

NEBRASKA SWINE REPORT

- Nutrition
- Genetics
- Management
- Reproduction
- Meats



Web site:

www.ianr.unl.edu/pubs/swine/pigpdf.htm

Prepared by the staff in Animal Science and cooperating Departments for use in Extension, Teaching and Research programs.

**Extension Division
Agricultural Research Division
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln**



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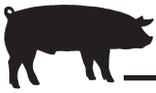


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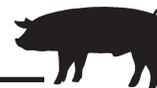


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2007 Nebraska Swine Report

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Michael Brumm

Practical Pig Research is His Niche

Mike Brumm, a veteran University of Nebraska–Lincoln swine extension specialist who recently retired to form a consulting business in Minnesota, really had just one goal in life: to be a farmer.

Brumm has virtually lived out that dream as a researcher and swine extension specialist at the University of Nebraska–Lincoln Haskell Agricultural Laboratory at Concord.

“I’ve always wanted to be a farmer. We lived on a livestock-grain farm and moved to town (Osage, Iowa), where Dad bought a hog-buying station, when I was in the 8th grade.”

His dream began to take shape when he switched from his first job after graduate school, as an area livestock extension agent with Oklahoma State University, to the current post at Nebraska.

“Since I have worked in Nebraska, I have been close to being a farmer without being one,” he says. “My life has been agriculture. That is the only thing I know and the only thing that I care to know.”

The Haskell research facility is in an isolated part of northeast Nebraska, just outside the city of Concord (population 160), and in an area that is home to over 50 percent of the state’s pork production.

Haskell is an applied research station, meaning research is hands-on. With only one research technician on staff overseeing the wean-to-finish research barns a mile from the Haskell lab, Brumm not only maintains a research focus on management and housing of the post-weaning pigs, he does his share of farm chores on weekends, holidays and the like.

“It has allowed me to think through some of the challenges that are involved in running a production unit. I doubt my science answers are any better. But it allows for that extra interpretation, because I can talk about broken waterlines, what to do when the pits plug or putting cable clamps on a curtain when the windchill is below zero, because I have been the one doing it,” states Brumm.

Brumm credits his service in the U.S. Army and carpentry work during summers between college studies with helping him complete his education and succeed in his job studying pig housing.

During college, he worked summers as an apprenticed carpenter for his uncle, who built everything from hog houses and pole barns to fancy homes.

In 1971, after graduation from Iowa State University with a degree in agricultural education, he was drafted in the U.S. Army during the Vietnam war. He was lucky

enough to draw a stateside assignment at the William Beaumont Army Medical Center in El Paso, Texas, where he worked as a medical research laboratory technician.

“The only reason I went back to college was because of my Army experience,” Brumm explains. “I would never have gone into research had it not been for that experience.”

Following that two-year stint in the Army, he went to graduate school and received a masters degree in animal management in 1976 from Purdue University. “I was actually trained in waste management, looking at the impact of nutrition on manure composition because that was what Al Sutton did, and I was his first graduate student.”

After receiving his doctoral degree in swine nutrition from Purdue in 1978, Brumm latched onto the job in Oklahoma. The area was not much to his liking, partly because back then that part of Oklahoma was mainly comprised of hobby farms and was not a big pig state.

But there was a silver lining to that first job. “The good news was I got to work with Bill Luce (longtime Oklahoma State University swine specialist), who was a good mentor, a tremendous individual to work with. He was very, very good to me and remains a personal friend.”

At Nebraska, Brumm has also encountered some solid mentors, but university swine nutritionist Ernie Peo Jr. stood above the rest. “As a young faculty member, he guided me in so many ways. It didn’t take me too long to understand that if I did a research project Ernie’s way, it worked.”

Peo also provided a young Brumm with the best advice he ever got: “You’ve got to learn to bite your tongue once in awhile, Mike,” Brumm recalls with a hint of a sheepish grin.

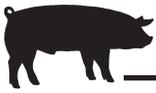


Research Accomplishments

Brumm kept his nose to the grindstone, cranking out over 100 research experiments (some with multiple replications), during a 27-year career at Nebraska that draws to a close with his retirement this summer.

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His research projects ranged from early work focusing on handling, feeding and managing commingled feeder pigs when he began in 1979, to work in the mid-'80s that focused on turning down the temperature in nurseries at night.

In fact, in a bit of *déjà vu*, Brumm is part of a group that has received a grant from the National Pork Board to take a renewed look at that nursery pig work, because diets and weaning ages have changed drastically during the last 20 years.

That earlier work aimed to improve pig comfort. The latest work will focus on the pig, but also cast an eye toward energy savings.

Since the late '80s, Brumm has studied pig drinkers.

His first pig crowding studies began 15-20 years ago, and remains an issue today. He wonders if once researchers determine the proper economics of space, whether animal welfarists will demand more requirements beyond the science.

Brumm has completed a variety of wean-to-finish projects and quite a bit of work with Concord's agronomists determining the nutrient value of manure distributed onto cropland from swine lagoons.

PorkBridge Program

The Nebraska swine researcher speaks most fervently these days about PorkBridge, an extension outreach tool he developed along with Don Levis of the University of Nebraska and Dale Ricker of Ohio State University.

PorkBridge's target audience are the people who are responsible for the daily care and feeding of pigs in nursery and grow-finish facilities.

PorkBridge allows these stockmen to gain production knowledge without leaving the farm. PorkBridge consists of a CD with speaker presentation and support material, and a toll-free telephone bridge.

For 2006-07, the program will reach producers, advisors and allied industry in 12 states, says Brumm.

Future Challenges

As proud as Brumm is of his educational accomplishments, he is most proud of his family: wife, Janet; three children in college; and Liz, their 16-year-old daughter.

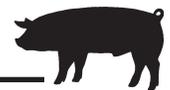
Liz has cerebral palsy and requires special treatment and care beyond what the Brumms can provide themselves.

That's why Brumm is retiring from the university at age 57, and his wife from a career as a librarian at Wayne State College at Wayne, Neb. They will move to North Mankato, Minn., where lifetime care for Liz is more comprehensive.

In hopes of retaining Brumm's position at the Concord research facility, the University of Nebraska has established the Haskell Ag Lab Swine Professorship Fund with a goal of \$250,000. The Nebraska Pork Producers have chipped in \$25,000 for this endowed professorship. For more details, contact Ann Bruntz at the university's Institute of Agriculture and Natural Resources at (402) 472-0372 or abruntz@foundation.Nebraska.edu.

Brumm's new venture, the Brumm Consultancy, has opened in North Mankato, Minn. Brumm hopes to continue much of the research and producer advisory endeavors he has focused on during his career.

— *by Joe Vansickle,
senior editor of National Hog Farmer*



History of the Nebraska Feeder Pig Expo

Robert Voboril¹

In the early 1970s a significant number of feeder pigs were imported into Nebraska. Recognizing the potential for increased feeder pig production within Nebraska, University of Nebraska President Woody Varner commissioned an ad hoc committee of pork producers, agri-business personnel and extension specialists. The newly formed Pork Industry Development Task Force recognized the need for new swine facilities, and improved animal health, markets, and banker-producer relations. This prompted a discussion to initiate a pork exposition.

Columbus was selected to host the exposition, because of the facilities available and significant concentration of producers in the area. The first Nebraska Feeder Pig Expo was a two-day event, held on Feb. 14-15, 1974, at Platte County Ag Park. Ag Park would become home to the annual Expo for the next 32 years.

Neal Pohlman, pork producer from Stanton, chaired a 15-member committee to plan the first Expo (Table 1). Extension Livestock Specialists Dr. W. T. Ahlschwede, Dr. Bill Zollinger, and later Dr. Mike Brumm were instrumental in coordinating an educational program with the help of a committee of pork producers and agribusiness personnel. The first

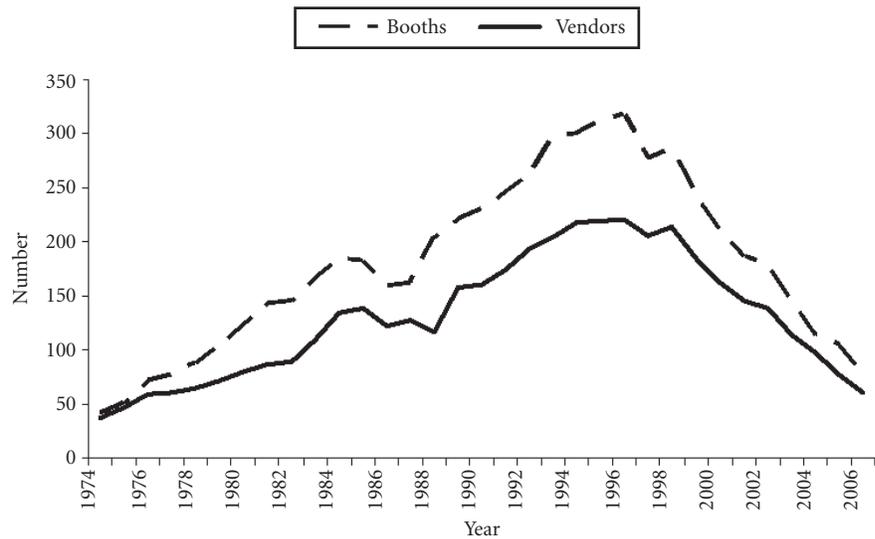


Figure 1. Number of exhibitor booth spaces and vendors represented at the Nebraska Pork Expo.

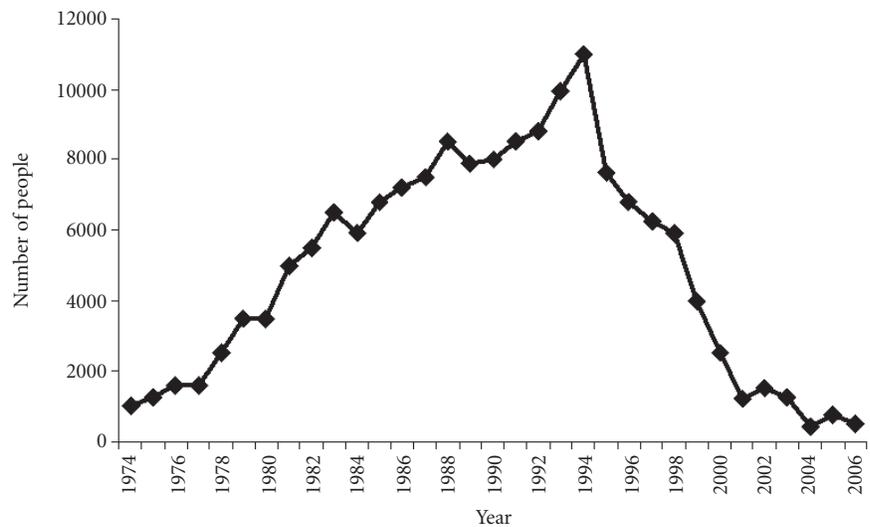


Figure 2. Estimated attendance at the Nebraska Pork Expo.

Table 1. Nebraska Pork Expo Committee Chairs

Year	Name
1974-1977	Neal Pohlman, Stanton, Neb.
1978-1981	Daryl Sander, Platte Center, Neb.
1982-1983	Rod Hassebrook, Platte Center, Neb.
1984-1986	Stan Rosendahl, Creston, Neb.
1987-1989	Daryl Sander, Platte Center, Neb.
1990-1991	Dave Rosendahl, Creston, Neb.
1992-1993	Con Mueller, Columbus, Neb.
1994	Carl Groteluschen, Schuyler, Neb.
1995-1996	Kevin Saalfeld, Schuyler, Neb.
1997-1998	Stan Rosendahl, Creston, Neb.
1999-2001	Daryl Sander, Platte Center, Neb.
2002-2003	Todd Stuthman, Platte Center, Neb.
2004-2006	John Sonderman, Columbus, Neb.

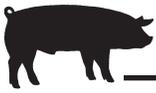
educational program was delivered by producers, agribusiness and Cooperative Extension personnel. Topics were “Facility Needs for Feeder Pig Production,” “The Feeder Pig Business,” “Reproduction and Fertility” and “Keeping Pigs Alive, Healthy and Growing.” A key component of each educational program was the inclusion of producers discussing their swine enterprises and their use of the technology.

Businesses with interests in the pork industry were invited to purchase

booth space to form a trade show. During the first Expo, 41 booth spaces were purchased by 37 vendors (Figure 1) with an estimated 1,000 people in attendance (Figure 2).

In the following year, a five pig/pen feeder pig show was added to the growing list of Expo events. Following the live pig show the feeder pigs were transported to a commercial facility and grown to market weight. At the end of the feeding period daily gain, feed efficiency, lean gain and standard

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carcass data were provided to the pigs' owners. In later years each pen was fed individually at J & C Swine Testing at Wymore, Neb. In the late 1990s a SEW division was added to the grow-out to reflect the growth of this segment of the swine industry. Data reported back to pig owners were expanded to include lean feed efficiency, loin muscle pH, and Minolta color score. In 2002, the live show was discontinued and a Feeder Pig Challenge begun with the pigs transported directly to the Wymore, Neb. facility by participating producers. Trophies and monetary awards were given to the owners of top performing pens.

In 1980 the Nebraska Feeder Pig Executive Committee agreed on the structure of a committee that planned and conducted all future Expos. The 21-member board of directors consisted of individuals representing the Nebraska Pork Producers Association Board of Directors, Pla-Co Pork Producers Association, pork producers

at large, agribusiness, University of Nebraska–Lincoln Extension and Bob Voboril as ex-officio member. Merline Spunk was named Expo secretary.

In the early '90s the Expo was renamed the Nebraska Pork Industry and Feeder Pig Show, although most producers in the state referred to it as the Columbus Feeder Pig Show. A youth program highlighting opportunities in the pork industry, a womens program and a pie baking contest joined the Expo lineup.

The Expo drew producers and others related to the swine industry from a 12-state area. Several businesses, led by Waldo Farms at DeWitt, Neb., exhibited at every Expo since its inception. Willard Waldo cites a combination of things that made the Expo outstanding, including a central location in Nebraska for pork producers, management of the Expo, facilities, exhibitors that were interested in pork producers, and valuable educational programs.



Nebraska Feeder Pig Chair Bill Luckey (right), Columbus, congratulates Bruce Wendt, a champion pen-of-five winner at the 1998 show. Luckey is the current Nebraska Pork Producers President.

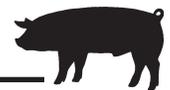
As the new millennium approached, Nebraska pork producers faced many challenges to survive and remain profitable. The Expo was there to assist producers, keeping them on the cutting edge of their industry. However, the number of pork producers in Nebraska continued to decline, matching the nationwide consolidation of the swine industry.

In 2006, after running for 33 consecutive years, the final edition of the largest indoor show for the pork industry in Nebraska was conducted. The Expo Board of Directors felt the Expo no longer served the industry as it had in the past, leading to the decision to end what many swine industry participants in Nebraska considered a tradition.



Mike Wilke, Leigh, (center) is congratulated by Louis Welch, Feeder Pig Chair at the 1976 Show for his champion pen of five pigs. Pla-Co Queen, Sylvia Janssen, is on the far left.

¹Robert Voboril was the Expo manager from 1974 to 2006. He wishes to thank all sponsoring companies and groups for their dedicated support and financial contributions to the Expo.



Impact of a Variable Number of Out-of-Feed Events on Grow-Finish Performance

Mike Brumm
Sheri Colgan
Kelly Bruns¹

Summary and Implications

Out-of-feed events are a growing problem in nursery and grow-finish facilities due to issues associated with feed delivery to bulk bins and bridging of feed in bulk bins. Reports of bridging are increasing as producers continue to reduce the fineness of grind for complete diets in order to improve feed conversion. A study was conducted to examine the effect of repeated out-of-feed events on barrow performance in a wean-to-finish facility beginning 37 days after weaning. Pigs were never out-of-feed or denied access to feed for a 20-hour period beginning at noon on 1, 2, or 3 days within each two-week period during a 16-week experiment. During the first eight weeks, increasing the number of out-of-feed events resulted in a linear decrease in daily gain ($P=0.003$) and daily feed intake ($P=0.011$). There was no effect of out-of-feed events on daily gain or feed intake ($P>0.1$) for the second eight-week period. Because of the linear result of decreasing daily gain with increasing numbers of out-of-feed events during the first eight-week period, there was a linear ($P=0.030$) decrease in overall daily gain with increasing numbers of out-of-feed events. There was no effect ($P>0.1$) of out-of-feed events on overall feed conversion. There was no effect ($P>0.1$) of out-of-feed events on the severity of skin lesions as measured by individual pig scoring using a 0 to 4 scale on alternate Fridays during the experiment. These results support previous results that repeated 20-hour out-of-feed events result in a decrease in daily gain, especially during the growing period.

Introduction

In theory, bulk bins and automated feed delivery systems assure an uninterrupted flow of feed to feeders in swine grow-finish facilities. In practice, growing-finishing pigs have varying disruptions in feed availability, some of which may have very serious consequences. While every swine grow-finish facility has occasional disruptions due to mechanical failures in the feed delivery system, there are additional disruptions due to human errors associated with delivering feed to the bulk bin and feed bridging associated with feed removal from the bin. Out-of-feed events are a known cause of being associated with increased incidence of hemorrhagic bowel syndrome and ileitis.

In results reported in the 2006 *Nebraska Swine Report*, a weekly 20-hour out-of-feed event on a random day within each week for a 16-week grow-finish trial resulted in an 8 lb reduction in gain for the first eight-week period and a net 8 lb reduction overall, with no impact on feed conversion. This suggests that 1) the growing pig may be more susceptible to out-of-feed events than the finishing pig; and 2) during the finishing period, the pig does not compensate for lost weight gain during the growing phase due to weekly out-of-feed events. Unknown from these results is the impact of a varying number of out-of-feed events on pig performance.

The following experiment was designed to examine the impact of a varying number of out-of-feed events on pig performance and welfare.

Materials and Methods

The research was conducted at the University of Nebraska's Haskell Ag Lab at Concord. The research facility was a fully slatted, naturally ventilated

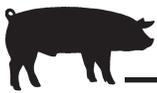
wean-to-finish unit with 16 pens (8 ft x 14 ft). Each pen had one two-hole Farmweld wean-to-finish feeder and one Drik-o-Mat wean-to-finish cup drinker. There were 15 pigs per pen at weaning (7.5 ft²/pig) and pen size was not reduced in the event of pig death or removal.

On the day of weaning (14-21 days of age), the pigs were transported approximately 200 miles to the research facility. At arrival, they were ear tagged, individually weighed (12.6 lb arrival weight), and assigned to pens on the basis of arrival weight such that all pens had similar mean weights and within pen coefficients of variation for weight. The experimental treatments began 37 days after weaning. There were four pens of pigs per experimental treatment combination. Only barrows were used in this experiment to minimize the random out-of-feed events associated with gilts urinating in a feed trough and plugging a feeder for an unknown length of time.

The experimental treatments were 0, 1, 2, or 3 out-of-feed events every two-week period during a 16-week grow-finish trial. The out-of-feed events consisted of closing the feeder delivery device completely at noon and reopening the device at 8 a.m. the following morning which resulted in a 20-hour period when no feed was available to a pen of pigs. The day(s) that the out-of-feed events began was randomly selected from Monday to Thursday for every two-week period. Pigs were weighed every other Friday, and on the week of pig weighing the feeders were never closed on Thursday evening so that pig weights on Friday morning were not confounded with an out-of-feed event. Additionally, days were selected so that there was at least one day between out-of-feed events.

Diets containing 100 g/ton tylosin from 40 to 80 lb body weight and 40 g/ton thereafter, were switched to the

(Continued on next page)



next lysine sequence on the basis of the average weight of all pigs in the facility. Lysine levels were 1.15% from 40-80 lb, 0.99% from 80-135, 0.77% from 130 to 195, and 0.62% from 195 to slaughter. Diets contained 3% added fat from 40 to 135 lb bodyweight and 1.5% added fat thereafter.

Skin lesions (i.e., lesions that were pink/bleeding), tail biting, and lameness were observed on every weigh day and independently scored by two observers. Lesions were ranked on a 0 to 4 scale with 0 being no fresh lesions observed and 4 being many (12+ small or 6+ large) lesions. Tail biting was ranked on a 0 to 4 scale with 0 being no tail biting and 4 being a large, deep and open wound. Lameness was ranked on a 0 to 2 scale with 0 being no lameness and 2 being complete inability to place weight on one or more limbs. The order of pen observation was varied each time to prevent possible score biases associated with the order of observation.

