Effect of a Low Energy, High Fiber Diet Challenge on Yorkshire Pigs Selected for Residual Feed Intake

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ABSTRACT: Purebred Yorkshire pigs from generations 8 and 9 (n=334) of the Iowa State residual feed intake (RFI) lines, selected for low and high RFI under a standard high energy and low fiber diet, were challenged with a low energy and high fiber diet. In two replicates, littermate gilts and barrows from each line were randomly split between diets and grown from ~40 to ~118 kg with individual feed intake recorded. Performance traits of average daily feed intake, average daily gain, gain to feed ratio, RFI, BF and LMA were evaluated. Results suggested that response to genetic selection for RFI under a high energy, low fiber diet may not translate into similar improvements in feed efficiency under a low energy, high fiber diet.

Keywords: Residual feed intake; Yorkshire pigs; Feed efficiency

Introduction

Feed costs remain the highest variable expense for swine producers, accounting for more than 70% of production costs in the U.S. (National Pork Board (2012)). Therefore, producers remain interested in selection for increased feed efficiency. Additionally, alternative feed stuffs provide an opportunity for producers to decrease feed costs. However, some alternative feed stuffs have low energy and high fiber content, and if fed at high inclusion rates can reduce performance. Conflicting results have been found about the effect of genetics on dietary fiber utilization (Yen et al. (2004) and Kemp et al. (1991)). Therefore, the objective of this study was to determine if pigs selected for increased feed efficiency on a high energy, low fiber diet would maintain their feed efficiency advantage when challenged with a low energy, high fiber diet.

Materials and Methods

Overview. This study focused on the utilization of unique selection lines of purebred Yorkshire pigs that were derived from a common base at Iowa State University (ISU). In this selection experiment, one line was selected for decreased residual feed intake for 9 generations and the other for increased residual feed intake for generations 5 through 9 (Cai et al. (2008) and Young and Dekkers (2012)). Residual feed intake (RFI), a measure of feed efficiency, is defined as the difference between an animal’s observed and expected feed intake based on growth, maintenance, and backfat. The ISU RFI lines were selected under a traditional high energy, low fiber (HELF) corn and soybean meal-based diet. In generations 8 and 9, pigs from the low RFI (LRFI; more efficient) and high RFI (HRFI; less efficient) lines were challenged with a low energy, high fiber (LEHF) diet.

Experimental Design. The second parities of generations 8 (G8; n=168) and 9 (G9; n=166) of the ISU RFI lines were utilized in a 2x2x2 factorial treatment design of line (LRFI vs. HRFI), diet (HELF vs. LEHF), and sex (gilts vs. barrows) in order to evaluate the performance of pigs on a LEHF diet. Treatment sample sizes were approximately 20 pigs in both generations.

Diets. The standard corn and soybean meal-based HELF diet contained 3.32 Mcal of metabolizable energy (ME) per kg of feed and 9.4% neutral detergent fiber (NDF), while the LEHF challenge diet contained 2.87 Mcal ME/kg feed and 25.9% NDF. To reduce dust observed from the LEHF diet in G8, 1% corn was replaced by oil on an ad fed basis in both diets in G9. Overall, the LEHF diet had ~12% less ME and ~150% more fiber than the HELF diet, resulting in a severe dietary challenge.

Trait Recording. In both generations (G8 and G9), littermate gilts and barrows from the LRFI and HRFI lines were split between the LEHF and HELF diets into 12 pens equipped with single-space electronic feeders (FIRE®, Osborne Industries Inc. Osborne, KS, USA). They were then grown from ~40 to ~118 kg, with a one week acclimation period prior to the on-test date. During the test period, individual feed intake was recorded with FIRE® equipment. Weights were also recorded every two weeks throughout the test period and utilized to establish a growth curve for each pig, as described by Cai et al. (2008). In G8 and G9, pigs were off-tested in three and two groups, respectively, when they reached ~118 kg or more, and ultrasound scans of 10th rib backfat (BF) depth and loin muscle area (LMA) were taken using an Aloka 500V SSD (Corometrics Medical Systems Inc., Wallingford, CT, USA). Based on those data, the following six performance traits were evaluated: average daily gain (ADG), average daily feed intake (ADFI), gain to feed ratio (G:F), RFI, BF and LMA.

Statistical Model. Statistical analyses were run in SAS (SAS Inst. Inc., Cary, NC, USA) using the Mixed procedure. The model for each trait included the fixed effects of generation, line, diet, sex and the interaction of line and diet. Other significant (P<0.10) interactions of fixed effects were included as appropriate for each trait. For ADG, ADFI, G:F, and RFI, on-test age was included as a covariate, while off-test weight was the covariate for the BF and LMA analyses. Interactions of covariates with line and diet were
retained in the model if they were significant (P<0.10). Random effects of pen and litter nested within generation were also included in the model for each performance trait.

Differences in RFI were evaluated by analyzing ADFI using the model for ADFI described above but with the addition of the following covariates to model the expected ADFI: ADG, BF, metabolic mid-test weight, off-test weight, and on-test age. All of these covariates were fit as interactions with diet to allow for differences in energy content and other properties of the two diets.

