EVALUATION OF A SATIETY HORMONE IN PIGS WITH DIVERGENT GENETIC POTENTIAL FOR FEED INTAKE AND GROWTH

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Story in Brief

Experiments were designed to study the role of an eight amino acid molecular form of the satiety hormone cholecystokinin (CCK-8) in lines of pigs with divergent genetic potential for feed intake. Differences in feed intake between the lines resulted from ten generations of selection for either fast (line F) or slow (line S) postweaning gain. In Experiment 1, barrows sampled from F (n=12) and S (n=11) were used to determine levels of plasma CCK-8 in response to ad libitum feed consumption. Absolute levels of CCK-8 were not different in barrows from F and S. However, the increase in CCK-8 per unit of feed consumption tended to be greater in S than in F, as did the ratio of CCK-8 to cumulative feed intake. In Experiment 2, some of the same barrows were used to measure the response in feed intake to infusion with exogenous CCK-8 (0, 60, 100 or 300 ng/kg/min). Five F barrows and four S barrows were evaluated at all dosage levels of CCK-8. There was an interaction of CCK-8 dosage and selection line. Feed consumption was reduced as dosage of CCK-8 increased, but the reduction was greater in S than in F. The results indicate a greater sensitivity in S than in F pigs to CCK-8. The genetic difference between these lines for feed intake may be due in part to a difference in sensitivity to this satiety signal. Knowledge of the physiological mechanisms that determine genetic merit for feed intake may suggest pharmacological treatments to enhance production and new approaches in genetic improvement programs.

(Key Words: Pigs, Cholecystokinin, Appetite, Growth, Selection.)

Introduction

Costs associated with feed intake are a primary determinant of profitability in pork production systems. A better understanding of the genetic control of appetite may lead to the development of more effective selection methods and the optimization of genetic potential for feed intake in breeding systems. Although the general physiological processes that result in hunger and satiety have been the focus of extensive research (see review by Morley, 1987),

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little is known of the specific mechanisms that explain genetic differences in appetite.

A study of appetite regulation was initiated in lines of pigs that had undergone ten generations of divergent selection for postweaning average daily gain (ADG). Woltmann et al. (1992) reported that after four generations of selection, the lines differed in ADG and feed intake when allowed ad libitum access to feed, but had similar ADG when feed intake was standardized. They concluded that most of the response in ADG was expressed through a difference in feed intake. Because these lines originate from a common base population and have been maintained in the same environment, differences between them can be attributed to selection-induced changes in the frequencies of genes. Thus, the lines provide an opportunity to better understand genetic differences in feed intake.

Experiments were designed to study an eight amino acid molecular form of cholecystokinin (CCK-8), a peptide secreted from intestinal cells in response to food intake and known to act as a satiety signal in several species, including the pig. The objectives were to determine if pigs with divergent genetic potential for feed intake differed in 1) plasma levels of CCK-8 in response to feeding, and 2) feed intake in response to infusion with exogenous CCK-8.

Materials and Methods

Lines of pigs were established at Oklahoma State University in 1981 to evaluate responses to divergent selection for postweaning ADG. Duroc and Hampshire boars were purchased in breed pairs from central performance testing stations where they were ranked on an index that emphasized high ADG and feed efficiency and low fat relative to lean. One of each purchased breed pair was above the test average for the index and the other below. A fast growth line (F) was initiated from pigs sired by high-indexing Duroc boars and out of gilts sired by high-indexing Hampshire boars. A slow growth line (S) was derived from pigs sired by low-indexing Duroc boars and out of gilts sired by low-indexing Hampshire boars. In the initial matings to establish the lines, Hampshire boars were crossed with a population of Duroc x Yorkshire x Landrace x Spotted crossbred gilts from a previous study. Following the initial matings, lines were closed and have undergone ten generations of selection for either fast or slow ADG (F and S, respectively). Approximately 8.5 standard deviations (SD) of cumulative, divergent selection differential have been achieved. As a result of selection, barrows and gilts from F consume 35% more feed per day (4.3 SD), exhibit 36% greater ADG (3 SD) and have 30% more backfat at 105 kg (2.7 SD) than those from S.