Pigs were vaccinated for erysipelas, M. hyo, and ileitis prior to the start of the out-of-feed events. All pigs that died were examined by a veterinarian for cause of death.

All pigs were scanned by real-time ultrasound for 10th rib backfat and loin muscle area on weeks 4, 8, 12, and 16. Carcass data was not collected at the termination of the experiment because the last day on test was the Friday prior to Christmas, meaning pigs would have been slaughtered during holiday periods with potential slaughter plant disruptions due to worker absences. The pen of pigs was the experimental unit for all statistical analyses.

Results and Discussion

Table 1 presents the pig performance results. There was a linear decrease in pig weight ($P=0.014$) on day 56 and daily gain ($P=0.003$) for the first eight-week period with increasing out-of-feed events. Daily feed also decreased in a linear ($P=0.011$) manner for this same period. There was no effect of out-of-feed events on feed conversion.

For the second eight-week period,

Table 1. Impact of experimental treatments on pig performance.

Item	Treatment ^a				SEM	P value ^b		
	0x	1x	2x	3x		Treatment	Linear	Quadratic
Pig wt, lb								
Day 0	39.2	39.8	41.0	39.2	0.8	0.379	0.765	0.154
Day 56	142.7	141.7	140.1	132.1	2.6	0.050	0.014	0.193
Day 112	257.9	259.2	259.0	251.0	2.6	0.134	0.097	0.097
Coefficient of variation pig weight within pen, %								
Day 0	21.4	17.6	19.0	21.6	2.7	0.678	0.881	0.257
Day 56	14.2	12.6	14.3	16.9	2.1	0.554	0.311	0.338
Day 112	11.9	9.8	10.8	12.5	1.7	0.710	0.730	0.298
Daily gain, lb								
0 to 56 days	1.85	1.82	1.77	1.66	0.04	0.018	0.003	0.286
56 to 112 days	2.06	2.10	2.12	2.12	0.03	0.500	0.149	0.550
0 to 112 days	1.96	1.96	1.95	1.89	0.02	0.076	0.030	0.133
Daily feed, lb								
0 to 56 days	4.12	4.08	3.98	3.70	0.10	0.049	0.011	0.245
56 to 112 days	7.04	6.88	7.07	6.97	0.11	0.609	0.972	0.760
0 to 112 days	5.58	5.48	5.53	5.34	0.09	0.300	0.111	0.615
Feed:gain								
0 to 56 days	2.23	2.24	2.25	2.23	0.02	0.912	0.924	0.527
56 to 112 days	3.45	3.32	3.37	3.31	0.04	0.165	0.095	0.402
0 to 112 days	2.86	2.80	2.84	2.82	0.03	0.408	0.510	0.380

^aNumber of 20-hour out-of-feed events every two weeks.

^bAll cubic effects $P > 0.15$.

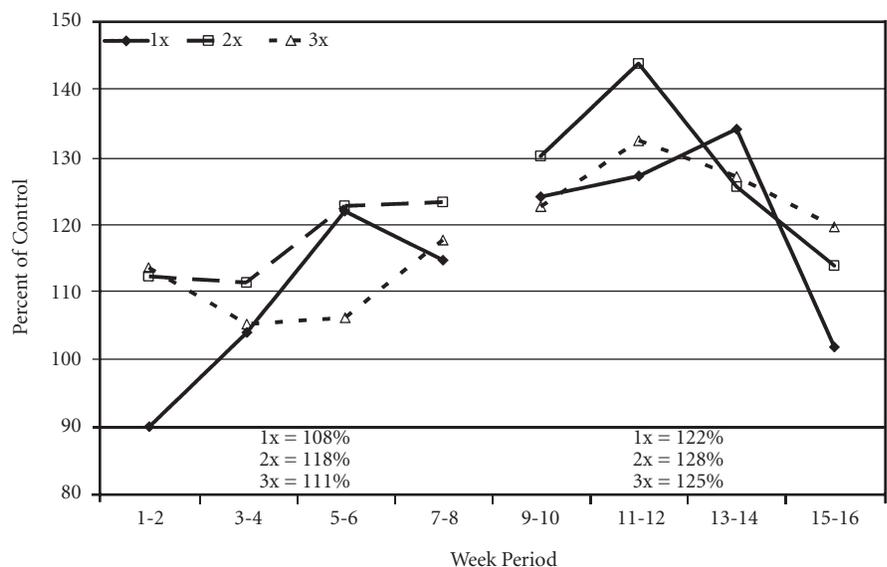


Figure 1. Feed intake the first 24 hours following a 0, 1, 2 or 3 times out-of-feed event every two weeks expressed as a percentage increase of the control treatment.

there was no linear, quadratic or cubic effects ($P>0.15$) of increasing numbers of out-of-feed events on daily gain or daily feed. There was a tendency for a linear ($P=0.095$) improvement in feed conversion with increasing numbers of out-of-feed events.

Overall, there was a tendency for a linear decrease in final weight

($P=0.097$) and a linear decrease in daily gain ($P=0.030$) with an increasing number of out-of-feed events. There was no overall effect ($P>0.1$) of increasing numbers of out-of-feed events on daily feed or feed conversion. There was no effect ($P>0.1$) of out-of-feed events on the variation in pig weight within a pen.

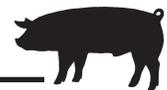


Table 2. Impact of experimental treatments on fat depth and loin muscle area.

Item	Treatment ^a				SEM	P value ^b		
	0x	1x	2x	3x		Treatment	Linear	Quadratic
10 th rib fat depth, in								
4 week	0.37	0.37	0.38	0.36	0.02	0.948	0.931	0.649
8 week	0.53	0.54	0.53	0.55	0.02	0.919	0.632	0.827
12 week	0.73	0.72	0.77	0.84	0.04	0.417	0.130	0.337
16 week	0.94	0.96	0.95	0.94	0.03	0.967	0.894	0.735
10 th rib loin muscle area, in ²								
4 week	1.92	1.85	1.79	1.92	0.07	0.395	0.929	0.127
8 week	3.31	3.25	3.23	3.32	0.08	0.789	0.963	0.338
12 week	4.45	4.43	4.36	4.55	0.12	0.810	0.713	0.461
16 week	5.74	5.52	5.64	5.94	0.10	0.097	0.134	0.028

^aNumber of 20-hour out-of-feed events every two weeks.

^bAll cubic effects P > 0.5. Pig weight as a co-variate.

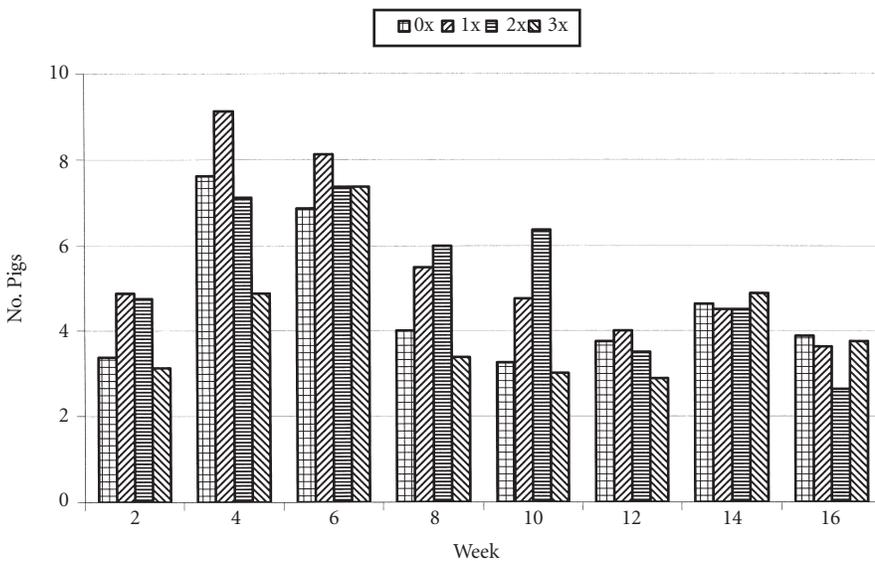


Figure 2. Effect of a 0, 1, 2, or 3 times out-of-feed event every two weeks on the number of pigs per pen with non-zero lesion scores.

The lack of effect for increasing numbers of out-of-feed events on pig performance during the second eight-week period can be explained in part by the results shown in Figure 1. This figure displays feed intake for the out-of-feed treatments expressed as a percentage of the feed intake for the control pens for the first 24-hour period following the return of feed availability. For the first eight-week period, the 1x, 2x, and 3x treatments only ate 8%, 18%, and 11% more feed than the control pigs for this 24-hour period. For the second eight-week period, the 1x, 2x, and 3x pigs ate 22%, 28% and 25% more feed than the control. In the experiment reported in the 2006 *Nebraska Swine Report* where an out-of-feed event occurred on a random day

every week, the corresponding feed intake increases relative to the control were 14% and 42% for the first and second eight-week periods, respectively. In both experiments, it appears that during the second eight-week period, the out-of-feed treated pigs modified their eating behavior resulting in a greater intake of feed when feed became available. Because the number of out-of-feed events varied and the shift in feed intake occurred independent of the number of out-of-feed events in this experiment, this suggests that the response is most likely related to the stage of growth (grower vs. finisher phase). That is, growing pigs may already be eating at a level close to their capacity for intake. When feed is made available following an out-of-

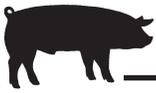
feed event, feed intake doesn't increase very dramatically since they are already consuming at an upper limit. However, in the finishing pig, feed intake may be limited by a number of factors, including the rate of lean deposition versus the rate of fat deposition and the impact of these depositions on feed intake. Thus, when feed becomes available following an out-of-feed event, the finishing pig has capacity to eat more feed in a 24-hour period, thus limiting the impact of the out-of-feed event on performance.

There was no effect of out-of-feed events on fat depth or loin muscle area at any of the time points (P>0.1; Table 2), other than a quadratic (P=0.028) effect on loin muscle area at 16 weeks. This is probably not important because the largest muscle areas were for the control and 3x treatments.

Both the number of pigs with lesions (Figure 2) and the mean lesion score (Figure 3) increased during weeks 4 and 6 and then declined. There was no effect of out-of-feed events on the number of pigs with lesions or the mean lesion score. It is interesting to note that the control treatment (never out-of-feed) was intermediate in both the number of pigs recorded with lesions and the mean lesion score. This suggests that the out-of-feed events in this experiment, at least as related to the incidence and severity of skin lesions, were not detrimental to the welfare of the pigs. There was no lameness recorded for any pig in this experiment and the incidence of tail biting was too low to be related to any treatment. Only one pig died during the experiment.

What is not known from these results is the impact of the timing of the out-of-feed events relative to when pigs eat. That is, in thermal-neutral conditions pigs consume a majority of their daily feed beginning at 6 a.m., with a peak in consumption around 2 p.m. and only limited intake from 6 p.m. to 6 a.m. The out-of-feed events in this experiment and the previous experiment occurred from noon to 8 a.m. Thus, pigs that experienced the out-of-feed events would have been

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expected to have been at the feeder one or more times already that day, possibly lessening the impact of the out-of-feed event. It is possible to speculate that a 20-hour out-of-feed event beginning at 7 a.m. would have larger impacts on performance since the pigs would just be ending the 12-hour period when they would not normally be eating, resulting in a 32-hour (or longer) out-of-feed period.

These results also don't address the response of the pig to repeated out-of-feed events that vary in duration. That is, what is the impact on performance if the out-of-feed events vary between five hours and 24 hours in duration, with the time of the start and stop of the event also varying relative to the preferred eating pattern?

Conclusion

Increasing the number of out-of-feed events from zero to three times during every two-week period resulted in a linear decrease in daily gain during the growing period with no impact on performance during the finishing

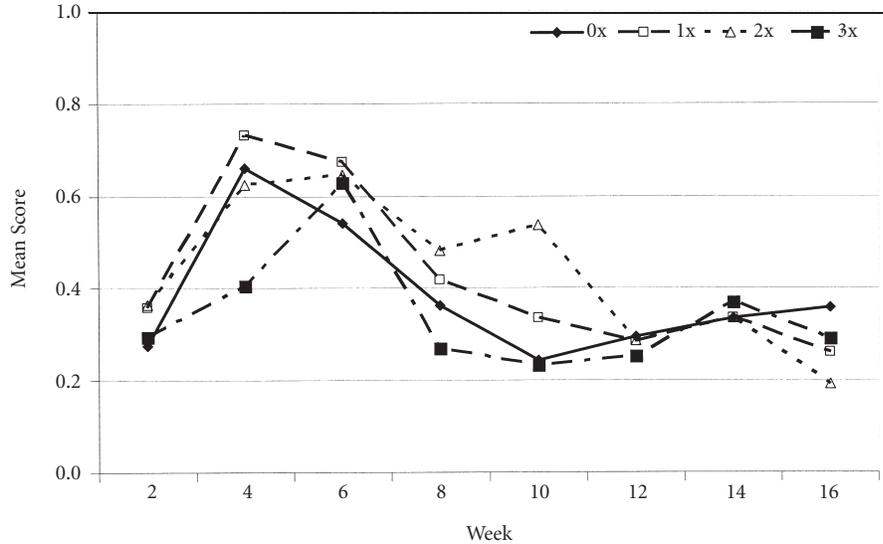


Figure 3. Effect of a 0, 1, 2, or 3 times out-of-feed event every two weeks on bi-weekly mean lesion score using a 0 to 4 scale.

period. The linear decrease in gain during the growing period resulted in an overall linear decrease in daily gain. These results support the previous conclusion that repeated 20-hour out-of-feed events result in a decrease in daily gain, especially during the growing period.

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Effects of Nutrition During Gilt Development on Lifetime Productivity of Sows of Two Prolific Maternal Lines: Preliminary Report of Reproductive Characteristics

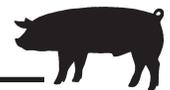
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Summary and Implications

This report is an annual update of an on-going experiment initiated in 2005 to investigate effects of energy restriction during gilt development on reproduction

through four parities. Semen of the same sires, an industry maternal line, was used to produce gilts of both lines, but their dams were from two uniquely different populations. Dams of one line were an industry Large White x Landrace (LW x LR) cross and dams of the other line were from a Nebraska line (Line 45) selected 23 generations for increased ovulation rate, uterine capacity, and litter size (L45X). Both crosses are expected to be prolific, but L45X females are expected to be earlier maturing and have larger litters; LW x LR gilts are expected to have greater rates of lean growth. The experiment is being conducted in three replications with 160 gilts per replication.

In each replication, littermate gilts of the two lines were developed with either ad libitum access to feed or were restricted in energy to 75% of ad libitum amounts from approximately 120 days of age to breeding. That phase of the experiment is complete for all replications. Feed intake, growth, backfat, and longissimus muscle area for gilts of each line on each feeding regimen are in the preceding report. Data for age at puberty, which is complete for all gilts, and litter data for Replication 1 (parities 1 and 2) and Replication 2 gilts (parity 1 only) are in this report. Replication 1 gilts completed the gilt development phase in summer of 2005 and produced parity one and



two litters in subsequent winter and spring seasons. Their parity three litters are expected in late summer, 2006. Replication 2 gilts were born in May 2005, produced parity 1 litters in spring 2006; their parity 2 litters are expected in early fall, 2006. Replication 3 gilts were born in November 2005, completed the gilt development phase in summer 2006, and are expected to produce parity 1 litters in fall 2006. The project will terminate when Replication 3 females wean their fourth parity litters. Of a total of 476 gilts starting the gilt development phase of the trial at 60 days of age, 462 completed this phase of the experiment (97.1%). Of those, the percentages that expressed a pubertal estrus were 95.4% for L45X gilts developed with either feeding regimen, but 91.5% and 78% ($P < 0.05$) for LW x LR cross gilts developed on ad libitum or restricted intake, respectively. Age at puberty for those gilts that were observed in estrus did not differ significantly between lines or feeding regimens. Litter traits for those females that have farrowed also did not differ significantly between lines or feeding regimens. LW x LR cross females were heavier pre-farrowing (24.6 lb, $P < 0.01$), but not when litters were weaned, than L45X females. Females of the two lines did not differ in backfat either pre-farrowing or when litters were weaned. Gilts developed on the restricted feeding regimen, however, had less backfat pre-farrowing (0.10 in, $P < 0.01$) and when litters were weaned (0.07 in, $P < 0.01$) than gilts developed with ad libitum access to feed. In these preliminary data, line by treatment interaction was significant for percentage of gilts that expressed estrus, but not for other traits. The objectives of the experiment are being accomplished and will answer the question of whether energy restriction during gilt development, and thus less backfat at breeding, affects lifetime productivity.

Introduction

Decreasing sow culling rates, which in recent years have reached greater than 50% in many U.S. herds, would have important economic benefits for pig producers. Many variables contribute to variation in sow

mortality including housing systems, management practices associated with gilt development, sow management practices, and possibly use of different genetic lines. At the University of Nebraska–Lincoln (UNL), we are focusing on two of these components, nutritional regimens during gilt development and prolific lines that differ in rate of lean growth.

Gilt development practices vary within the industry. Some producers provide gilts ad libitum access to feed until weights of 230 to 250 lb, then limit their intake until breeding at 280 to 300 lb, with a flush just prior to breeding. Another practice is to maintain gilts with ad libitum access to feed right up to breeding. In most cases, breeders attempt to mate gilts at their second or third post-pubertal estrus and mate them again for subsequent litters within five to 10 days of weaning after a 15- to 23-day lactation period.

Optimum gilt development regimens, however, may depend on the prolificacy of the line and on its rate of lean growth. We initiated an experiment to address the effects of different nutritional regimens during gilt development on sow reproduction and longevity. The experiment was designed to determine whether gilt nutritional development strategies affect longevity and lifetime productivity of prolific gilts that differ in rate of lean growth. Sow longevity was defined as production through four parities. The time between when females are mated to produce project gilts until gilts wean their fourth litter is just over two years. The project is being conducted in three replicates at approximately four-month intervals; therefore, the entire experiment will take approximately three years to complete. Gilts in each replication have completed the development phase of the experiment. Replication 1 gilts have produced two litters, Replication 2 gilts have produced one litter, and Replication 3 gilts have yet to farrow. This report presents the age at puberty data for all gilts, and weight and backfat at farrowing and weaning and litter traits through weaning for Replication 1 and 2 gilts.

Materials and Methods

Production of experimental gilts

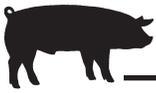
Litters from which project gilts were selected were born in three replications. Replication 1 gilts were born beginning December 2004 through the first week of January 2005. Replication 2 gilts were born during May 2005, and Replication 3 gilts were born during November 2005. Dams of these gilts were from two distinctly different maternal lines (see below) that were inseminated with semen from boars of an unrelated industry maternal line (L_M). Project gilts were selected randomly from these litters when pigs were 56 days of age. When possible, at least two gilts were selected per litter so that gilts of each litter could be assigned to each of the two gilt development regimens.

Gilt Population I (LW x LR): Population 1 gilts were the progeny of L_M boars and females of the Large White-Landrace female population that is used routinely in the UNL swine nutrition research program. It is maintained using artificial insemination in a rotation cross between industry Large White (LW) and Landrace (LR) lines. These females are designated as industry LW x LR cross. A total of 260 project gilts were selected from a total of 119 litters, 20 litters in Replication 1, 68 in Replication 2, and 31 in Replication 3.

Gilt Population II (L45X): Population 2 gilts were progeny of the same L_M boars that sired LW x LR gilts. Their mothers were from Generation 23 of the Nebraska line (Line 45) that has been selected for increased litter size. This population is designated L45X. Selection over the generations in the Nebraska line included combinations of ovulation rate, uterine capacity, and litter size at birth. During the last six generations, Line 45 also was selected for increased growth rate, decreased backfat, and increased longissimus muscle area.

A total of 216 project gilts from 87 litters (45, 19, and 23 litters in Replications 1, 2, and 3, respectively) were used. Litters within each replication were sired by 9 to 10 L_M boars. Thus,

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the gilts within each replication were half-sib families that contained both LW x LR and L45X gilts.

