq 0.05$) in the LRFI line. Furthermore, the LRFI pigs also tended to have improved ($P = 0.08$) N retention compared to the HRFI after ADFI correction. Phosphorus retention was not affected by line.

The effect of pig genotype on apparent total tract nutrient digestibility of nutrients and energy is widely reported in the literature but normally not in the context of FE. Interestingly, our data are contradictory to those reported from a similar RFI pigs selection project (Barea et al., 2010). The pigs used in the similar RFI selection project were of similar weight but selected for LRFI and HRFI in a pure Large White line. Digestibility values for OM, DM, N, P, and energy and DE and ME values were not altered in the lines due to their divergent selection. However, Barea et al. (2010) reported that their HRFI line tended to have higher N intake and absorption and N and P retention vs. the LRFI line. Instead, our LRFI line tended to have higher N retention, after adjusting for ADFI, compared to our HRFI line without difference in P retention.

Pigs with higher lean tissue accretion and FE may better use dietary nutrients and energy (Rivera-Ferre et al., 2006; Barea et al., 2011). Rivera-Ferre et al. (2006) suggested that the difference in N digestibility and retention is a result of the leaner, faster growing genotype pigs having a greater capacity for protein synthesis and deposition than indigenous-type breeds. Furthermore, these higher protein deposition genotypes are associated with a lower rate of digesta passage and greater nutrient and energy digestibility (Varel et al., 1988). Although we did not measure digesta passage rates in our RFI lines, it is possible that having an increased activity of microflora and digestive enzymes in the gastrointestinal tract coupled with a higher retention time in the hindgut may contribute to the increased nutrient digestibility and absorption.

In conclusion, these data indicate that the variation in RFI reflects differences in nutrient digestibility and energy use. Therefore, along with other postabsorptive metabolism differences, digestive function and capacity may partially explain FE gains by selecting for LRFI. These pigs use nutrients and energy more efficiently for metabolic functions and maintenance to support similar rates of growth.

LITERATURE CITED

Barea, R., S. Dubois, H. Gilbert, P. Sellier, J. van Milgen, and J. Noblet. 2010. Energy utilization in pigs selected for high and low residual feed intake. J. Anim. Sci. 88:2062–2072.

Barea, R., R. Nieto, F. Vitari, C. Domeneghini, and J. F. Aguilera. 2011. Effects of pig genotype (Iberian v. Landrace × Large White) on nutrient digestibility, relative organ weight and small intestine structure at two stages of growth. Animal 5:547–557.

Boddicker, N., N. K. Gabler, M. E. Spurlock, D. Nettleton, and J. C. Dekkers. 2011. Effects of ad libitum and restricted feed intake on growth performance and body composition of Yorkshire pigs selected for reduced residual feed intake. J. Anim. Sci. 89:40–51.

Cai, W., D. S. Casey, and J. C. Dekkers. 2008. Selection response and genetic parameters for residual feed intake in Yorkshire swine. J. Anim. Sci. 86:287–298.

Herd, R. M., and P. F. Arthur. 2009. Physiological basis for residual feed intake. J. Anim. Sci. 87:E64–E71.

Htoo, J. K., X. Meng, J. F. Patience, M. E. Dugan, and R. T. Zijlstra. 2008. Effects of coextrusion of flaxseed and field pea on the digestibility of energy, ether extract, fatty acids, protein, and amino acids in grower-finisher pigs. J. Anim. Sci. 86:2942–2951.

Koch, R. M., K. E. Gregory, D. Chambers, and L. A. Swiger. 1963. Efficiency of feed use in beef cattle. J. Anim. Sci. 22:486–494.

Luiting, P. 1990. Genetic-variation of energy partitioning in laying hens – Causes of variation in residual feed consumption. Worlds Poult. Sci. J. 46:133–152.

National Research Council (NRC). 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Rivera-Ferre, M. G., J. F. Aguilera, and R. Nieto. 2006. Differences in whole-body protein turnover between Iberian and Landrace pigs fed adequate or lysine-deficient diets. J. Anim. Sci. 84:3346–3355.

Varel, V. H., H. G. Jung, and W. G. Pond. 1988. Effects of dietary fiber of young-adult genetically lean, obese and contemporary pigs: Rate of passage, digestibility and microbiological data. J. Anim. Sci. 66:707–712.