Two experiments were designed to determine if the satiety hormone CCK-8 has a role in determining the difference in appetite between F and S. In

Experiment 1, barrows sampled from F and S were used to measure total plasma CCK-8 at ad libitum feed intake. Repeated blood samples were collected following overnight fast to simulate a normal morning meal with ad libitum access to feed. Barrows were restricted to maintenance feeding for 14 days prior to Experiment 1. This allowed 3 to 4 days for adjustment to the nutritional level and an additional 10 days to achieve zero growth. The samples collected when these previously maintenance-fed pigs were allowed ad libitum consumption were expected to determine plasma CCK-8 associated with full expression of appetite, independent of differences between the lines in growth rate.

Twelve litters from S and 12 litters from F were chosen at random to each provide a barrow for Experiment 1. Litters were chosen so that the candidate barrow from each weighed approximately 85 kg at data collection. When individuals in the litter reached an approximate average weight of 80 kg, the barrow closest to the average weight was chosen to participate in the experiment. On the morning of Experiment 1, blood samples were collected via jugular catheter at 30, 15 and 1 min prior to regular introduction of feed at 0800 h and then at 10, 20, 30, 60, 90 and 120 min after introduction of feed. Individual feed consumption was also determined at 10, 20, 30, 60, 90 and 120 min after introduction of feed.

Plasma levels of CCK-8 were determined by radioimmunoassay of samples at each of the nine points relative to feeding, and analyzed by least-squares procedures with a model that included the effects of line, animal within line, time of sample, and the line x time interaction. Line effects were tested using animal within line as the error term; time and time x line were tested using the residual. In addition, methods of analyses were desired that would allow comparison of CCK-8 in F and S, adjusted for the amount of feed consumed. In one such analysis, CCK-8 values were regressed on cumulative feed intake to compare CCK response in the lines relative to feed intake. In a second analysis, the ratio of CCK-8 to cumulative feed intake was evaluated.

In Experiment 2, response in feed intake to infusion with exogenous CCK-8 was determined. Animals remained at maintenance feeding following Experiment 1 and during the next 48 h were periodically infused with saline during meals to acclimate animals to the treatment procedure. Each pig within a line was assigned randomly to one of the 24 sequences possible for four CCK-8 doses of 0 (saline), 60, 100 and 300 ng/kg/min. The first dose was administered on the morning after the 48-h acclimation and at least 2 d separated successive doses. The CCK-8, regardless of dose, was infused continuously for 12 min using Harvard Model 22 infusion pumps. Each infusion began 2 min before pigs were allowed ad libitum access to feed for 2 h. Individual feed intakes were determined at 10, 20, 30, 60, 90 and 120 min after

introduction of feed. Feed intakes during saline infusion established the control meal size for each animal.

Cumulative feed intakes were analyzed at each time period following introduction of feed. The meal size for each individual at 60, 100 and 300 ng/kg/min of CCK-8 was expressed as a percentage of meal size during control infusion of saline. The experiment design was a split-plot in which line was the whole plot and the subplots were the repeated measures of each animal at three doses of CCK-8.

Results and Discussion

Eleven barrows from S and 12 from F completed Experiment 1. Results are summarized in Figures 1 and 2. In both lines, there were significant changes ($P<.01$) in CCK-8 levels in response to feeding (Figure 1); CCK-8 decreased initially, then increased to levels similar to those observed pre-feeding. The initial decline in CCK-8, and similar levels before and after feeding were unexpected, but seem to be consistent across lines. Plasma levels of CCK-8 did not differ between the lines ($P>.20$) during the 2-h period.

As expected, barrows from F consumed more feed ($P<.05$) during the experiment than those from S. Thus, methods of analyses were desired that would allow comparison of CCK-8 in F and S adjusted for the amount of feed consumed. In one such analysis, CCK-8 values were regressed on cumulative feed consumption to compare CCK response in the lines relative to feed consumption (Figure 2). The increases in CCK-8 per unit of feed consumption tended to be greater ($P<.20$) in S than in F. In a second analysis, the ratio of CCK-8 to cumulative feed consumption was evaluated. The difference in this ratio between the selection lines (9.20 and 13.89 in F and S, respectively) also approached significance ($P=.18$). Additional data must be collected for Experiment 1 to determine if these tendencies reflect true differences between the lines. A greater amount of plasma CCK-8 per unit of feed intake in S vs F may explain in part the relatively lesser intake that is characteristic of S pigs.