Management of gilts

At birth, pigs from litters the gilts were born in were crossfostered both within and between sows of the two populations to reduce variation in number of pigs nursed by dams. Litters were weaned at an average age of 13.3 days (Replication 1), 16.7 days (Replication 2), and 15.7 days (Replication 3), with a range from 11 to 19 days. At weaning, pigs were placed in a nursery with 30 pigs per pen where they remained until approximately 56 days of age. Standard nursery diets and management were used.

Gilts were moved from the nursery to a modified-open-front, curtain-sided building (MOF) at an average age of 56.2 days (Replication 1, range = 48 to 61 days), 53.8 days (Replication 2, range = 46 to 63 days), or 72.2 days (Replication 3, range = 61 to 80 days). They were weighed and placed in pens of 10 head per pen by population, age, and litter. All pens were identical with 1/3 slatted and 2/3 solid surface, providing approximately 8.5 sq ft per gilt. Gilts of LW x LR and L45X populations were assigned to alternate pens and littermates were assigned to different pens (e.g., Pens 1 and 3 contained littermates, Pens 2 and 4 contained littermates, etc.) Within each of these pairs of pens within populations, one pen was randomly assigned to Treatment 1 (see below), the other received Treatment 2.

Treatments. Gilts received the same diet and management from when they were placed in the MOF until an average age of 123 days. During that time, they had ad libitum access to a standard corn-soybean meal diet. A three-phase feeding regimen was used. Phase 1 diet contained 1.15% lysine and was fed from 56 days of age to when pigs in a pen averaged 80 lb body weight, Phase 2 diet contained 1.0% lysine and was fed from 80 lb to mean weight of 130 lb, Phase 3 diet contained 0.9% lysine and was fed until gilts were 123 days of age when they were placed on experimental dietary regimens.

Treatment 1 was a feeding regimen in which gilts were provided ad libitum access to feed in a self-feeder during the entire period from 123 days of age until they were moved to the breeding barn approximately one week before breeding commenced. The diet was corn-soybean meal-based and formulated to contain 0.70% lysine, 0.70% Ca, and 0.60% P. All other nutrients met or exceeded requirements for developing gilts outlined in the UNL/SDSU Swine Nutrition Guide (2000).

Gilts on Treatment 2 received a daily allotment of feed by weight that was 75% of that consumed by gilts on Treatment 1. The diet was formulated similar to the diet described for Treatment 1 except that it was fortified to contain 0.93% lysine, 1.0% Ca, and 0.8% P. All trace minerals, except selenium, and vitamins were also increased to compensate for reduced feed intake. Daily intake of all nutrients except energy was expected to be similar for gilts on both diets. The daily allotment was adjusted at two-week intervals and was based on average daily feed intake of gilts of the same population with ad libitum access to feed.

When moved to the MOF and at two-week intervals thereafter, feed delivered to each pen during that interval was recorded, and beginning and ending feeder weights were recorded. Average daily feed intake (ADFI) for pens of gilts with ad libitum access to feed (T1 and T2 before 123 days of age, T1 after 123 days of age) in each pen during each two-week period, and the mid-weight (MW) of gilts in that pen ((mean beginning weight + mean final weight)/2) were calculated. After each weigh-day, quadratic regression equations of ADFI on MW were calculated separately for LW x LR and L45X gilts. Beginning at 123 days of age, predicted MW of gilts in each pen on Treatment 2 during the next two-week period was calculated from past growth and used in the regression equation to calculate the expected average feed intake for the pen if ad libitum access to feed was permitted. The average daily allotment for gilts in that pen during the next period was set at 75% of that value. The allotment of feed was placed on

the solid flooring daily in two feedings, one-half at approximately 8:00 a.m. and one-half in late afternoon. At the end of the trial, Replication 1, 2, and 3 gilts averaged 235.8, 218.3, and 225.7 days of age, respectively.

Traits. Gilt weight was recorded at two-week intervals from the beginning to the end of the feeding period, and backfat (BF) and longissimus muscle area (LMA) at the 10th rib were recorded at two-week intervals from when gilts were placed on the feeding regimen at 123 days of age until the end of the feeding regimen.

Beginning when mean age of pigs in each pen was 140 days, heat-checking to determine age at puberty commenced. It was accomplished once daily by moving pigs from each pen to an adjacent building where they were exposed to a boar and observed for the standing response indicative of estrus. The day of first observed estrus was considered to be age at puberty. Heat checking continued until the end of the trial or until all gilts in the pen had been observed in estrus at least twice. Length of estrus, the number of consecutive days they remained in estrus, and the intervals between estrous periods were recorded.

All gilts that had expressed estrus and could be mated at 2nd or later estrus were moved to the breeding facility approximately one week after the feeding period ended. Gilts were approximately 235 days of age. They were observed twice daily for estrus and were inseminated each day they were in estrus with pooled semen from an industry terminal sire line. The breeding period for gilts was approximately 30 days within each replication. Gilts were inseminated each time they were in estrus during that period. Gilts that expressed estrus during the first 10 days of the breeding period and returned to estrus within the 30-day period were inseminated again. Gilts that expressed estrus during the last 20 days of the breeding period did not have an opportunity for a rebreed. All females not pregnant as detected by ultrasound pregnancy testing at 50 days of gestation or that lost litters late in gestation and did not farrow were culled.

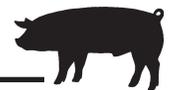


Table 1. Number of gilts at beginning (N_0) and end (N_F) of gilt development period, number expressing pubertal estrus (N_P), number entering breeding (N_B), and numbers of parity 1 (N_1) and parity 2 (N_2) litters for L45X and LW x LR gilts developed with ad libitum access to feed (Ad lib) or restricted to 75% ad libitum amounts (Rest).

Line	TRT	N_0	N_F	N_P	N_B	N_1	N_2
Rep1: Gilt development period from Feb. 23 to Aug. 18, 2005 ^a							
L45X	Ad lib	40	36	35	31	28	23
L45X	Rest	40	38	37	31	25	16
LWx LR	Ad lib	40	40	38	31	26	16
LWx LR	Rest	40	40	34	31	20	16
Rep 2: Gilt development period from July 6 to Dec. 14, 2005							
L45X	Ad lib	29	28	26	26	24	
L45X	Rest	28	27	25	25	18	
LWx LR	Ad lib	50	50	44	43	32	
LWx LR	Rest	50	49	32	31	25	
Rep3: Gilt development period from Jan. 9 to June 8, 2006 ^b							
L45X	Ad lib	39	39	39	37		
L45X	Rest	40	38	35	31		
LWx LR	Ad lib	40	39	36	31		
LWx LR	Rest	40	38	33	31		
Total							
					Percent Finishing trial	Percent with puberty	
L45X	Ad lib	108	103	100	95.4	97.1	
L45X	Rest	108	103	97	95.4	94.2	
LWx LR	Ad lib	130	129	118	99.2	91.5	
LWx LR	Rest	130	127	99	97.7	78.0	

^aSome gilts expressing puberty were randomly culled because of space restrictions.

^bGilts expressing puberty late that could not be mated at 2nd or later estrus were culled.

Table 2. Weight and backfat pre-farrowing and at weaning for gilts of each line and treatment.

Item ^a	Weight, lb		Backfat, in	
	Pre-farrow	Weaning	Pre-farrow	Weaning
L45X	467.1	366.0	0.87	0.76
LwxLR	447.7	383.1	0.85	0.79
Ad lib	459.6	374.4	0.91	0.81
Rest	455.2	374.6	0.81	0.74
P values for line, treatment, and interaction effects				
Line	0.003	0.03	0.77	0.41
TRT	0.40	0.98	0.0007	0.006
Line x TRT	0.49	0.96	0.10	0.19

^aL45X is Line 45 cross, LWxLR = Large White – Landrace cross, Ad lib = ad libitum access to feed during gilt development, Rest = daily feed intake restricted to 75% of ad libitum intake from 123 days to breeding.

After weaning litters, all sows were returned to the breeding area, checked for estrus daily, and inseminated with pooled terminal sire semen each day they were in estrus. The breeding period for sows lasted 24 days from when the first sow in a replication farrowed and was such that all sows were given at least 10 days to express estrus and be inseminated. Sows that did not express estrus during that period were culled.

All gilts and sows were fed alike

during the breeding, gestation, and lactation periods. Diets were formulated according to the UNL/SDSU Swine Nutrition Guide (2000). From when they were moved to the breeding area until inseminated, gilts were flushed with approximately 6 lb of feed daily. Gilts and sows received approximately 4.0 lb of feed during the gestation period until approximately 90 days of gestation when daily allotment of feed was increased to approximately 5.0

lb. Pregnant females were moved to farrowing at approximately 110 days of gestation. A limited amount of feed was fed on the day of farrowing and the following day and then sows were allowed ad libitum access to feed until weaning their litters at approximately 15 days (range of 11 to 20 days).

Sows were weighed and 10th rib backfat was recorded when they were moved to the farrowing room and when they weaned their litter.

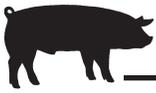
Analyses: Age at puberty was analyzed with a model including line, gilt development regimen, their interaction, and the random effect of litter as the error variance. Sow weight, backfat, and litter traits were analyzed with a model that accounted for line, gilt development treatment, and their interaction. Replication effect was accounted for as a random effect and because littermate gilts were assigned to treatments, effects of litter gilts were born in and repeated measures on sows were accounted for as random effects. Pigs were transferred among litters within one day of birth. Number of pigs after transfer and age of litters at weaning were included in models for number and weight of pigs at weaning to adjust to average number nursed by sows and to average weaning age.

Differences in survival rate during the gilt development period and in percentages of gilts expressing estrus between lines and between treatments were tested with chi-square tests.

Results

Table 1 contains numbers gilts of each line-diet combination at each stage of the experiment, by replication and overall. Losses during the gilt development period due to unthrifty pigs and death of pigs averaged 3.1% and did not differ between lines or between gilt development treatments. However, percentage of gilts expressing estrus differed ($P < 0.05$) between lines, averaging 95.6% for L45X gilts and 84.8% for LW x LR gilts. Gilt development regimen did not affect proportion of L45X gilts that expressed puberty. However, 91.5% of

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LW x LR gilts developed with ad libitum access to feed expressed puberty whereas only 78% of those developed with restricted feed intake expressed puberty ($P < .05$).

Table 2 contains mean weight and backfat at farrowing and weaning of those Replication 1 and 2 gilts that farrowed. LWxLR females were 19.4 lb heavier pre-farrowing and 17.1 lb heavier when litters were weaned than L45X gilts ($P < 0.01$). Gilts of the two lines did not differ significantly in average backfat. Although gilts developed on the two regimens differed in weight at the end of the development period (see following report), they did not differ significantly in either pre-farrow weight or weight when litters were weaned. They did, however, differ significantly in backfat. Gilts developed with ad libitum access to feed had 0.10 in and 0.07 in more fat depth at the 10th rib pre-farrowing and when litters were weaned, respectively, than gilts whose feed intake was 75% of ad libitum amounts.

Thus far, first parity litter data are available only for Replication 1 and 2 females ($n = 198$) and second parity data are available only for Replication

Table 3. Age at puberty (AP), numbers of total (TB) and live (NBA) pigs per litter and number (NW^a) and litter weight (LWT^a) of pigs at weaning.

Item ^b	AP, days	TB	NBA	NW	LWT, lb
L45X	166.8	12.75	11.48	9.77	106.0
LwxLR	170.3	13.21	11.95	9.73	108.4
Ad lib	169.4	12.75	11.62	9.65	104.8
Rest	167.7	13.21	11.80	9.85	109.6
P values for line, treatment, and interaction effects					
Line	0.34	0.32	0.3	0.84	0.46
TRT	0.57	0.31	0.7	0.38	0.14
Line x trt	0.07	0.32	0.07	0.95	0.28

^aNumber of pigs weaned and litter weaning weight adjusted to same number of pigs dams allowed to nurse and for weaning age.

^bL45X is Line 45 cross, LWxLR = Large White – Landrace cross, Ad lib = ad libitum access to feed during gilt development, Rest = daily feed intake restricted to 75% of ad libitum intake from 123 d to breeding.

1 females ($n = 71$). In these preliminary data (Table 3), no significant differences in litter traits due to either line or gilt development regimen exist. Analyses of causes of reproductive failure from the beginning of breeding gilts to weaning Parity 2 litters have not been done.

The objectives of the experiment are being accomplished. Questions of whether energy restriction during gilt development, and thus less backfat at breeding, affects lifetime productivity differently in lines that differ in lean

growth rate will be answered. Also, when all data through four parities for all females are collected, causes of reproductive failures will be better understood.

¹Rodger Johnson and Phillip Miller are professors of Animal Science; Matt Anderson is manager of the UNL Swine Research Farm; Jeff Perkins, Don McClure, Darryl Barnhill, and Tom McGargill are research technicians at the UNL Swine Farm; Laura Albrecht is an Animal Science graduate student, and Roman Moreno is research technician for swine genetics and nutrition.

Effects of Nutrition During Gilt Development on Lifetime Productivity of Sows of Two Prolific Maternal Lines: Growth Characteristics of Replicate 1, 2, and 3 Gilts

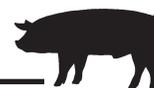
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Summary and Implications

A study was designed to evaluate the effects of energy intake during the

gilt development period (day 123 to day 226 of age) on sow lifetime productivity in two prolific sow lines. Elaboration of the design and preliminary results are available in the 2005 and 2006 University of Nebraska–Lincoln Swine Reports. The two populations used were created by crossing a maternal line boar available from the industry with either sows from the UNL Nutrition Herd (designated LW × LR) or the Nebraska Index Line (designated L45X). At approximately day 123, half the gilts within each genetic line were

allocated to receive ad libitum (A) access to a corn-soybean meal diet or 75% of the ad libitum feed (energy) intake (R). During the developmental period, pigs were weighed, and ultrasound measurements of 10th-rib backfat (BF) and longissimus muscle area (LMA) were recorded every 14 days. In addition, feeders were weighed for the estimation of average daily feed intake for the A groups. Feed intake in the R groups was restricted to 74 to 76% of the A-group gilts. Restricting energy intake was effective at reducing bodyweight gain and BF



depth and LMA in both genetic lines. Subsequent analyses of sow productivity will be based in part on these findings. This type of analysis will be important in evaluating potential gilt development strategies (based on a constant age or body weight) for prolific gilt lines similar to those used in this study.

Introduction

In the 2006 Nebraska Swine Report, we provided an update regarding a research study designed to evaluate effects of nutrition (specifically energy intake) during the gilt development phase (day 123 until breeding) on subsequent sow performance (4 parities). This longevity study was conducted using two prolific maternal lines that maintained different carcass and growth characteristics. The description of reproductive performance data currently collected for the 3 replicates of the study is provided in a companion report (see Johnson et al., 2007 Nebraska Swine Report).

The study was developed to address the significant death losses and culling rates currently experienced by the swine industry. Although a multitude of factors potentially affect sow longevity, we focused on examination on energy intake during the developmental period and sow genetic background. The intention was to reproduce two developmental scenarios commonly used by seedstock companies and swine producers to develop gilts. To our knowledge, no other studies have been conducted that examine effects of energy intake during the developmental period on sow performance during 4 parities. Also, this type of study has not been conducted using sow populations documented to be highly prolific.

The reader is encouraged to consult the 2005 and 2006 Nebraska Swine Reports regarding the basic design of the study and preliminary results. The study was initiated during September 2005. Currently, growth performance criteria have been collected for three separate replications and the replication-3 sows will complete their fourth parity early in 2008.

Table 1. Gilts development diets (as-fed basis).

Ingredient, %	(A)d libitum	(R)estricted
Corn	77.375	67.740
Soybean meal, 47.5% CP	14.600	25.000
Tallow	3.000	3.000
Dicalcium phosphate	1.475	2.375
Limestone	0.650	0.850
Salt	0.500	0.500
Vitamin mix	0.250 ^a	0.334 ^b
Mineral mix	0.150 ^c	0.200 ^d
Total	100.000	100.000
Calculated composition		
ME ^e , kcal/lb	1,561	1,542
Calcium, %	0.70	1.00
Phosphorus, %	0.60	0.80
Crude protein, %	13.50	16.80
Lysine, %	0.70	0.93

^aSupplied per kilogram of diet: vitamin A (as retinyl acetate), 4,400 IU; vitamin D (as cholecalciferol), 440 IU; vitamin E (as α -tocopheryl acetate), 24 IU; vitamin K (as menadione dimethylpyrimidinol bisulfite), 3.5 mg; riboflavin, 8.8 mg; d-pantothenic acid, 17.6 mg; niacin, 26.4 mg; vitamin B₁₂, 26.4 mg.

^bSupplied per kilogram of diet: vitamin A (as retinyl acetate), 5,878 IU; vitamin D (as cholecalciferol), 588 IU; vitamin E (as α -tocopheryl acetate), 32 IU; vitamin K (as menadione dimethylpyrimidinol bisulfite), 4.7 mg; riboflavin, 11.8 mg; d-pantothenic acid, 23.5 mg; niacin, 35.3 mg; vitamin B₁₂, 35.3 mg.

^cSupplied per kilogram of diet: Zn (as ZnO), 128 mg; Fe (as FeSO₄·H₂O), 128 mg; Mn (as MnO), 30 mg; Cu (as CuSO₄·5 H₂O), 11 mg; I (as Ca(IO₃)·H₂O), 0.26 mg; Se (as Na₂SeO₃), 0.3 mg.

^dSupplied per kilogram of diet: Zn (as ZnO), 171 mg; Fe (as FeSO₄·H₂O), 171 mg; Mn (as MnO), 40 mg; Cu (as CuSO₄·5 H₂O), 14.7 mg; I (as Ca(IO₃)·H₂O), 0.35 mg; Se (as Na₂SeO₃), 0.3 mg.

^eMetabolizable energy.

Materials and Methods

Gilt populations

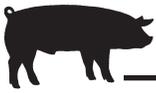
Population-1 gilts were the progeny of UNL swine nutrition females and an industry maternal line (L_M) boar and will be subsequently denoted as LW × LR. Population-2 gilts were the progeny of the L_M boars described above and females from the Nebraska Index Line (L45) selected for increased litter size. In addition, the Nebraska Index Line was selected for improved growth and carcass characteristics during the last six generations. Population-2 gilts will be denoted as L45X. Two-hundred fifty-three LW × LR and 206 L45X gilts completed the growth performance portion of the longevity trial.

Gilt management and dietary treatments

Gilts from both populations were similarly managed in the nursery until approximately 60 days of age (46 lb). Gilts were penned in groups (n = 10) and received identical diets (corn-soybean meal-based) and management until 123 days of age (3-phase grow-

ing-finishing period: phase 1, 1.15% lysine [d 56 to 80 lb]; phase 2, 1.0% lysine [80 to 130 lb]; and phase 3, 0.90% lysine [130 to 123 days]). At this time, gilt pens were assigned to receive one of two dietary regimens (see Table 1 for dietary treatments and calculated nutrient analyses); ad libitum treatment (A) that was a corn-soybean meal diet (0.70% lysine, 0.70% Ca, 0.60% P) provided (ad libitum access to feed and water) until gilts were moved into the breeding barn, or a restricted treatment (R). The R group received a corn-soybean diet at approximately 75% of the energy intake of the A group until moved into the breeding barn. This was achieved by developing a quadratic relationship between body weight (BW) and average daily feed intake (ADFI) for the A groups (maintained within population). The predicted ad libitum feed intake (based on the projected mean BW for the upcoming two-week period), was multiplied by 0.75 to determine the ADFI for the R groups. The diet provided to the R groups contained 0.93% lysine, 1.0% Ca, and

(Continued on next page)



0.80% P. All vitamins and minerals (except Selenium) were also increased similarly relative to the A treatment diet. Therefore, the R treatments were designed to only restrict energy intake and maintain the intake of all other nutrients. The reader is encouraged to consult the companion article (Johnson et al., 2007 *Swine Report*) regarding the specifics documenting pig allotment to treatment and facilities.

Measured traits

Beginning at approximately 123 days of age, pigs were weighed every 14 days and ultrasound measurements of 10th-rib longissimus muscle area (LMA) and backfat (BF) depth were recorded. In addition, feeders were weighed for the determination of ADFI (A groups only). The feeding regimens were continued until pigs were moved into the breeding barn (approximately day 226).