Results

Average Daily Gain. ADG was found to be similar between the RFI lines fed the HELF diet (P=0.55) and also when fed the LEHF diet (P=0.14; Figure 1). ADG was lower for both RFI lines when pigs were fed the LEHF compared to the HELF diet (P<0.0001).

Average Daily Feed Intake. In G8, ADFI was lower for the LRFI line than for the HRFI when fed the HELF diet (P<0.0001; Figure 2). This trend was also seen in G9 (P=0.09). These line differences in ADFI were also present under the LEHF diet but line differences were significant only in G9 (P=0.04). In G8, ADFI on the LEHF diet tended to be lower than on the HELF diet, but the differences were not significant (P=0.12). Across lines, ADFI on the LEHF diet was similar to ADFI under the HELF diet in G8 (P=0.32) but was higher in G9 (P=0.01).

Gain to Feed Ratio. In both generations, G:F was higher in the LRFI line than in the HRFI line when pigs were fed the HELF diet (P<0.0007; Figure 3). When challenged with the LEHF diet, the LRFI still had numerically higher G:F than the HRFI line but differences were not significant (G8: P=0.60, G9: P=0.21). Across lines, G:F was lower for the LEHF diet than for the HELF diet (P<0.05).

Backfat. The LRFI line had lower BF than the HRFI line when fed the HELF diet (G8: P=0.0003, G9: P=0.09; Figure 4). The same trend was seen with the LEHF diet (G8: P=0.11, G9: P=0.01). Across lines, the LEHF diet resulted in lower BF than the HELF diet (P<0.05). However, the magnitude of the diet effect on BF was greater in G8 than in G9 for the HRFI line but not for the LRFI line.

Loin Muscle Area. LMA was significantly greater on the LEHF diet than on the HELF diet in G8 (P<0.0001; Figure 5) but lower in G9, although not significantly (P=0.26). In G8, LMA was significantly higher in the LRFI line than in the HRFI line on both diets (P<0.03). In G9, line had no significant effect on LMA when fed either diet (P=0.05), although LMA was numerically greater in the LRFI line.

Residual Feed Intake. Due to the way ADFI was adjusted for expected ADFI to get at RFI, with separate covariates by diet, LS means for adjusted ADFI were not comparable across diets. However, because covariates within a diet were the same for both lines, LS means for adjust-
ed ADFI can be compared between lines within a diet and reflect differences in RFI (Figure 6). Results show that under the HELF diet, the LRFI line had significantly lower RFI than the HRFI line (P<0.007). The LRFI still had numerically lower RFI than the HRFI line when fed the LEHF diet, but differences were not significant (P>0.05).

Discussion and Conclusions

Results from this study support previous findings about the differences between the RFI lines under a standard HELF diet: the LRFI line had more lean muscle and less fat than the HRFI line, while consuming less feed but maintaining a similar growth rate, resulting in greater feed efficiency for the LRFI line. In addition, this study sheds light on the effects of a LEHF diet. Across both lines, feeding the LEHF diet resulted in lower feed efficiency, ADG and BF compared to pigs fed the HELF diet. Results were inconsistent between generations for ADFI and LMA, which suggests further replicates are needed to establish which of these generations is most representative of the biological changes that occur under this feed challenge. Possible explanations for the different results for LMA and ADFI in these two replicates may be environmental stressors, including a heat wave during farrowing of the G9 pigs, which may have depressed appetite.

Under the LEHF diet, compared to the HRFI line, the LRFI line had greater lean and less fat growth but similar feed consumption, ADG, and feed efficiency. Although the trends for ADG, BF, and LMA between lines were similar under the two diets, the difference in feed efficiency between the two lines was significantly reduced under the LEHF diet. This was likely due to differences in ADFI under the different diets; the line difference in feed intake between the two lines was much greater when fed the HELF diet compared to the LEHF diet.

In conclusion, selection for RFI under conventional diets and then raising these lines on a lower quality feedstuff may result in a reduction of the feed efficiency advantage. However, the LEHF diet reduced performance compared to the HELF diet, regardless of line.

Figure 5: LS means for Off-Test Loin Muscle Area.

Figure 6: LS means for Average Daily Feed Intake adjusted for expected feed intake to evaluate Residual Feed Intake.

In a similar study by Montagne et al. (2014) on divergent RFI selection lines established at INRA, feeding a high fiber diet only reduced ADG and G:F of the HRFI line, while our results showed reductions in ADG and G:F in both RFI lines when fed the LEHF diet. In addition, Montagne et al. (2014) reported a lower ADFI in both lines when fed a high fiber diet, which was similar to our G8 ADFI results. They also reported that the LRFI line maintained a higher G:F regardless of diet fed, while our results indicated a loss of line differences for G:F when fed a high fiber diet. Difference may be due to the more extreme LEHF diet used in our study and due to population differences.

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Literature Cited