Five F barrows and four S barrows have been evaluated at all dosage level of CCK-8. Response in feed consumption to infusion of exogenous CCK-8, expressed as the percentage of control consumption, is presented in Figure 3. There was an interaction of CCK-8 dosage and selection line ($P<.01$). Feed consumption was reduced in both lines as dosage of CCK-8 increased, but the reduction was greater ($P<.01$) in S than in F. The results indicate a greater sensitivity in S than in F pigs to CCK-8. The genetic difference between these lines for appetite may be due in part to a difference in sensitivity to this satiety signal. Future studies of physiological mechanisms and molecular genetic markers in these lines will likely enhance our understanding of variation in feed intake. Knowledge of the physiological mechanisms that determine genetic

merit for feed intake may suggest pharmacological treatments to enhance production and new approaches in genetic improvement programs.

Literature Cited

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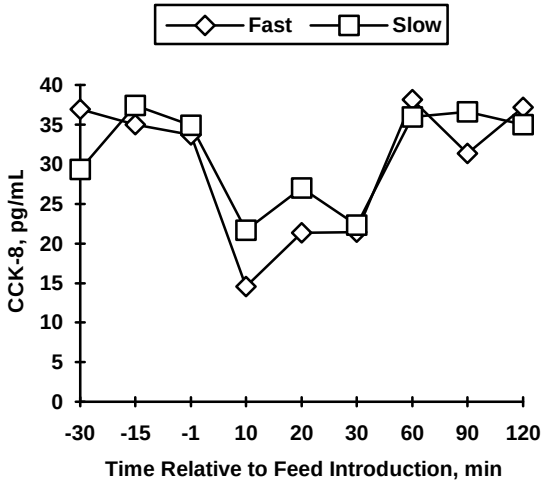

Figure 1. Plasma CCK-8 in barrows from F and S at 85 kg body weight and zero growth. F was not different from S (P>.20).

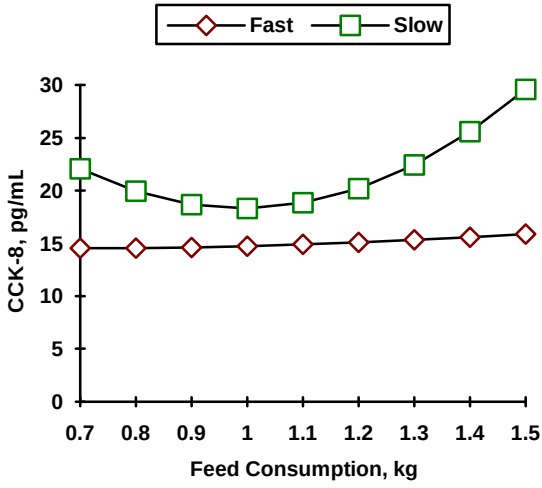

Figure 2. Plasma CCK-8 in barrows from F and S at 85 kg body weight and zero growth, regressed on average cumulative ad libitum feed consumption of S pigs in Experiment 1. CCK-8 per unit of feed consumption tended (P<.20) to be greater in S than in F.

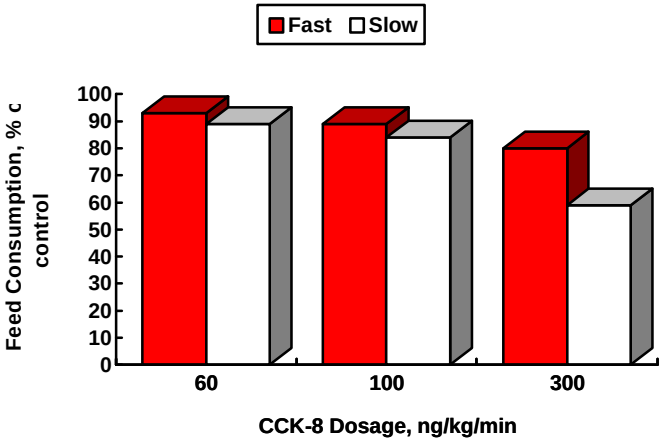

Figure 3. Feed consumption of F and S barrows in response to infusion with exogenous CCK-8. Values expressed as a percentage of control (saline infusion) consumption. There was a greater decline (P<.01) in feed consumption in S than in F with increasing dosage of CCK-8.