Statistical analyses

Body weight and composition data were analyzed with a model that included line, gilt development regimen and their interaction. Replication and pen were considered random effects and pen was considered the experimental unit. Quadratic regressions were developed to examine the relationships between, BW and age, LMA and BW, and BF and BW for gilts from both lines receiving the two developmental nutritional regimens. See Johnson et al., 2007 *Swine Report* for additional details regarding statistical analyses.

Results and Discussion

Figure 1 depicts the relationship between ADFI and BW for the three trial replications. Body weights used were the period (14 day) average. The feed restriction groups consumed approximately 74 to 76% of the feed intake reported for the ad libitum groups. Examination of feed intake patterns among the three replications demonstrates the variability in ADFI typically observed in our growing-

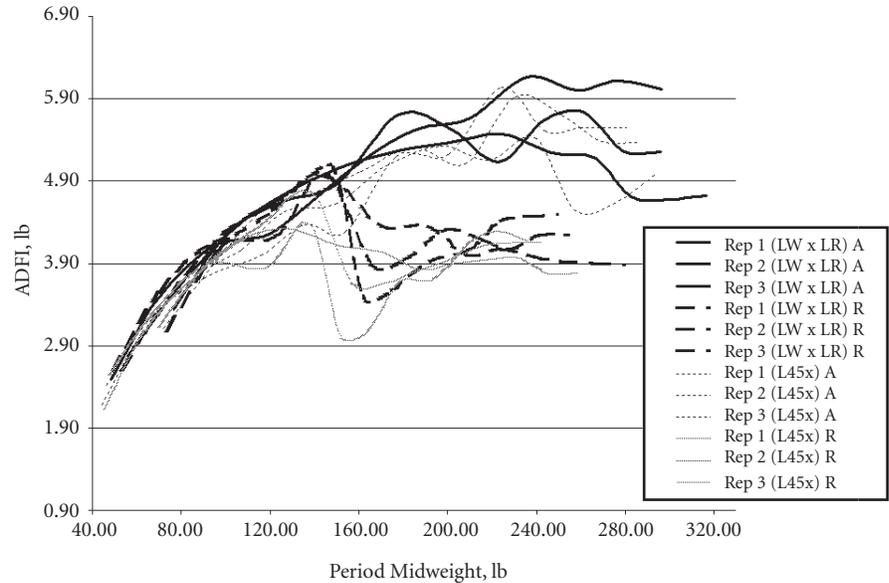


Figure 1. Actual average daily feed intake (ADFI) relative to midweight for LW x LR and L45x gilts receiving ad libitum (A) or 75% of ad libitum (R) treatments. Data for Replicates 1, 2, and 3 are provided.

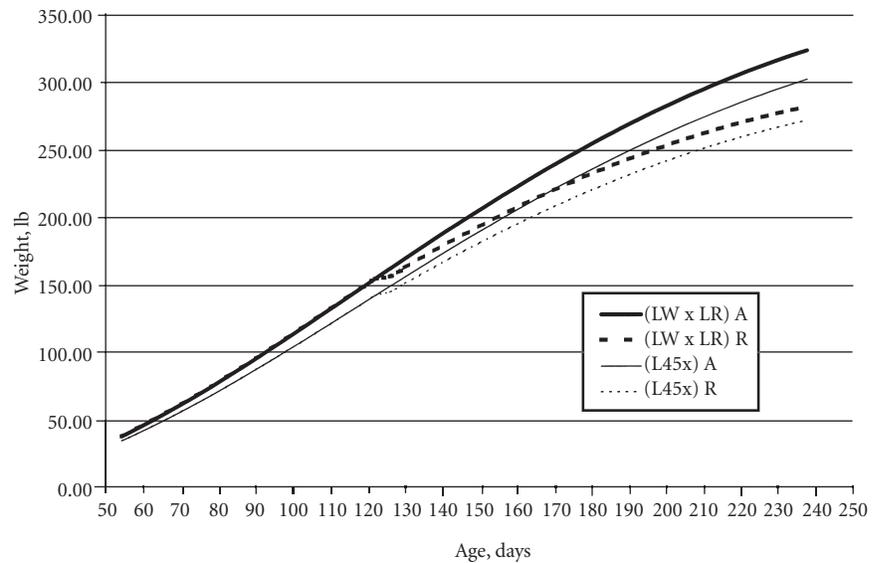


Figure 2. Relationship between weight and age for LW x LR and L45x gilts fed ad libitum (A) or 75% ad libitum (R) treatments from 123 days of age to breeding.

finishing facility. The variation in feed intake observed for the R groups was reduced compared to A groups and was dependent on the feed intake pattern for the A groups. The summary of production traits for gilts is provided in Table 2. Because gilts were allocated to cohort groups at approximately 56 days of age, differences in BW, BF depth, and LMA were detected when feeding regimens were initiated at day 123. Therefore, at a common age, LW x LR gilts were heavier ($P < 0.01$) and maintained greater ($P < 0.05$) backfat depth and LMA compared with L45x

gilts. Figure 2 shows the relationship between BW and age (d). Separate lines for each diet x line combination are presented beginning at day 123 when dietary regimens were initiated. Although no interaction between genetic line and dietary treatment was detected, differences between line and treatment were significant (similar to results presented in Table 2). The LW x LR gilts receiving ad libitum access to feed were the heaviest and the L45x gilts restricted to approximately 75% of ad libitum feed intake had the lowest BW. Therefore, the LW x LR gilts

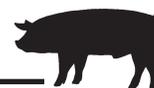


Table 2. Average daily feed intake (ADFI), body weight (BW), ultrasound 10th-rib backfat (BF) and longissimus muscle area (LMA) for LW × LR and L45X gilts fed ad libitum (A) and restricted (R) dietary regimens.

Item	Line				SEM ^a	P value	
	LW × LR		L45X			Line	Diet
	A	R	A	R			
day 123							
No. gilts	130	130	108	108			
BW, lb	158.8	157.2	144.2	145.5	3.29	P < 0.01	NS ^b
BF, in	0.63	0.65	0.60	0.61	0.014	P < 0.05	NS
LMA, in ²	4.08	4.04	3.79	3.81	0.184	P < 0.01	NS
day 226							
No. gilts	129	127	103	103			
ADFI, lb	5.51	4.10	5.22	3.88	0.092	P < 0.01	P < 0.01
BW, lb	312.0	267.5	297.2	252.3	3.78	P < 0.01	P < 0.01
BF, in	1.16	0.79	1.23	0.80	0.02	NS	P < 0.01
LMA, in ²	6.65	5.98	6.40	5.64	0.240	P < 0.01	P < 0.01

^aStandard error of the mean.

^bNonsignificant, P > 0.10

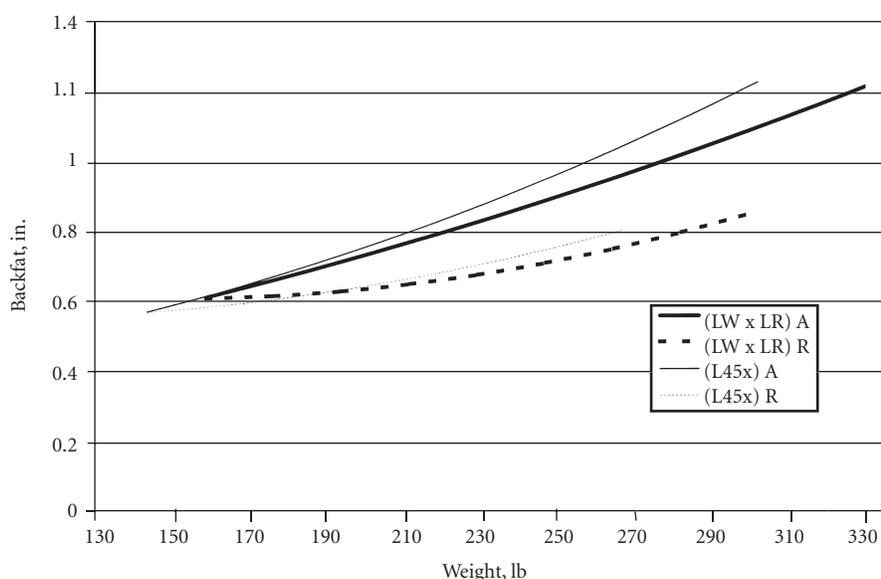


Figure 3a. Within line-treatment regressions of backfat on weight for LW x LR and L45x gilts fed ad libitum (A) or 75% ad libitum (R) treatments from 123 days of age to breeding.

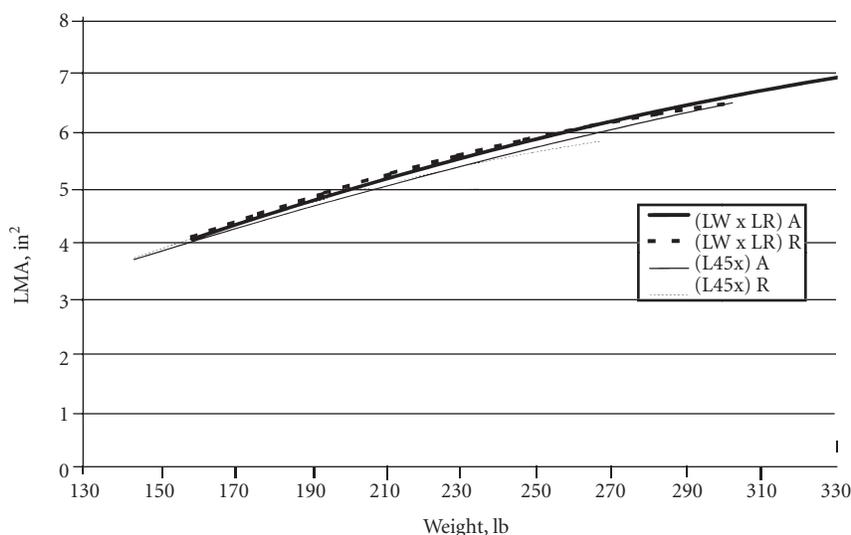


Figure 3b. Within line-treatment regressions of longissimus muscle area on weight for LW x LR and L45x gilts fed ad libitum (A) or 75% ad libitum (R) treatments from 123 days of age to breeding.

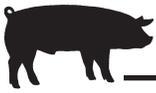
had greater growth rate and accumulated less BF compared with the L45X gilts. Energy restriction was equally effective at reducing BW gain and fat deposition in both genetic lines.

The restricted dietary regimens were designed to primarily restrict energy intake. It appears that restricting ME intake affected fat deposition to a greater extent than muscle deposition (which might be expected if lysine intake was severely limiting). Restricting energy intake during the development period reduced BF 32 to 35% between lines, respectively; however, LMA was only reduced 10 to 12%. This is further substantiated viewing the relationships of BF and LMA vs. BW (see Figures 3a and b). These relationships were developed from the quadratic regression of BW on BF or LMA. The differences in BF (Figure 3a) associated with feeding regimen are more pronounced than differences in LMA (Figure 3b). In addition, fat deposition relative to body weight increased as gilts approached breeding.

Conclusion

Overall, these results indicate that growth and body composition differences between LW × LR and L45X were observed at the end of the developmental period. In addition, restricting energy intake during the developmental period significantly reduced breeding weight, BF, and LMA on day 226 of the study. Also, there were no interactions between feeding regimen and genetic line. Because gilt development systems vary according to dietary regimens used and the reference point at which gilts are bred (i.e., constant age or BW), both points of reference will be used in subsequent analyses to examine the effects of gilt development (as manipulated by energy intake and genetic background) on lifetime reproductive performance.

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Effect of a Commercial Feed Additive on Sow Feed Disappearance and Litter Performance in Two Maternal Lines

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Summary and Implications

One hundred-seventy six parity 2 to 9 line 241 and 482 Danbred NA (Columbus, Neb.) females were used at a parity-segregated commercial farm to evaluate the effect of a feed additive (Luctarom "S" 5597Z®; Lucta S.A., Barcelona, Spain) on sow feed disappearance and litter performance. Treatments were arranged as a 2 x 2 factorial. Control or Luctarom feed was introduced to sows when they were moved into the farrowing quarters four days on average before farrowing. Sows remained on their respective dietary treatment until weaning (average 16.8 days of lactation). Prior to farrowing, sows were limit-fed, but after farrowing they were allowed ad libitum access to feed until weaning. Each sow's allotment of feed was weighed prior to dispersal. Feed disappearance was calculated the next morning by weighing any feed that remained in the feeder. Feed disappearance before and following farrowing was not affected by dietary treatment. During the prefarrowing phase, line 482 sows made more feed disappear than line 241 sows (5.90 vs. 4.83 lb/day; $P = 0.010$). However, during lactation feed disappearance was not different between the lines ($P = 0.865$). Litter size at birth was not affected by dietary treatment. In conclusion, the feed additive used in the study did not improve sow feed intake or reproductive performance in either maternal line. Producers are encouraged to apply basic management techniques to ensure lactating sows maximize their feed intake; for example, provide adequate

temperature control and feed and water access in the farrowing quarters.

Introduction

Low feed intake during lactation continues to limit sow productivity in many operations. It's well established that low lactational feed intake results in excessive sow body weight loss during lactation, lower litter weaning weights and delayed return to estrus following weaning. Several management factors including, farrowing room temperature, feed and water availability, and gestation feeding level affect lactation feed intake. There has also been interest in the use of dietary sweeteners, aromatic compounds and certain natural ingredients to increase sow appetite during lactation. A study conducted by the University of Minnesota found that the inclusion of a 4% sucrose and 2% chocolate additive to a corn-soybean meal-based diet did not enhance voluntary feed intake or improve nursing piglet performance. A cooperative study among several universities determined that a lactation diet containing 2.5% feed grade sucrose (sugar) did not affect sow feed consumption or reproductive performance. In this study we examined the effect of a commercial feed additive on sow feed disappearance and litter performance in two maternal lines.

Materials and Methods

An experiment, replicated twice, was conducted from May to August at a parity-segregated commercial farm in Nebraska using 176 Danbred NA (Columbus, Neb.) parity two to nine females. The experimental design was a generalized randomized complete block. Treatments were arranged as a 2 x 2 factorial with diet and genetic line as main factors:

- 1) Corn-soybean meal based diet
- 2) Corn-soybean meal based diet containing 1.5 lb/ton of Luctarom "S" 5597Z^{®2}
- 3) Danbred NA maternal line 241
- 4) Danbred NA maternal line 482

The corn-soybean meal diet contained 1.2% total lysine, 1482 kcal of metabolizable energy/lb and 3% added fat. Line 241 sows were F₁ Large White x Landrace whereas Line 482 sows were line 241 x 241. In each replication, two farrowing rooms consisting of approximately 60 sows each were selected. One-half of the sows within each room were randomly selected to receive the control diet while the others received the Luctarom diet.

Diets were introduced when the sows were moved into the farrowing quarters 4 days on average before farrowing. Sows remained on their respective dietary treatment until weaning, having lactated an average of 16.8 days. Prior to farrowing, the maximum amount of feed offered was 7 lb/day. In addition, all sows were given 60 g/day of a laxative prior to farrowing. After farrowing, sows were allowed ad libitum access to feed until weaning.

Sows were hand-fed once daily before farrowing and three times daily during lactation. Each sow's allotment of feed was weighed prior to dispersal. Feed disappearance was calculated the next morning by weighing any feed that remained in the feeder. All feed that was weighed back was discarded. Feed wastage was not measured.

Sows and litters were managed according to the farm's standard operating procedures. Piglets were processed within 48 hours of birth and crossfostered within 2 days of birth irrespective of diet or line. Caretakers were blind to the treatments. In addition to feed disappearance, the total number of pigs born, born alive and weaned were recorded. Litter weights

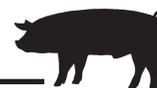


Table 1. Incidence and reason for sow removal from the study according to diet and maternal line.

Diet	Line	Reason
Control	241	Poor prefarrow feed intake
Control	241	Poor prefarrow feed intake
Control	482	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake
Luctarom	482	Poor prefarrow feed intake
Luctarom	241	Poor prefarrow feed intake

Table 2. Effect of diet and maternal line on sows and litter performance – LS means using parity as a covariate.

Item	Diet		Maternal line ^b		SEM ^c	P values		
	Control	Luctarom ^a	241	482		Diet	Line	Diet x line
No. sows	90	75	112	53				
Avg. parity	5.24	5.01	4.04	7.47				
Feed disappearance, lb/day ^d								
Prefarrow	5.19	5.55	4.83	5.90	0.300	0.222	0.010	0.452
Postfarrow	14.97	14.98	14.91	15.03	0.455	0.989	0.856	0.596
Piglets								
Total born/litter	13.35	13.90	14.51	12.74	0.649	0.353	0.040	0.745
Born alive/litter	12.21	12.66	13.31	11.57	0.613	0.429	0.034	0.911

^aLucta S.A., Barcelona, Spain.

^bDanbred NA, Columbus, Neb.

^cSEM = Standard error of the mean.

^dPrefarrow period = 4 days; postfarrow period = 16.8 days.

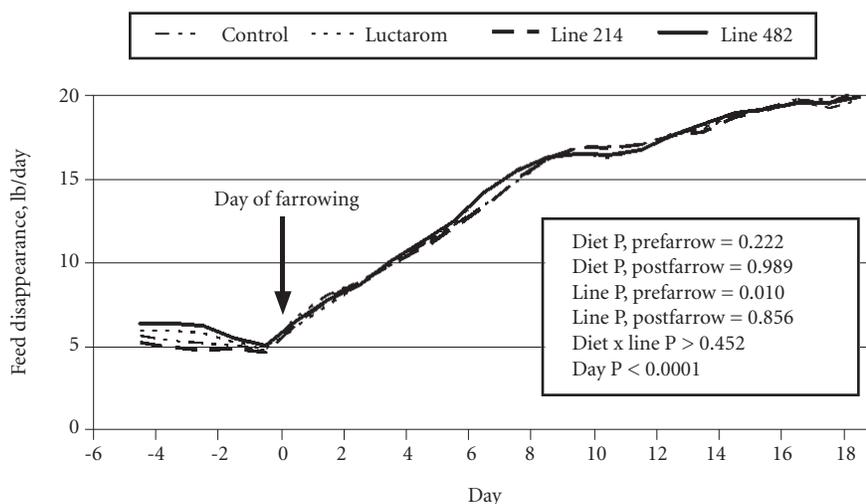


Figure 1. Estimation of feed disappearance during gestation and lactation according to diet and maternal line using parity as a covariate.

were determined at weaning. Twenty-one day litter weights were calculated using the procedures of the National Swine Improvement Federation.

Farrowing rooms were equipped with evaporative coolers; farrowing crates utilized Osborne *Big-Wheel*[®] Model S110 single space feeders, with-

out the self-feeding option employed.

Statistical analysis. Farrowing room was considered as block and sows (or litters) as experimental units in each room. Data were analyzed using analysis of covariance with parity as a covariate and with block as a random factor. Feed disappearance

data were analyzed with a repeated measures analysis of covariance.

Results and Discussion

Ten sows were removed from the study before they farrowed because of poor feed consumption (Table 1). Six of the 10 sows removed were line 241 females consuming the Luctarom diet. One sow consuming the Luctarom died during lactation. There were too few animals represented in each diet and line combination to perform a reliable statistical analysis on this information.

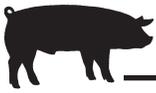
There were no diet x maternal line interactions observed for any of the response variables (Table 2). Feed disappearance before and following farrowing was similar between control and Luctarom sows. Similarly, diet did not affect the number of total or live-born piglets. These results are consistent with those from previous reports where the effects of appetite enhancers on sow feed disappearance were examined.

During the prefarrowing phase line 482 sows made more feed disappear than line 241 sows (5.90 vs. 4.83 lb/day; $P = 0.010$). However, during lactation feed disappearance was not different between the lines ($P = 0.865$).

The pattern of feed disappearance from when the treatments were initiated (4 days on average before farrowing) to day 16.8 on average of lactation is shown in Figure 1. Feed disappearance decreased as farrowing day approached. In addition, sows made disappear less feed than the 7 lb daily maximum amount of feed they were offered. Following farrowing sows had ad libitum access to feed; feed disappearance increased such that sows were making about 20 lb of feed disappear daily at the end of the lactation period.

While the pattern of feed disappearance during lactation that we observed is similar to that reported by previous researchers, the amount of feed that sows in our study made disappear during lactation is significantly greater than that previously reported

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for sows in commercial operations. In 1996, Minnesota researchers reported that sows on 30 commercial farms that lactated for 17 days made disappear 10.5 lb of feed/day. Sows in our study made an average of 15 lb of feed disappear per day during a 17-day lactation period—a 43% increase.

Part of the reason we observed a higher rate of feed disappearance was that there were no parity 1 females used in our study. In contrast, about 25% of the sows in the Minnesota study were parity 1. It is well documented that parity one females consume 10 to 15% less feed than later parity females.

However, given the clear impact that ambient temperature in the farrowing quarters has on sow feed disappearance, the increase in disappearance we observed is remarkable

considering our sows farrowed during the summer while those represented in the Minnesota study farrowed throughout the year. Farrowing room temperature averaged 77°F in our study. Taken together, this indicates significant progress has been made to achieve higher sow lactation feed intake during the last 10 years.

Line 241 sows farrowed more total and live born pigs than line 482 sows (14.51 vs. 12.74; $P = 0.040$ and 13.31 vs. 11.57; $P = 0.034$, respectively). Line 241 females, being F_1 , processed a higher amount of maternal heterosis, resulting in better production efficiency.

Due to pigs being crossfostered irrespective of diet or line, overall averages for litter size weaned (9.65), litter weaning weight (133.52 lb) and 21-day adjusted litter weaning weight (155.35 lb) were determined.

Conclusion

The commercial feed additive used in the study did not improve sow feed intake or reproductive performance in either maternal line. Differences in reproductive performance were apparent between the maternal lines.

¹Dan Towey is an undergraduate student at the University of Nebraska; John Sonderman is manager of technical services, Danbred NA, Columbus, Neb.; Daryl Travnicek is a SAS programmer and Kent Eskridge is a professor, statistics at the University of Nebraska; Duane Reese is an extension swine specialist at the University of Nebraska. Appreciation is expressed to Lucta S.A. and Danbred North America for their contributions to this project.

²Lucta S.A. Barcelona, Spain; feed flavoring additive.

Serum Vitamin B₁₂ and Homocysteine Concentrations of Weanling Pigs Fed Increased Levels of Dietary Vitamin B₁₂

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Summary and Implications

Data were published (2006 Nebraska Swine Report) in which weanling pigs (weaned 13- to 14-days) were fed graded levels of dietary vitamin B₁₂ in a 35-day study (phase 1, day 0 to day 14; phase 2, day 14 to day 35). Dietary treatments included: NC, negative control, basal diet without supplemented vitamin B₁₂; or the basal diet with the inclusion of 100% (1X, 7.94 µg/lb), 200% (2X, 15.87 µg/lb), 400% (4X, 31.75 µg/lb), 800% (8X, 63.49 µg/lb), or 1,600% (16X, 126.98 µg/lb) of NRC requirements for the 11- to 22-lb pig. Throughout phase 1, there were no differences among treatments. During phase 2 and overall (phase

1 and phase 2), the inclusion of vitamin B₁₂ resulted in a linear increase ($P < 0.05$) in ADG and ADFI. Subsequently (after the publication of the 2006 swine report), serum samples were analyzed for vitamin B₁₂ and homocysteine. On day 0, there were no differences in serum concentrations of vitamin B₁₂ or homocysteine among treatments. On day 14 and 35, serum vitamin B₁₂ and homocysteine concentrations increased linearly and quadratically ($P < 0.05$) to dietary B₁₂ addition. The average daily change in homocysteine decreased linearly and quadratically ($P < 0.05$) to the inclusion of vitamin B₁₂ in the diet. The average daily change in serum vitamin B₁₂ increased linearly ($P < 0.05$) as the inclusion of vitamin B₁₂ in the diet increased. Although there is conflicting growth data, the data from the analyses of serum metabolites suggests that the vitamin B₁₂ requirement lies between

the 1X and 4X treatments (7.94 µg/lb and 31.75 µg/lb, respectively) to prevent the accumulation of homocysteine. The responses of serum metabolites (vitamin B₁₂ and homocysteine) are more sensitive to dietary B₁₂ status compared to growth performance criteria.

Introduction

Vitamin B₁₂ is a water-soluble vitamin that is involved in the utilization of dietary protein and energy. Vitamin B₁₂ is required as a coenzyme in the conversion of homocysteine to methionine. Without a sufficient supply of vitamin B₁₂, homocysteine cannot be converted to methionine and an increase of homocysteine occurs. Homocysteine is a toxic metabolite which can negatively impact processes leading to muscle growth (DNA synthesis and protein accretion).

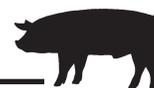


Table 1. Composition of phase 1 and phase 2 dietary treatments (as-fed basis).

Ingredients, %	Phase 1 ^{1,2}						Phase 2 ^{1,3}					
	NC	1X	2X	4X	8X	16X	NC	1X	2X	4X	8X	16X
Corn	31.81	31.81	31.81	31.81	31.81	31.81	45.09	45.09	45.09	45.09	45.09	45.09
Soybean meal, 46.5% CP	10.63	10.63	10.63	10.63	10.63	10.63	30.59	30.59	30.59	30.59	30.59	30.59
Soy protein concentrate	6.25	6.25	6.25	6.25	6.25	6.25	0.00	0.00	0.00	0.00	0.00	0.00
Whey, dried	30.00	30.00	30.00	30.00	30.00	30.00	14.99	14.99	14.99	14.99	14.99	14.99
Animal plasma	8.00	8.00	8.00	8.00	8.00	8.00	2.00	2.00	2.00	2.00	2.00	2.00
Blood cells	0.00	0.00	0.00	0.00	0.00	0.00	3.00	3.00	3.00	3.00	3.00	3.00
Lactose	4.00	4.00	4.00	4.00	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
Dicalcium phosphate	1.28	1.28	1.28	1.28	1.28	1.28	1.60	1.60	1.60	1.60	1.60	1.60
Limestone	0.69	0.69	0.69	0.69	0.69	0.69	0.53	0.53	0.53	0.53	0.53	0.53
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Corn oil	5.00	5.00	5.00	5.00	5.00	5.00	3.00	3.00	3.00	3.00	3.00	3.00
Mecadox [®]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UNL mineral mix ⁴	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
UNL vitamin mix ⁵	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.2	0.25	0.25
Zinc oxide	0.40	0.40	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine • HCl	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.10	0.10
DL-methionine	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin B ₁₂ , µg/lb	0.00	7.94	15.87	31.75	63.49	126.98	0.00	7.94	15.87	31.75	63.49	126.98

¹NC = negative control, 1X = 100% of NRC vitamin B₁₂ requirement (7.94 µg/lb), 2X = 200% of NRC vitamin B₁₂ requirement (15.87 µg/lb), 4X = 400% of NRC vitamin B₁₂ requirement (31.75 µg/lb), 8X = 800% of NRC vitamin B₁₂ requirement (63.49 µg/lb), 16X = 1,600% of NRC vitamin B₁₂ requirement (126.98 µg/lb).

²Phase 1 diets formulated to contain: lysine, 1.60%; Ca, 0.91%; P, 0.80%; available P, 0.57%.

³Phase 2 diets formulated to contain: lysine, 1.42%; Ca, 0.85%; P, 0.75%; available P, 0.45%.

⁴Supplied per kg of diet: Zn (as ZnO), 128 mg; Fe (as FeSO₄•H₂O), 128 mg; Mn (as MnO), 30 mg; Cu (as CuSO₄•5 H₂O), 11 mg; I (as Ca (IO₃)•H₂O), 0.26 mg; Se (as Na₂SeO₃), 0.3 mg.

⁵UNL vitamin mix excluding vitamin B₁₂. Supplied per kg of diet: vitamin A (as retinyl acetate), 5,500 IU; vitamin D (as cholecalciferol), 550 IU; vitamin E (as α-tocopheryl acetate), 30 IU; vitamin K (as menadione dimethylpyrimidinol bisulfite), 4.4 mg; riboflavin, 11 mg; d-pantothenic acid, 22.5 mg; niacin, 33 mg.

Previously at the University of Nebraska, research was conducted which showed a linear increase in average daily gain (ADG) and average daily feed intake (ADFI) in weanling pigs with the inclusion of vitamin B₁₂ at graded levels in excess of the NRC recommendations for the 11- to 22-pound pig (2003 and 2006 Nebraska Swine Report). After the publication of the 2006 Swine Report, serum samples were analyzed for vitamin B₁₂ and homocysteine. The analysis of these serum metabolites will help to more precisely define the vitamin B₁₂ requirement of weanling pigs in the 11- to 44-lb weight range. Therefore, this article combines the growth data published in the 2006 Swine Report with additional serum metabolite data.

Materials and Methods

Experimental design

The experimental protocol was reviewed and approved by the Institutional Animal Care and Use Committee of the University of Nebraska–Lincoln. One hundred

Table 2. Phase 1, phase 2, and overall growth responses of 10- to 45-lb pigs. NC = negative control, 1X = 100% (7.94 µg/lb), 2X = 200% (15.87 µg/lb), 4X = 400% (31.75 µg/lb), 8X = 800% (63.49 µg/lb), and 16X = 1,600% (126.98 µg/lb) of NRC vitamin B₁₂ requirements for the 11- to 22-lb pig.

	Dietary treatment						P values		
	NC	1X	2X	4X	8X	16X	SEM ^a	Treatment	Linear
ADG, lb									
Phase 1	0.46	0.50	0.50	0.47	0.55	0.54	0.033	0.423	0.092
Phase 2	1.080	1.18	1.22	1.18	1.23	1.24	0.035	0.032	0.016
Overall	0.83	0.91	0.93	0.90	0.96	0.96	0.023	0.005	0.002
ADFI, lb									
Phase 1	0.67	0.71	0.71	0.72	0.77	0.77	0.036	0.384	0.057
Phase 2	1.59	1.65	1.72	1.69	1.74	1.75	0.044	0.120	0.029
Overall	1.22	1.28	1.31	1.30	1.35	1.35	0.033	0.071	0.012
ADG/ADFI, lb/lb									
Phase 1	0.68	0.69	0.70	0.66	0.71	0.70	0.038	0.335	0.381
Phase 2	0.68	0.72	0.71	0.70	0.71	0.71	0.026	0.305	0.301
Overall	0.68	0.71	0.71	0.69	0.71	0.71	0.021	0.093	0.154

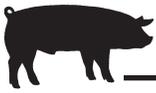
^aSEM = standard error of the mean.

forty-four pigs were weaned (13 to 14 days post farrowing), sorted based on initial weaning weight and litter-of-origin, and randomly assigned to one of six dietary treatments. There were four pigs per pen (two gilts/two barrows) and six replications per treatment. Average initial weight

was approximately 10 lb. The study consisted of two, five-week trials, each divided into phase 1 (day 0 to day 14) and phase 2 (day 14 to day 35).

The six dietary treatments included (Table 1): NC, negative control, basal diet without supplemented

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vitamin B₁₂; or the basal diet with the inclusion of 100% (1X, 7.94 µg/lb), 200% (2X, 15.87 µg/lb), 400% (4X, 31.75 µg/lb), 800% (8X, 63.49 µg/lb), or 1,600% (16X, 126.98 µg/lb) of NRC vitamin B₁₂ requirements for the 11- to 22-lb pig.

Live animal care and measurements

Pigs were housed in pens (6.3 x 3.4 ft) with wire flooring, one nipple waterer, and one stainless steel feeder under constant lighting. Pigs had ad libitum access to feed and water throughout the entire study. Room temperature was maintained at approximately 80°F. Mats and heat lamps were placed in pens for phase 1 (day 0 to day 14) and removed for the remainder of the trial. Blood was collected each week for analysis of serum vitamin B₁₂ and homocysteine. Pigs and feeders were weighed weekly for determination of ADG, ADFI, and ADG/ADFI.

Laboratory analyses

Blood was collected weekly via venipuncture from the brachial region and immediately centrifuged. Serum was collected and frozen (0°C) until analyses. Serum homocysteine was analyzed using a HPLC (high performance liquid chromatography) procedure developed by Pfeiffer et al. Serum vitamin B₁₂ was analyzed using a competitive radioassay (SimulTRAC-S radioassay kit, MP Biomedicals) which used ⁵⁷Co as the competitive binder.

Statistical analysis

Growth and serum data were analyzed as completely randomized designs using the MIXED procedure of SAS. The main effect of the statistical models was dietary treatment. Pen was considered the experimental unit for analyses. Contrasts were made to observe linear and quadratic responses to the addition of dietary vitamin B₁₂.

Results and Discussion

Table 2 shows the growth criteria responses to dietary treatments. The growth performance data were

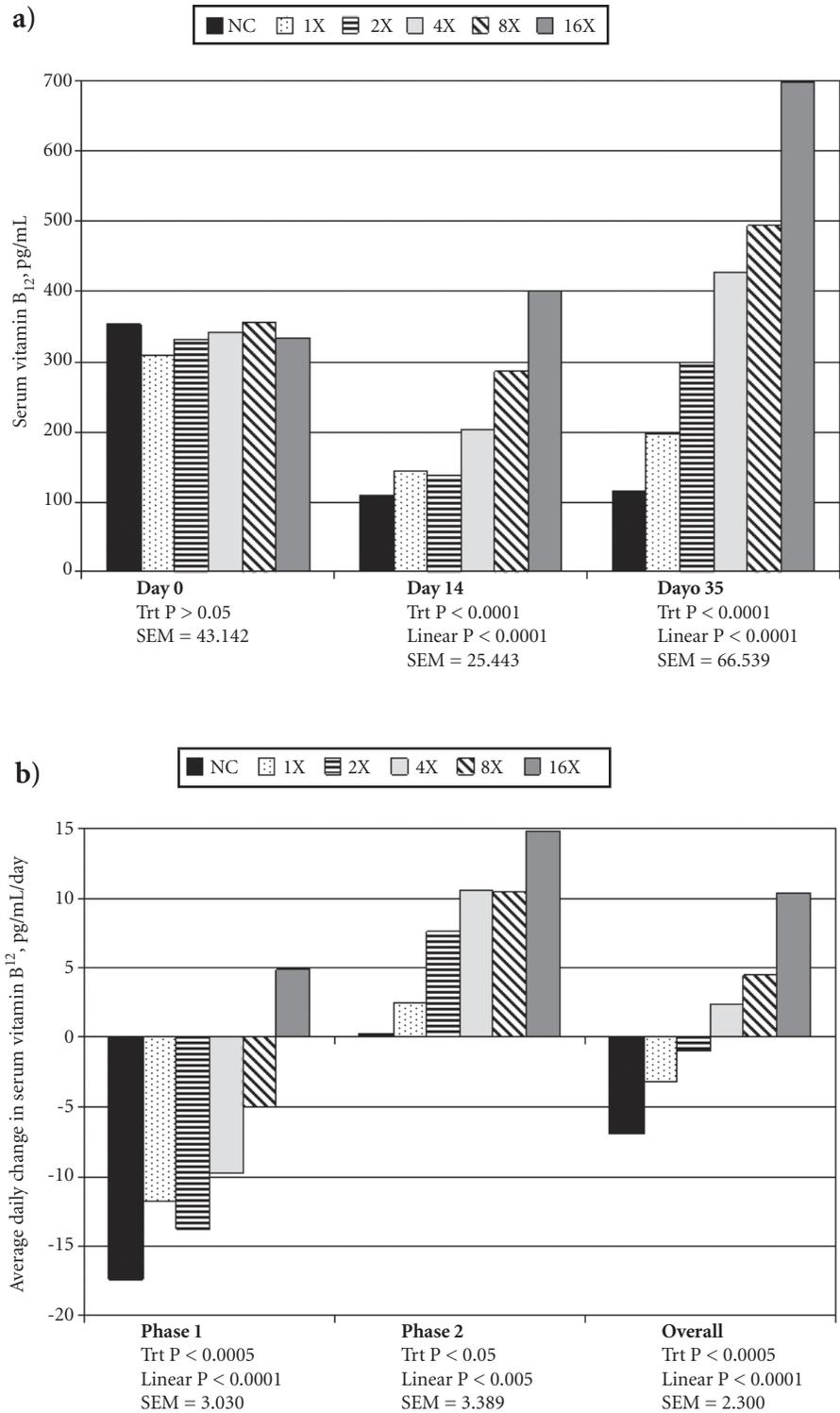


Figure 1. Serum vitamin B₁₂ concentrations in response to dietary treatments. a) Serum vitamin B₁₂ concentrations at day 0, 14, and 35, b) Average daily change in serum vitamin B₁₂ concentrations during phase 1, phase 2, and overall. NC = negative control, 1X = 100% (7.94 µg/lb), 2X = 200% (15.87 µg/lb), 4X = 400% (31.75 µg/lb), 8X = 800% (63.49 µg/lb), and 16X = 1,600% (126.98 µg/lb) of NRC vitamin B₁₂ requirement for the 11- to 22-lb pig. SEM = standard error of the mean.

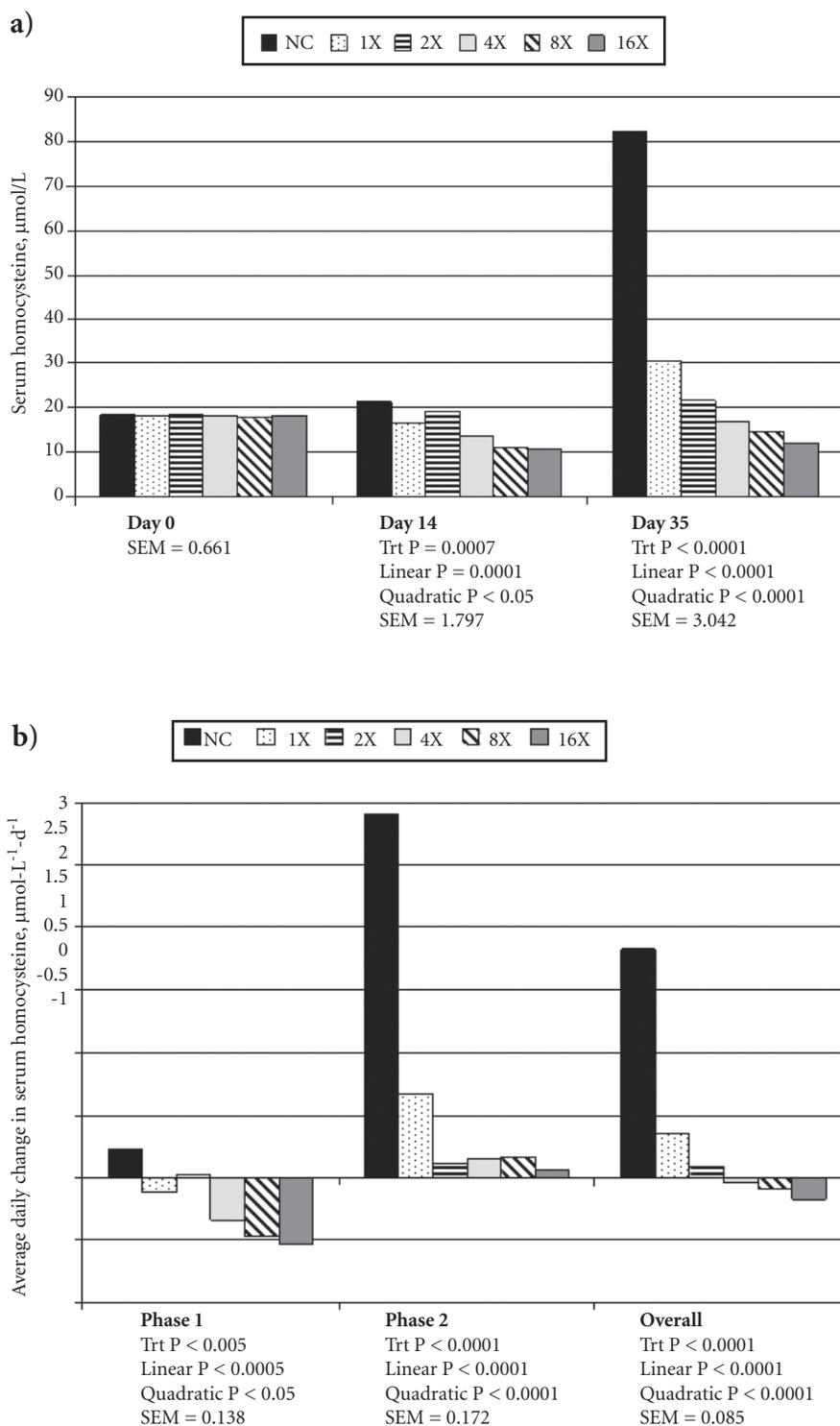
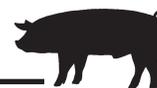


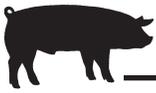
Figure 2. Serum homocysteine concentrations in response to dietary treatments. a) Serum homocysteine concentrations at day 0, 14, and 35, b) Average daily change in serum homocysteine concentrations during phase 1, phase 2, and overall. NC = negative control, 1X = 100% (7.94 $\mu\text{g/lb}$), 2X = 200% (15.87 $\mu\text{g/lb}$), 4X = 400% (31.75 $\mu\text{g/lb}$), 8X = 800% (63.49 $\mu\text{g/lb}$), and 16X = 1,600% (126.98 $\mu\text{g/lb}$) of NRC vitamin B₁₂ requirement for the 11- to 22-lb pig. SEM = standard error of the mean.

previously published in the 2006 *Nebraska Swine Report*. There were no effects of dietary B₁₂ addition on ADG, ADFI, or ADG/ADFI during phase 1. Average daily gain and ADFI responded linearly ($P < 0.05$) to the addition of vitamin B₁₂ during phase 2. Pigs receiving the NC had lower ADG and ADFI (ADG = 1.08 lb; ADFI = 1.59 lb) compared with other treatments, and the pigs receiving the 16X treatment had the greatest ADG and ADFI (ADG = 1.24 lb; ADFI = 1.75 lb). For the overall experimental period, there was an effect of B₁₂ addition ($P = 0.005$) on ADG. Also, the addition of B₁₂ resulted in a linear increase ($P < 0.05$) in ADG and ADFI for the overall experimental period. Overall, pigs receiving the NC had the lowest ADG and ADFI (ADG = 0.83 lb, ADFI = 1.22 lb) while the 8X and 16X treatments had the greatest ADG and ADFI (ADG = 0.96 lb, ADFI = 1.35 lb).

Figure 1a shows the serum vitamin B₁₂ concentrations at day 0, 14, and 35. There were no differences (336.98 pg/mL, $P > 0.05$) in serum concentrations on day 0. On day 14 and 35, serum B₁₂ concentrations increased linearly ($P < 0.0001$) as dietary B₁₂ concentration increased. Pigs receiving the 16X treatment had the greatest (400.61 pg/mL) serum vitamin B₁₂ concentration compared with pigs receiving the NC (109.57 pg/mL) on day 14. On day 35, there was a similar response with the 16X treatment having the greatest (696.99 pg/mL) serum vitamin B₁₂ concentration compared with the NC (115.47 pg/mL). Figure 1b shows the average daily change in serum concentrations of vitamin B₁₂. For phase 1, phase 2, and the overall experimental period, the change in serum B₁₂ concentration increased linearly ($P < 0.005$) in response to increased dietary B₁₂ concentration.

Figures 2a and b show the serum homocysteine concentrations in response to dietary treatment. Figure 2a shows the serum homocysteine concentrations on day 0, 14, and 35. There were no differences ($P > 0.05$) among treatments for baseline (day

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0) serum homocysteine concentrations. On day 14, serum homocysteine decreased linearly ($P < 0.0001$) and quadratically ($P < 0.05$) to the addition of dietary vitamin B₁₂. The NC had the greatest homocysteine concentration (21.5 $\mu\text{mol/L}$) whereas the 16X treatment had the lowest concentration (10.7 $\mu\text{mol/L}$). On day 35, a linear and quadratic reduction ($P < 0.001$) in homocysteine in response to vitamin B₁₂ addition was observed. The NC had the greatest homocysteine concentration (82.4 $\mu\text{mol/L}$) while the 16X treatment (12.1 $\mu\text{mol/L}$) had the lowest homocysteine concentration. Figure 2b shows the average daily change in serum homocysteine. For phase 1, phase 2, and the overall experimental period, the daily change in serum homocysteine decreased (linear, $P < 0.0005$; quadratic, $P < 0.05$). The greatest decrease in daily homocysteine change was observed during phase 2. This change ranged from 2.90 $\mu\text{mol/L}$ for the NC to 0.065 $\mu\text{mol/L}$ for the 16X treatment group.

The ingestion of sufficient concentrations of vitamin B₁₂ allows

homocysteine to be converted to methionine. The accumulation of homocysteine is associated with detrimental effects. Throughout the study, as dietary vitamin B₁₂ intake increased, serum vitamin B₁₂ also increased and serum homocysteine decreased. Determination of serum parameters (vitamin B₁₂ and homocysteine) may be a more sensitive method of detecting a change in the B₁₂ status of an animal than growth parameters (ADG, ADFI, and ADG/ADFI). Therefore, a change in serum parameters may occur prior to a change in the growth parameters. This may explain why there were no differences among treatments in ADG, ADFI, or ADG/ADFI during phase 1; however differences ($P < 0.005$) among treatments were observed in the change in concentrations of vitamin B₁₂ and homocysteine. During phase 1, pigs may have had sufficient vitamin B₁₂ stores to fulfill essential biological roles. Although the concentration of serum vitamin B₁₂ decreased, it had not reached a concentration which caused serum homocysteine to increase. The deter-

mination of a vitamin B₁₂ requirement from the response of growth performance parameters is less evident than previously identified in other studies conducted by our group. However, based on serum concentrations and changes in concentrations of B₁₂ and homocysteine we believe that the vitamin B₁₂ requirement is between the 1X and 4X treatments.

Conclusions

This study suggests that the dietary vitamin B₁₂ requirement to prevent the accumulation of homocysteine is between 100% (7.94 $\mu\text{g/lb}$) and 400% (31.75 $\mu\text{g/lb}$) of the swine NRC requirement for the 11- to 44-lb pig. This study also suggests that analyzing serum homocysteine concentrations is a useful means of determining vitamin B₁₂ status in the weanling pig.

¹Laura R. Albrecht is a graduate student, Robert L. Fischer is a former graduate student and research technologist, and Phillip S. Miller is a professor in the Animal Science Department.

Effects of Repaxol® and Aciprol on Growth Performance of Weaned Pigs Challenged with *Escherichia Coli* K88

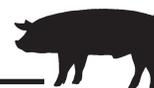
T.E. Burkey
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Summary and Implications

A 28-day experiment was conducted to compare the effects of feeding Repaxol® and Aciprol to weanling pigs in diets otherwise free

of commonly used antibiotic growth promotants (AGPs). Pigs were fed experimental diets for 1 week, then challenged orally with enterotoxigenic *Escherichia coli* (ETEC) K88 in order to model the diarrhea and growth retardation commonly observed following weaning. Growth performance (average daily gain, average daily feed intake and feed efficiency) was monitored and analyzed for the periods between days 0 to 7 (Phase I), days 8 to 28 (Phase II) and days 0 to 28. In addition, bacterial shedding was quantified and fecal scores were obtained on days 8, 14,

and 28 (corresponding to days 1, 7, and 21 post-inoculation). There were no significant effects of treatment on growth performance or fecal score over the length of this experiment. However, Repaxol® fed pigs tended to shed greater amounts of ETEC K88 on day 1 following oral inoculation than pigs in all other treatment groups ($P = 0.15$). Taken together, these results indicate that pigs fed Repaxol® may be afforded an advantage in the clearance of ETEC K88 from the gastrointestinal tract. The mechanism(s) by which Repaxol® may affect ETEC K88 clearance will require further investigation. The level

**Table 1. Composition of phase I (PI) and phase II (PII) diets (as-fed basis) %^a**

Ingredient, %	Control		Zinc		RepaXol®		RepaXol® + Aciprol	
	PI	PII	PI	PII	PI	PII	PI	PII
Corn	44.00	58.54	43.67	58.21	44.00	58.52	43.89	58.43
Soybean meal, 46.5 % CP	30.50	34.79	30.53	34.81	30.50	34.79	30.51	34.79
Select menhaden fish meal	5.00	0.00	5.00	0.00	5.00	0.00	5.00	0.00
Spray dried whey	15.00	0.00	15.00	0.00	15.00	0.00	15.00	0.00
Soybean oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Monocal. phosphate, 21% P	0.80	1.40	0.80	1.40	0.80	1.40	0.80	1.40
Limestone	0.50	1.00	0.50	1.00	0.50	1.00	0.50	1.00
Salt	0.20	0.30	0.20	0.30	0.20	0.30	0.20	0.30
Zinc oxide	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Vitamin premix with phytase	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lysine•HCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-methionine	0.15	0.13	0.15	0.13	0.15	0.13	0.15	0.13
L-threonine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
RepaXol®	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01
Aciprol	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^aPhase II diets did not include fish meal or spray dried whey.

of enteric disease burden observed in this experiment does not allow for a complete assessment of the effects of RepaXol®, the combination of RepaXol® and Aciprol or zinc on growth performance, fecal shedding or fecal scores.

Introduction

Enterotoxigenic *Escherichia coli* (ETEC) are a common cause of diarrhea in newborn and weaned pigs. ETEC are typically characterized by the presence of fimbrial adhesins and the production of enterotoxins. In swine, ETEC strains most commonly associated with diarrheal diseases possess adhesins known as either F18 or K88. In addition, ETEC may produce combinations of three types of enterotoxins that disrupt intestinal fluid homeostasis, leading to hypersecretion of electrolytes and water resulting in diarrhea. Enterotoxins produced by ETEC include heat-labile (LT), and heat-stable (STa and STb) enterotoxins. In addition to ETEC K88 virulence factors, environmental and genetic factors may also contribute to the onset of diarrhea which may result in poor growth performance and increased mortality in young pigs. To date, various strategies (in-feed antibiotics, pro- and prebiotics, etc.) have been utilized in an attempt to control diar-

rhea in young pigs and experiments investigating these strategies have resulted in variable outcomes. Another possible intervention which may hold promise utilizes special blends of essential oils and organic acids. RepaXol® is an encapsulated blend of essential oils (cinnamon, oregano, thyme, capsicum and citrus extracts) that is protected by double coating to improve feed utilization. Aciprol is a combination of organic and inorganic acids (fumaric, citric, malic and orthophosphoric acids) that has been encapsulated using MICROPEARLS® technology that enables Aciprol to reach the hind gut. These products may enhance the utilization of feed by stimulating enzyme secretions, controlling the harmful bacteria, increasing beneficial bacteria and improving digestion leading to improved animal performance. The current study was designed to evaluate growth performance, fecal shedding and fecal scores in pigs fed RepaXol® or the combination RepaXol® and Aciprol prior to and after challenge with ETEC K88. Although statistically it was possible to compare the effectiveness of RepaXol® alone versus the combination of RepaXol® and Aciprol, the primary objective was to compare pigs fed each of these treatments individually to either pigs fed diets containing no antibiotic growth promotants (AGPs),

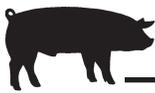
or to pigs fed diets containing a pharmacological level of zinc supplied by zinc oxide.

Materials and Methods

Experimental Design

This research was conducted at Kansas State University and the experimental protocol used in this study was approved by the Kansas State University Institutional Animal Care and Use Committee. A total of 96 pigs weaned at 21 days of age were blocked by weight and assigned randomly within blocks to four dietary treatments in a 28-day study. Treatments had 12 replicates (pens) with four pens per block, and two pigs per pen. The four dietary treatments (Table 1) included a negative control diet with no AGPs (control), a positive control diet containing zinc oxide (zinc; 3000 ppm; as-fed basis), and the test diets containing RepaXol® (220 ppm) or the combination of RepaXol® and Aciprol (100 ppm RepaXol® and 1,000 ppm Aciprol). None of the diets contained other AGPs. To ensure that pigs began the study free of ETEC K88, fecal samples were obtained and cultured between arrival at the study facility and the onset of the experiment. All initial fecal samples were free

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of culturable nalidixic acid-resistant ETEC K88 (detailed below). Thus, 10 days separated weaning from the onset of the study and ensured all pigs began the study free of obvious clinical signs of enteric disease. Pigs were fed Phase I diets with the indicated treatments for one week. Then, all pigs were given 10^{10} CFU ETEC K88 orally (detailed below), and the study continued for an additional three weeks with pigs receiving a Phase II diet with the indicated treatments. Inclusion rates for RepaXol® and Aciprol were consistent with manufacturer-recommended levels. All pigs were housed in a temperature-controlled barn with constant lighting. Each pen contained a single nipple waterer and a single self-feeder to facilitate ad libitum access to water and feed. An initial weight was obtained on day 0, with subsequent pig weights and feed disappearance measurements obtained on days 7, 14, 21, and 28. Pig weights and feed intake were used to determine ADG, ADFI, and feed/gain ratio.

Bacterial Culture and Oral Challenge

The ETEC K88 used in the current study was from a swine clinical isolate. The isolate was selected for resistance to 100 µg/mL nalidixic acid using standard microbiological procedures. Following selection for nalidixic resistance, the isolate was confirmed in a multiplex PCR assay to be positive for K88, LT and STb. Moreover, the isolate used for inoculation was evaluated *in vitro*, and found to stimulate inflammatory chemokine secretion in a model swine intestinal epithelium.

For inoculation, primary cultures of the ETEC K88 were grown for 10 hours in tryptic soya broth and 100 µg/mL nalidixic acid at 98.6°F. On day 7 of the experiment, all pigs received 9 mL of the bacterial suspension (delivering approximately 10^{10} CFU) through a catheter inserted into the esophagus. Pen fecal samples were obtained by mixing feces from both pigs in a pen. Samples of feces were collected on days 8, 14 and 28 (corresponding to days 1, 7 and 21

Table 2. Body weights (BW), average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (F/G) of nursery pigs fed various dietary additives and challenged with *Escherichia coli* K88.

	Treatments ^a				SEM	P value
	Control	Zinc	RepaXol®	RepaXol® + Aciprol		
Avg BW						
Day 0	22.0	21.7	21.7	21.9	0.62	
Day 7	26.3	26.2	25.6	26.3	0.77	
Day 14	35.8	34.9	34.9	35.1	0.98	
Day 21	41.9	41.3	40.9	41.4	1.09	
Day 28	53.5	53.4	53.0	53.4	1.16	
Day 0 - 7						
ADG, lb	0.61	0.65	0.56	0.64	0.04	0.39
ADFI, lb	0.96	1.00	0.89	0.93	0.05	0.12
F/G	1.57	1.54	1.59	1.45	0.03	0.38
Day 8 - 28						
ADG, lb	1.30	1.30	1.30	1.29	0.03	0.99
ADFI, lb	2.01	1.91	1.91	1.93	0.05	0.39
F/G	1.55	1.47	1.47	1.50	0.03	0.17
Day 0 - 28						
ADG, lb	1.13	1.13	1.12	1.13	0.03	0.99
ADFI, lb	1.75	1.69	1.66	1.68	0.04	0.38
F/G	1.55	1.50	1.48	1.49	0.01	0.30

^aControl = diet containing no added antimicrobials; Zinc = Control diet with 3000 ppm zinc oxide; RepaXol® = Control diet with 220 ppm RepaXol®; RepaXol® + Aciprol = Control diet with 100 ppm RepaXol® and 1000 ppm Aciprol.

post-inoculation) to quantify bacterial shedding and for fecal scoring (0 = dryer, harder than normal feces; 1 = normal feces; 2 = softer, more liquid than normal feces; 3 = moderately liquid feces; 4 = extremely liquid feces).

Results and Discussion

Pig body weight and growth performance characteristics are summarized in Table 2. Pigs were approximately 31 days of age on day 0 of the study, and body weight averaged 22.0, 21.7, 21.7, and 21.9 lb for pigs fed control, zinc, RepaXol® and the combination of RepaXol® and Aciprol diets, respectively. At the conclusion of the study, pigs fed control, zinc, RepaXol® and the combination of RepaXol® and Aciprol diets averaged 53.5, 53.4, 53.0, 53.4 lb, respectively. An evaluation of the growth performance during the week prior to inoculation (day 0 to 7), the three weeks following infection (day 8 to 28), and during the overall length of this experiment (day 0 to 28) revealed no significant effects of treat-

ment on ADG, ADFI, feed efficiency, or final body weight. Although the ETEC K88 isolate used for inoculation contained appropriate virulence factors and was provided at an oral dose similar to other published reports, experimental exposure to ETEC did not negatively impact growth in the current study. Thus, the current study may not have provided sufficient enteric disease burden to adequately assess the ability of RepaXol® or the combination of RepaXol® and Aciprol to intervene in ETEC-associated growth challenge in nursery pigs.

Fecal scores were obtained to provide ancillary evidence of treatment effects on gut health following ETEC K88. Fecal scores (Figure 1) were similar among treatments and no treatment by day interaction was observed. However, when fecal scores were averaged across all treatments, fecal scores were lower on day 21 post-inoculation compared to day 1 ($P < 0.01$) or day 7 post-inoculation ($P < 0.001$). Pen fecal scores of 4 were not observed. Fecal scores of 3 (indicating a moderate

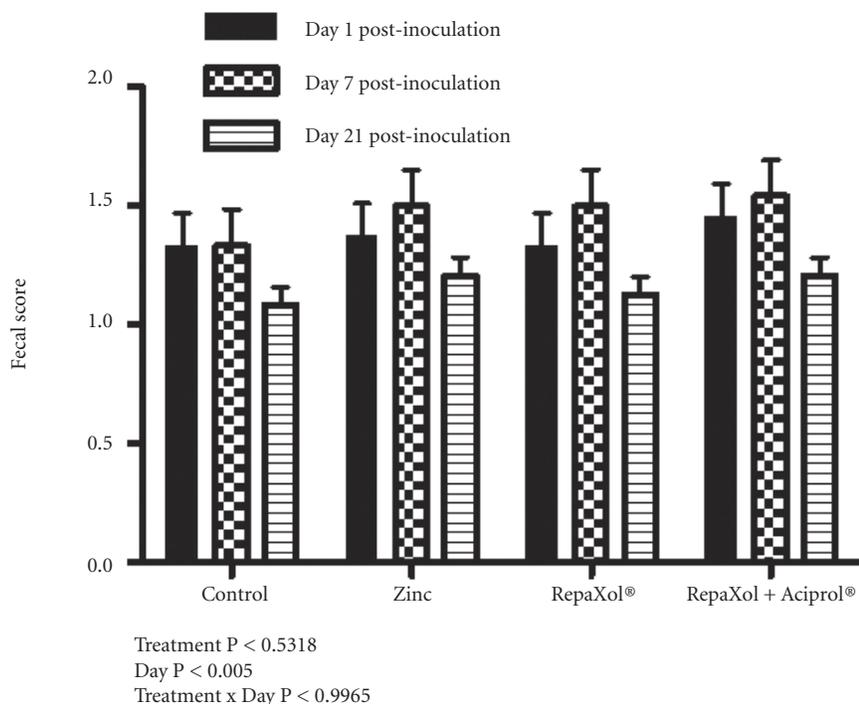
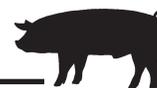


Figure 1. Fecal scores from nursery pigs fed RepaXol® and RepaXol® plus Aciprol and challenged orally with 10^{10} CFU *Escherichia coli* K88. Pen fecal scores were assigned as follows: 0 = dryer, harder than normal feces; 1 = normal feces; 2 = softer than normal feces; 3 = moderate diarrhetic feces; 4 = severe diarrhetic feces.

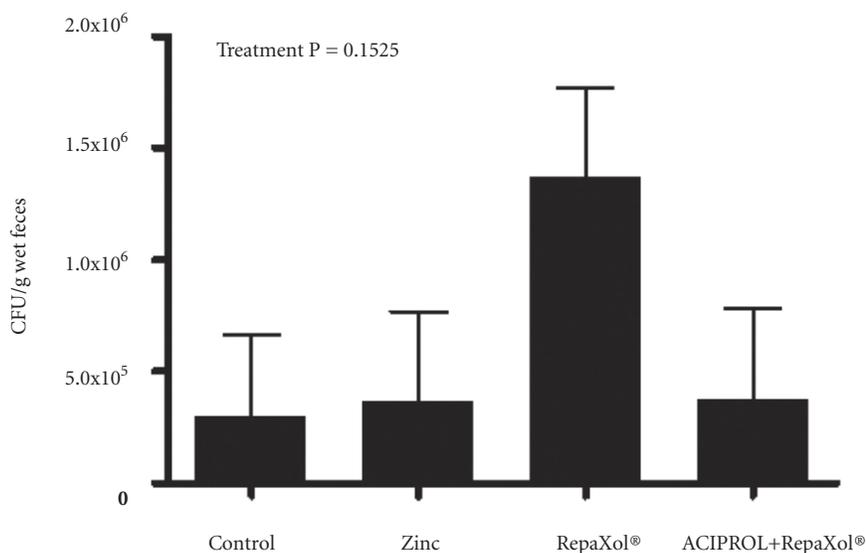
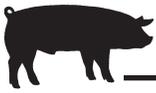


Figure 2. Shedding of *Escherichia coli* K88 from nursery pigs fed RepaXol® and RepaXol® + ACIPROL 1 day (day 8 of the experiment) following oral challenge with 10^{10} CFU *Escherichia coli* K88. Dietary treatment tended to affect shedding (P = 0.1525 for the main effect) with pigs fed RepaXol® tending to have greater shedding.

degree of diarrhea) were only observed at day 7 post-inoculation in three of 48 total pens. At both 1 and 7 days post-inoculation, approximately 17% (8 of 48 pens on both days) had fecal scores of 2 or greater, whereas no pens scored greater than 1.5 at 28 days. The consistent return to fecal scores close to 1 across all treatments appears to account for the strong day effect observed in the current study.

Bacterial shedding of ETEC K88 was observed from all pens on day 1 following oral inoculation (Figure 2) and was observed from only two and one pen, respectively, at day 7 and day 27 post-inoculation. On day 1 post-inoculation, pigs fed RepaXol® tended to have greater shedding of ETEC K88 following oral dosing compared to all other treatments (P = 0.15). The tendency for RepaXol® feeding to increase bacterial shedding of ETEC K88 is intriguing and the mechanism accounting for this observation cannot be determined with certainty from our study. In addition, the current study may not have provided sufficient enteric disease burden to adequately assess the effects of RepaXol®, the combination of RepaXol® and Aciprol or zinc on growth performance, fecal shedding and fecal scores. However, the data may suggest a slightly more rapid clearance of ETEC K88 from pigs fed RepaXol® compared to other treatments.

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Effect of Ractopamine (Paylean[®]) and Lysine:net Energy Ratio on Growth Performance and Plasma Urea Nitrogen Concentration of Late-finishing Barrows Fed Low-protein Amino Acid-supplemented Diets

Roman Moreno
Phillip S. Miller¹

Summary and Implications

The feeding of reduced dietary crude protein (CP) to late-finishing pig diets has been a strategy to reduce the amount of nitrogen (N) excreted. Nitrogen from the excess of amino acids is later eliminated by the pigs in the feces and urine, and depending on the waste disposal system may contaminate water supplies. This study was conducted to evaluate the effect of Ractopamine (RAC; Paylean[®]) and lysine (lys):Net energy (NE) ratio on growth performance and plasma urea nitrogen concentration (PUN) of late-finishing barrows fed low-protein amino acid-supplemented diets. Thirty-six late-finishing barrows with an initial body weight of 170 lb were used in a 28-day experiment. Pigs were individually penned and had ad libitum access to feed and water. The pigs were randomly allotted to one of six dietary treatments consisting of one standard diet and two low-protein amino acid-supplemented diets with different lys:NE (5.23 or 6.31g lys/Mcal NE) and RAC counterparts (0 and 20 ppm). Body weight and feed disappearance were measured weekly. Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI) were calculated. Blood samples were collected weekly by venipuncture and plasma separated. During the overall experimental period, RAC increased ADG ($P = 0.019$) and ADG/ADFI ($P = 0.021$). The inclusion of RAC resulted in a reduction on PUN on day 7 ($P = 0.0286$), and 28 ($P = 0.0069$) as well as in the overall experimental period ($P = 0.0179$). Growth performance was not affected by reduction in dietary CP concentration; however PUN

decreased in response to CP reduction for all sampling days and the overall experimental period ($P = 0.0003$). The increased Lys:NE in low-protein amino acid-supplemented diets did not change growth performance or PUN for any of the experimental weeks or the overall experimental period. Ractopamine inclusion increased ADG, and ADG/ADFI for weeks 1 and 2 ($P = 0.025$) and the overall experimental period ($P = 0.017$) when added to low-protein amino acid-supplemented diets. These results indicate that RAC (20 ppm) inclusion and low-protein amino acid-supplemented diets increased the efficiency of amino acid utilization for late-finishing pigs. Increasing lys:NE of low-protein amino acid-supplemented diets fed to finishing pigs did not improve growth performance or reduce PUN. The results of this study indicate that RAC (20 ppm) inclusion increased growth performance and the efficiency of amino acid utilization for growth in late-finishing pigs fed different dietary CP concentrations (17.4 or 14%). Increasing lys:NE did not improve growth performance in pigs fed low-protein (14%) amino acid-supplemented diets. Low-protein amino-acid supplemented diets can provide amino acids and energy in adequate amounts to allow RAC to increase growth performance of pigs from the UNL herd fed for 28 days to a target weight of 240 lb.

Introduction

The use of ractopamine (RAC) requires increased dietary protein concentration to supply the pigs with adequate amounts of amino acids needed to improve growth performance. This increased dietary protein concentration will result in excess amino acids being metabolized and converted to urea, which ultimately will be excreted

in feces and urine and released to the environment, which may create the possibility of ground and underground water contamination. Different strategies have been used to reduce the amount of N released to the environment including the use of low-protein diets. Researchers have reported that reduced dietary protein content must be supplemented with limiting amino acids to prevent reduction in growth performance and carcass quality. The use of low-protein amino acid-supplemented diets serves two purposes; maintain growth performance, and to reduce the amount of N released to the environment from swine facilities.

The objective of the present investigation was to determine if feeding late-finishing barrows with standard or low-protein amino acid-supplemented diets with different lysine (lys):Net energy ratios and RAC results in similar growth performance and plasma urea nitrogen (PUN) concentration. This study was planned based on the result of a previous experiment conducted to establish a response range for dietary crude protein (CP) and RAC additions for pigs from the UNL herd.

Procedures

Animals and treatments

Thirty six crossbred [Danbred × (Danbred × Nebraska White Line)] finishing barrows were used in a 28-day experiment. The average initial weight was 170 lb and the final weight was 242 lb. Pigs were individually penned in fully-slotted pens, maintained at 72°F, and had ad libitum access to feed and water. All management and experimental procedures were approved by the Institutional Animal Care and Use Committee at UNL.

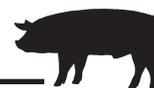


Table 1. Ingredient and calculated nutrient composition of the experimental diets, as-fed basis.

Item, %	Treatment	Diet 1		Diet 2		Diet 3	
		1	2	3	4	5	6
	CP, % ^a	17.40	17.40	14.00	14.00	14.00	14.00
	Lys:NE, g/Mcal ^b	5.23	5.23	5.23	5.23	6.31	6.31
	RAC, ppm ^c	0.00	20.00	0.00	20.00	0.00	20.00
Corn		71.95	71.86	80.78	80.69	80.70	80.61
Soybean meal, 46.5% CP		23.23	23.23	13.75	13.75	13.10	13.10
Tallow		2.00	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate		0.80	0.80	0.80	0.80	0.80	0.80
Limestone		0.70	0.70	0.70	0.70	0.70	0.70
Salt		0.25	0.25	0.25	0.25	0.25	0.25
Vitamin mix ^d		0.20	0.20	0.20	0.20	0.20	0.20
Mineral mix ^e		0.10	0.10	0.10	0.10	0.10	0.10
L-lysine·HCl		0.46	0.46	0.78	0.78	1.12	1.12
L-Tryptophan		0.04	0.04	0.10	0.10	0.16	0.16
L-Threonine		0.15	0.15	0.30	0.30	0.48	0.48
DL-Methionine		0.11	0.11	0.22	0.22	0.37	0.37
Paylean® (Ractopamine hydrochloride; 9 g/lb)		0.00	0.09	0.00	0.09	0.00	0.09
Total		100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition							
ME, Mcal/lb ^f		1,545.00	1,543.00	1,536.00	1,535.00	1,525.00	1,524.00
CP, %		17.40	17.40	14.00	14.00	14.00	14.00
Total Lysine, %		1.20	1.20	1.20	1.20	1.45	1.45
Calcium, %		0.60	0.60	0.57	0.57	0.56	0.56
Available phosphorus, %		0.20	0.20	0.19	0.19	0.19	0.19

^aCP = Crude protein.

^bLys:NE = Lysine: net energy (g/Mcal)

^cRAC = Ractopamine.

^dSupplied per kilogram of diet: vitamin A (as retinyl acetate), 4,400 IU; vitamin D (as cholecalciferol), 440 IU; vitamin E (as α -tocopheryl acetate), 24 IU; vitamin K (as menadione dimethylpyrimidinol bisulfite), 3.5 mg; riboflavin, 8.8 mg; d-pantothenic acid, 17.6 mg; niacin, 26.4 mg; vitamin B₁₂, 26.4 mg.

^eSupplied per kilogram of diet: Zn (as ZnO), 128 mg; Fe (as FeSO₄·H₂O), 128 mg; Mn (as MnO), 30 mg; Cu (as CuSO₄·5 H₂O), 11 mg; I (as Ca(IO₃)·H₂O), 0.26 mg; Se (as Na₂SeO₃), 0.3 mg.

^fME = Metabolizable energy.

Experimental diets

The pigs were randomly assigned to one of six dietary treatments designed as follows: Three experimental diets were formulated to contain 17.4 or 14.0% CP and 5.23 or 6.31 g lys/Mcal NE (1.20 and 1.45% lys). All other nutrients met or exceeded the NRC (1998) requirements. The diets were supplemented with 0 or 20 ppm ractopamine to produce a total of 6 dietary treatments (Table 1).

Data and sample collection

Average daily gain (ADG) average daily feed intake (ADFI) and feed efficiency (ADG/ADFI) were estimated weekly based on pig weight and feed disappearance. Blood samples for the PUN determinations were taken by venipuncture of the vena cava region at the beginning of the experiment and weekly thereafter. The samples were centrifuged at 2000 × g for 20 minutes. Plasma was extracted and maintained

at -4°F until analysis for urea nitrogen content (PUN).

Statistical analysis

Each pig was considered an experimental unit and data were analyzed as repeated measures in time using the mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.). Pen was considered to be a random effect. Contrasts compared 1) The standard diet vs. low protein diets [diet 1 vs. (diets 2 + 3)/2] used to examine the effect of CP; 2) RAC 0 ppm vs. RAC 20 ppm [(Trt 1 + Trt 3 + Trt 5) vs. (Trt 2 + Trt 4 + Trt 6)] to study RAC effect; 3) interaction between diet and RAC [(Trt 1 + Trt 4 + Trt 6) vs. (Trt 2 + Trt 3 + Trt 5)]; 4) low protein diets with 20 ppm RAC vs. low protein diets with 0 ppm RAC [(Trt 3 + Trt 5 vs. Trt 4 + Trt 6)] to evaluate the effect of RAC at low CP concentration; and 5) low CP high lys:NE vs. low CP low lys:NE diets (diet 2 vs. diet 3) to test the effect of lys:NE at low CP concentration.

Results and Discussion

The response of ADG, ADFI, and ADG/ADFI to dietary treatments is shown in Table 2. The significance of the effect of RAC, diet and lys:NE on ADG, ADFI, and ADG/ADFI is shown in Table 3.

There was no weekly ($P = 0.638$) or overall effects of diet on ADG ($P = 0.993$), which indicates that pigs consuming low-protein amino acid-supplemented diets performed similarly compared to pigs fed standard diets. Average daily feed intake did not change in response to diet for any individual weekly period ($P = 0.845$) or the overall experimental period ($P = 0.902$). Similar to ADG and ADFI, diet did not affect ADG/ADFI for any week ($P = 0.437$) or the overall experimental period ($P = 0.763$). The response to diet was studied to assess the effect of reducing dietary CP on growth performance of finishing pigs; therefore,

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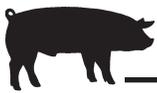


Table 2. Response of ADG^a, ADFI^b, ADG/ADFI^c to dietary treatments.

Treatment	Diet 1		Diet 2		Diet 3		SEM
	1	2	3	4	5	6	
CP, % ^d	17.40	17.40	14.00	14.00	14.00	14.00	
Lys:NE, g/Mcal ^e	5.23	5.23	5.23	5.23	6.31	6.31	
RAC, ppm ^f	0.00	20.00	0.00	20.00	0.00	20.00	^g SEM
No. of pigs	6	6	6	6	6	6	
Initial weight, lb	169.19	166.21	174.25	170.68	168.08	173.04	
Final weight, lb	237.63	248.05	243.87	243.91	227.3	253.82	
Day 0 to 7							
ADG, lb	2.71	2.29	2.49	2.98	2.08	2.89	0.2845
ADFI, lb	5.62	5.74	5.65	5.46	5.16	6.05	0.4660
ADG /ADFI, lb/lb	0.48	0.39	0.44	0.53	0.40	0.47	0.0353
Day 7 to 14							
ADG, lb	2.48	3.16	2.37	2.78	2.24	3.37	0.2845
ADFI, lb	6.73	6.71	6.67	6.88	6.08	7.53	0.4660
ADG /ADFI, lb/lb	0.36	0.46	0.35	0.40	0.36	0.44	0.0353
Day 14 to 21							
ADG, lb	2.48	2.75	2.61	2.35	2.04	2.79	0.2845
ADFI, lb	6.76	7.33	7.45	6.97	6.38	7.82	0.4660
ADG /ADFI, lb/lb	0.37	0.37	0.35	0.33	0.317	0.35	0.0353
Day 21 to 28							
ADG, lb	2.09	2.21	2.45	2.34	2.08	2.48	0.2845
ADFI, lb	6.58	6.92	6.55	6.28	6.15	7.05	0.4660
ADG /ADFI, lb/lb	0.31	0.31	0.37	0.37	0.34	0.35	0.0353
Day 0 to 28							
ADG, lb	2.44	2.60	2.48	2.61	2.11	2.88	0.1855
ADFI, lb	6.42	6.67	6.58	6.40	5.94	7.11	0.3974
ADG /ADFI, lb/lb	0.38	0.38	0.38	0.41	0.35	0.40	0.0147

^aADG = Average daily gain.

^bADFI = Average daily feed intake.

^cADG /ADFI = Average daily gain/Average daily feed intake.

^dCP = Crude protein.

^eLys:NE= Lysine:net energy ratio, g/Mcal.

^fRAC = Ractopamine.

^gSEM = Standard error of the mean.

we showed no evidence that changes in growth performance of finishing pigs can be attributed to reduction in dietary CP during any individual week or the overall experimental period.

No RAC effect on ADG was observed for individual weeks except for week 2 ($P = 0.007$). These results are consistent with previous studies that report a greater increase in ADG two or three weeks after RAC inclusion. The addition of RAC resulted in increased ADG for the overall period ($P = 0.019$).

Similarly to a previous experimental results and in contrast to the majority of literature findings, we showed no change on ADFI due to RAC for individual weeks ($P = 0.439$) or the overall period ($P = 0.186$).

The use of RAC increased ADG/ADFI on week 2 ($P = 0.007$) and for the overall experimental period ($P = 0.021$); but showed no change for weeks 3 and 4 ($P = 0.976$). Similarly to other reports we confirmed that RAC increases ADG/ADFI to greater

Table 3. Significance of ADG^a, ADFI^b, and ADG/ADFI^c to Diet^c, RAC^d and Lys:NE^e.

	Contrasts, P-value ^f				
	Diet	RAC	Diet × RAC	14% CP	
				lys/NE	RAC
Final weight, lb	0.859	0.0002	0.091	0.397	0.093
Day 0 to 7 (Week 1)					
ADG, lb	0.638	0.190	0.011	0.358	0.020
ADFI, lb	0.800	0.439	0.580	0.913	0.424
ADG /ADFI, lb/lb	0.388	0.413	0.004	0.177	0.025
Day 8 to 14 (Week 2)					
ADG, lb	0.582	0.005	0.19	0.398	0.006
ADFI, lb	0.845	0.313	0.122	0.941	0.066
ADG /ADFI, lb/lb	0.437	0.007	0.694	0.398	0.052
Day 15 to 21 (Week 3)					
ADG, lb	0.457	0.250	0.733	0.804	0.369
ADFI, lb	0.771	0.160	0.719	0.813	0.286
ADG /ADFI, lb/lb	0.232	0.704	0.814	0.855	0.711
Day 22 to 28 (Week 4)					
ADG, lb	0.422	0.533	0.808	0.670	0.601
ADFI, lb	0.513	0.369	0.784	0.680	0.479
ADG /ADFI, lb/lb	0.107	0.976	0.878	0.453	0.912
Day 0 to 28 (Overall)					
ADG, lb	0.993	0.019	0.096	0.774	0.017
ADFI, lb	0.902	0.186	0.426	0.916	0.203
ADG /ADFI, lb/lb	0.763	0.021	0.033	0.394	0.008

^aADG = Average daily gain.

^bADFI = Average daily feed intake.

^cCP = Crude protein.

^dRAC = Ractopamine.

^eLys:NE = lysine:net energy, g/Mcal.

^fContrast: standard diet vs. low protein diets = diet 1 vs. (diets 2 + 3)/2; RAC = (Trt 1 + Trt 3 + Trt 5) vs. (Trt 2 + Trt 4 + Trt 6); Diet × RAC = (Trt 1 + Trt 4 + Trt 6) vs. (Trt 2 + Trt 3 + Trt 5); RAC at 14% CP = [(Trt 3 + Trt 5) vs. (Trt 4 + Trt 6)]; Lys:NE at 14% CP = diet 2 vs. diet 3.

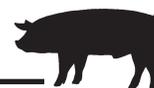


Table 4. Response of PUN^a and significance of diet, RAC^b and Lys:NE^c.

Diet	PUN, mg/100 mL						SEM ^e	Contrast, P-value ^f						
	Diet 1		Diet 2		Diet 3			14% CP						
	Treatment	1	2	3	4	5		6	Diet	RAC	Diet × RAC	Lys:NE	RAC	SEM ^e
CP,% ^d	17.40	17.40	14.00	14.00	14.00	14.00								
Lys:NE,g/Mcal	5.23	5.23	5.23	5.23	6.31	6.31								
RAC, ppm	0.00	20.00	0.00	20.00	0.00	20.00								
Day														
0	18.17	18.48	16.81	16.86	18.71	19.34	1.68	0.8400	0.7066	0.8240	0.1342	0.7182	1.9459	
7	19.83	16.42	13.79	10.76	14.90	12.71	1.68	0.0003	0.0286	0.6405	0.3459	0.1081	1.9459	
14	20.00	17.62	12.09	11.74	15.49	13.44	1.68	<0.0001	0.2215	0.9958	0.1167	0.4581	1.9459	
21	22.72	20.42	16.65	14.05	15.62	15.25	1.68	<0.0001	0.1785	0.8610	0.9573	0.3585	1.9459	
28	23.10	20.45	15.93	12.86	18.74	13.74	1.68	<0.0001	0.0069	0.1670	0.2560	0.0140	1.9459	
0 to 28 (Overall)	21.411	8.73	14.60	12.35	16.19	13.78	1.68	<0.0001	0.0179	0.5024	0.2252	0.0642	1.9459	

^aPUN, mg/100 mL

^bRAC = Ractopamine.

^cLys:NE= Lysine:Net energy ratio g/Mcal NE.

^dCP = Crude protein.

^eSEM = Standard error of the mean.

^fContrast: standard diet vs. low protein diets = diet 1 vs. (diets 2 + 3)/2; RAC = (Trt 1 + Trt 3 + Trt 5) vs. (Trt 2 + Trt 4 + Trt 6); Diet × RAC = (Trt 1 + Trt 4 + Trt 6) vs. (Trt 2 + Trt 3 + Trt 5); RAC at 14% CP = [(Trt 3 + Trt 5) vs. (Trt 4 + Trt 6)]; Lys:NE at 14% CP = diet 2 vs. diet 3.

extent during the first two weeks after inclusion in the diet.

The lys:NE ratio of low-protein amino acid-supplemented diets had no effect on growth performance. The inclusion of RAC in low-protein amino acid-supplemented diets (14% CP) increased ADG for the overall experimental period ($P = 0.017$) and weeks 1 and 2 ($P = 0.020$). Similarly, ADG/ADFI increased due to the inclusion of RAC in low-protein amino acid-supplemented 14% CP diets during the overall experimental period and week 1 ($P = 0.025$). For week 2, RAC tended ($P = 0.052$) to increase ADG/ADFI. The later results agree with previous experiments that showed a greater ADG and ADG/ADFI in response to RAC during the first two or three weeks after the inclusion of RAC. Numerous experiments have demonstrated a reduction in ADFI in response to RAC inclusion in standard corn-soybean meal diets; however, we showed no change on ADFI due to RAC inclusion in low-protein amino acid supplemented diets fed to finishing pigs.

There was no effect of diet or RAC on PUN for day 0 (Table 4). Similarly no effect of lys:NE or RAC on PUN of pigs fed low-protein (14% CP) amino acid-supplemented diet was detected.

The reduction in dietary CP concentration from 17.4 to 14%, examined by the diet contrast [diet 1 vs. (diets 2 + 3)/2] resulted in a reduction in PUN for sampling days 7, 14, 21 and 28 ($P = 0.0003$). These results agree

with previous reports that demonstrated reductions in PUN of finishing pigs in response to decreasing dietary CP concentration.

The RAC contrast showed a reduction in PUN on days 7 ($P = 0.0286$), and 28 ($P = 0.0069$) due to RAC inclusion in the standard and low-protein amino acid supplemented diets. Also, a reduction ($P = 0.0179$) in PUN due to RAC inclusion was detected for the overall experimental period (days 0 to 28). Plasma urea nitrogen was not affected by RAC ($P = 0.7182$) inclusion on low-protein amino acid supplemented for all sampling days except day 28 ($P = 0.014$); however, a trend for PUN reduction due to RAC inclusion in low-protein amino acid supplemented diets was detected for the overall experimental period ($P = 0.0642$). The evaluation of the effect of increasing lys:NE in low protein-amino acid-supplemented diets by the contrast lys:NE at 14% CP (diet 2 vs. diet 3) showed that the increased lys:NE ratio did not affect PUN in any of the sampling days ($P = 0.9573$) or in the overall experimental period ($P = 0.2252$).

Because PUN concentration is indicative of more efficient utilization of dietary amino acids for carcass lean accretion, the results of this trial suggest that dietary CP reduction is associated with increased efficiency of amino acid utilization by finishing pigs when reduced CP diets are adequately supplemented with crystalline amino

acids. This later observation is affected primarily by the reduction in the excess dietary N supplied by the low protein diets. Also, reduced CP-amino acid supplemented diets supported similar growth rates compared to intact protein-based corn-soybean meal diets.

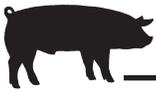
Conclusions

Results from this experiment suggest that RAC (20 ppm) inclusion and low-protein amino acid-supplemented diets increased efficiency of dietary amino acid utilization for growth in late-finishing pigs.

Increasing lys:NE in low-protein amino acid-supplemented diets fed to finishing pigs did not improve growth performance or alter the efficiency of amino acid utilization.

The results of this investigation suggest that growth performance was improved by RAC inclusion in standard or low-protein amino-acid supplemented diets fed to finishing pigs for 28 days to a target weight of 240 lb. Low-protein amino-acid supplemented can adequately provide amino acids to allow RAC to increase growth performance of pigs from the UNL herd.

¹Roman Moreno is a research technologist and graduate student, and Phillip S. Miller is a professor in the Animal Science Department.



The Effect of Dietary Selenium on Pork Carcass Quality and Longissimus Color Stability

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Phillip S. Miller¹

Summary and Implications

Selenium (Se) -supplemented diets during the growing-finishing period alter pork quality, thereby affecting pork value. The objective of this study was to evaluate the effects of dietary Se on carcass quality and color stability in the pork longissimus dorsi (LD) muscle when added to growing-finishing diets. Thirty pigs weighing ≈ 50 lb were selected for the study. Three pigs were assigned to each of 10 pens and fed one of five treatment diets: Basal/Control (1), Basal + 0.15 ppm (2) or 0.30 ppm (3) Se from inorganic (selenite) Se, Basal + 0.15 ppm (4) or 0.30 ppm (5) Se from organic (selenized yeast) Se. The feeding period continued for 80 days, at which time the final market weight (≈ 250 lb) was achieved. One boneless chop from the 10th to 13th thoracic portion of the LD was assigned to 48-hour drip loss and two remaining chops were aged for 7 days and then used for retail color stability measurements (ΔE_{cmc} , L^* , a^* and b^*); evaluation of color continued through day 12. The organic 0.30 ppm Se treatment resulted in the highest ΔE_{cmc} values, while the organic 0.15 ppm Se treatment and the control had the lowest ΔE_{cmc} . As time progressed, L^* values increased for all treatments, except those supplemented with 0.15 ppm organic Se ($P < 0.05$). As time progressed, regardless of treatment, a^* values decreased ($P < 0.0001$). Diets containing 0.30 ppm Se had lower b^* values when compared to the control ($P < 0.05$). During the 12-day period shelf life study period, there was a significant decrease in b^* value from day 3 to 12 ($P < 0.0001$). Pigs fed diets

supplemented with Se have a different LD color during storage that is lighter, less red, and less yellow. In addition, the use of organic Se results in the greatest overall color differences over time. Therefore, producers desiring to raise pork with a darker lean color should carefully evaluate the impact of dietary Se supplementation.

Introduction

Recent studies suggested selenium (Se) added to feed during the growing-finishing period affects pork quality. To investigate this work, a regional project was developed by NCCC-042 to evaluate the efficacy of inorganic and organic Se when fed to growing-finishing pigs.

Selenium is a trace mineral that, when incorporated into proteins, formulates important antioxidant enzymes, called selenoproteins. Selenoproteins, specifically, assist in preventing cellular damage from free radicals. In addition, Se is also an essential cofactor for glutathione peroxidase (an enzyme that helps to prevent lipid peroxidation, especially in the cell membrane). Moreover, recent studies indicate organic Se indigenous to grains may be retained more effectively than inorganic Se (sodium selenite) when included in pig diets.

Procedures

Experimental Design

The experimental guidelines were followed as per instructions from the NCCC-042 Swine Growing-Finishing Subcommittee. Thirty cross-bred pigs weighing approximately 50 lb were used. Pigs were separated into five dietary treatment groups. Each treatment was fed on an ad libitum basis for 80 days until market weight

(≈ 250 lb). Three pigs were assigned to each grower pen and fed one of five treatment diets: Basal/Control (1), Basal + 0.15 ppm (2) or 0.30 ppm (3) Se from inorganic (selenite) Se, Basal + 0.15 ppm (4) or 0.30 ppm (5) Se from organic (selenized yeast) Se. Two replications of this study were conducted. Pigs were housed in the University of Nebraska–Lincoln (UNL) Swine Unit at Ithaca, Neb. and harvested in the UNL Meat Lab. Carcasses were assessed on pork carcass quality and longissimus muscle quality. All procedures were approved by the UNL Institutional Animal Care and Use Committee.

Carcass Quality Measurements

Carcass lean quality data were collected approximately 24 hours postmortem. All quality assessments were completed according to protocol outlined in *Pork Composition & Quality Assessment Procedures*,

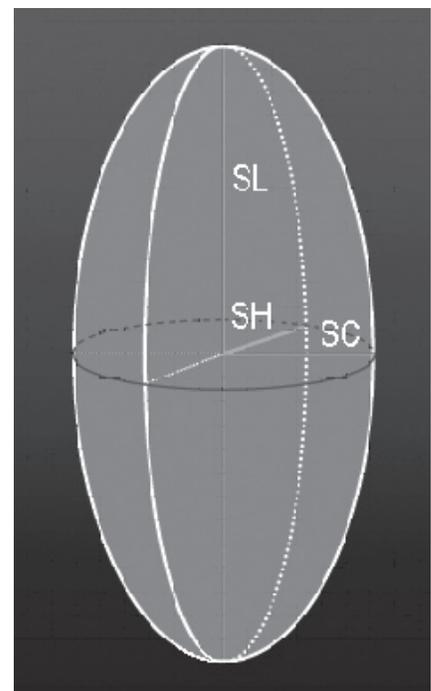


Figure 1. ΔE_{cmc} Ellipsoid

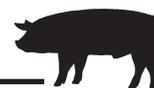


Table 1. Effect of selenium source on carcass traits.

Treatment	Inorganic selenium			Organic selenium		SEM ^a	P > F
	1	2	3	4	5		
Diet	Control	Basal + 0.15ppm	Basal + 0.30ppm	Basal + 0.15ppm	Basal + 0.30ppm		
Live wt (lb)	282.67	271.67	268.83	270.50	282.67	3.82	0.62
HCW (lb)	217.25	210.08	208.42	209.00	215.75	3.14	0.84
Dressing percent	77.81	77.27	77.54	77.33	76.35	0.84	0.86
10th rib LMA ^a (in ²)	7.25	6.64	6.63	7.19	6.96	2.22	0.58
10th rib fat depth (in)	1.11	1.15	0.99	1.04	1.02	0.16	0.41
% fat free lean	49.39	48.17	49.81	50.06	49.94	0.94	0.62
Last rib back fat (in)	1.20	1.02	1.18	0.99	1.08	0.22	0.32
Muscle score	2.6	2.3	2.3	2.5	2.6	0.21	0.66
USDA grade	2.1	1.7	2.4	1.4	1.6	0.42	0.53
Lean quality							
Marbling score	1.6	1.5	1.8	1.5	1.6	0.29	0.92
Color	2.5	3.0	3.1	2.3	2.8	0.35	0.44
L*	53.46	54.11	53.59	54.27	54.21	0.97	0.96
a*	11.69	11.25	11.28	12.57	11.50	0.49	0.33
b*	13.51	13.41	12.90	14.33	13.61	0.33	0.07
Drip loss (%)	6.00	5.50	5.33	7.33	5.83	0.01	0.66
pH	6.12	5.86	6.19	5.97	6.07	0.20	0.78
Proximate analysis							
Lipid (%)	3.61	4.11	3.41	4.20	5.94	1.02	0.44
Moisture (%)	72.83	72.64	72.86	72.16	70.40	1.01	0.41
Ash (%)	1.27	1.21	1.25	1.29	1.27	0.03	0.22

^aSEM = Standard Error of the Mean.

^bLMA = Loin Muscle Area.

published by the National Pork Producers Council (NPPC) and the American Meat Science Association (AMSA). Lean quality assessment procedures included: 10th rib fat depth, loin muscle area, last rib fat thickness, and percent fat free lean. NPPC Official Color and Marbling Standards were used to evaluate the longissimus at the 10th rib of each carcass 24 hours after harvest.

Longissimus Muscle Quality Measurements

Loins were aged 7 days in a vacuum bag before fabrication for retail display. Two, 1-inch-thick boneless chops from the 10th to 13th thoracic portion of the longissimus dorsi (LD) were assigned to the 48-hour drip loss and color stability measurements. Water Holding Capacity (WHC) was determined using a 48-hour drip loss test. Drip loss measurements began approximately 24 hours post-harvest. A slice of longissimus muscle from each carcass was weighed (approximately 100g) and placed individually in a sealed plastic bag. Each sample was weighed

to the nearest .01-g and immediately suspended on an S-type hook for 48 hours at 39°F. At 48 hours, sample surfaces were blotted for excess moisture and weighed again to the nearest .01 g.

Chops identified for color evaluation were placed in styrofoam trays, over-wrapped with an oxygen-permeable film, and allowed to bloom for 30 minutes prior to color testing; evaluation of color continued through day 12.

ΔE_{cmc} is a change in color measurement HunterLab developed to better correlate color differences with visual assessments. ΔE_{cmc} values were calculated for each day of display from L*, a*, and b* using the average value for day one of display for the standard color. The CMC ratio *l:c* (lightness:chroma) alters the shape of the ellipsoid (Figure 1). The *l:c* ratio is normally 2:1 because humans typically perceive larger shifts in lightness than in chroma. The ellipsoid's shape is based on SL (lightness), SC (chroma), and SH (hue) values, which are calculated from CIELCh values. Simply stated,

ΔE_{cmc} represents the total color difference value between a standard and a sample, and can be used in correlation with visual assessments.

Longissimus muscle samples were dipped in liquid nitrogen and powdered in order to complete pH and proximate analyses. Percentages of moisture and ash were completed using a Thermogravimetric Analyzer (TGA-601), Leco Corp. The fat extraction procedure used Soxhlet extraction tubes.

Statistical Analysis

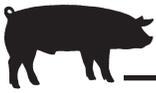
Data were analyzed as a completely randomized design by analysis of variance (ANOVA) using the GLIMMIX procedure of SAS (Version 9.1, Cary, NC, 2002) with a predetermined significance level of $P \leq 0.05$. Carcass data and ΔE_{cmc} were analyzed as a completely randomized design while colorspace values were analyzed as a repeated measures design. When significance was indicated by ANOVA, means separations were performed using the LSMEANS and DIFF function of SAS.

Results and Discussion

Carcass traits for the Se and control treatments are listed in Table 1. The carcasses represented typical market hogs as the population averages were: 275 lb live weight, 212 lb hot carcass weight (HCW), 1.06 in 10th-rib fat depth, and 6.94 in² loin muscle area (LMA). The addition of Se to the diet did not significantly affect any of the carcass traits measured. Because Se is a cofactor for antioxidant enzyme systems, especially for the cell wall, no effect on carcass measurements for leanness would be expected. However, Se could play a role in LD color and others have indicated it may affect WHC (% drip loss).

In our study, longissimus lean color scores visually evaluated on the ribbed carcass were not affected by Se diets (Table 1). In addition, Se diets did not affect Hunter Lab color (L*,

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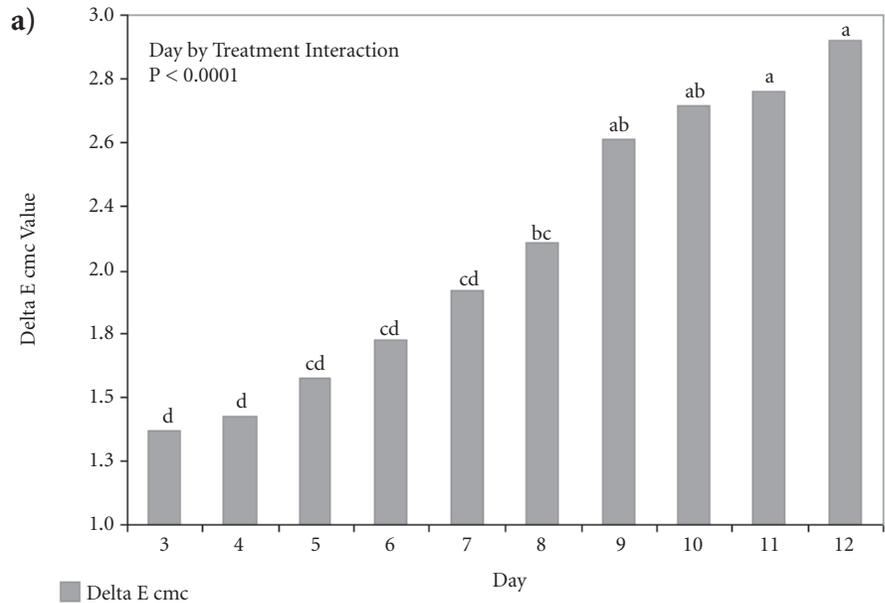
a*, b*; Table 1) measured on a LD sample removed from the carcass at approximately 24 hours after slaughter. It is possible the time and temperature conditions within 24 hours of slaughter did not allow oxidation to influence LD color.

Loins were aged for seven days before preparing retail displays. This shelf-life study of boneless pork chops is a useful measure to view the course of oxidation and/or the potential antioxidant capabilities for pigs fed diets with added Se. At day 0 of display, there were initial color differences among treatments and colorspace values. These differences persisted through day 12 of the shelf-life study (data not shown). Although it was originally expected for Se to prevent oxidation in the muscle samples, it was not observed in this study. If oxidation had been prevented by the enhancements of Se (treatments 2 through 5), over time L* values should remain below the control, a* values should decrease slower than the control, and overall ΔE_{cmc} values should remain more consistent with the control.

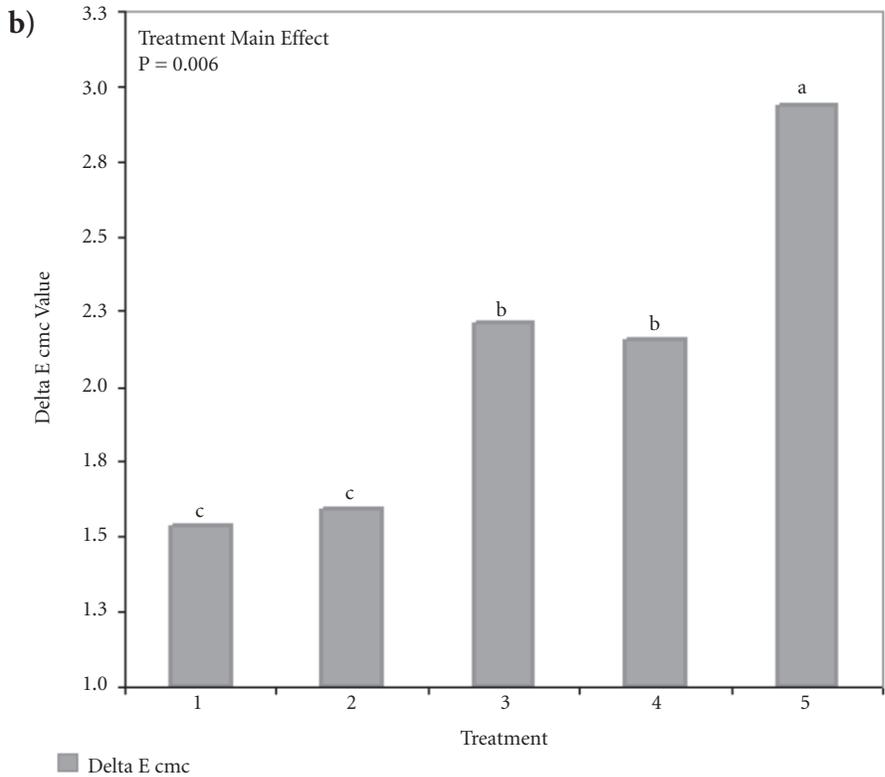
The organic 0.30 ppm Se treatment resulted in the highest ΔE_{cmc} values, while the organic 0.15 ppm Se treatment and the control had the lowest ΔE_{cmc} (Figure 2b). These results show the greater effects that high levels of organic Se have on the LD muscle. ΔE_{cmc} also increased as the days of retail display progressed, suggesting overall color changes in all samples through day 12 (Figure 2a).

As time progressed, L* values increased for all treatments, except diets containing 0.15 ppm organic Se in Figure 3 ($P < 0.05$). L* is an indicator of the lightness and L* values increase as the product lightens in color. As was noted earlier, an antioxidant should decrease the rate L* values increase. However, in this study, all Selenium-supplemented samples started and ended the retail display with greater L* values than the control.

As time advanced, regardless of treatment, a* values decreased



Bars (means without a common letter are different ($P < 0.05$))^{abcd}.



Bars (means without a common letter are different ($P < 0.05$))^{abc}.

Figure 2. ΔE_{cmc} Values by: a) Shelf-life display day (3-12), b) Treatment: Basal/Control (1), Basal + 0.15 ppm Inorganic Se (2), Basal + 0.30 ppm Inorganic Se (3), Basal + 0.15 ppm Organic Se (4), Basal + 0.30 ppm Organic Se (5).

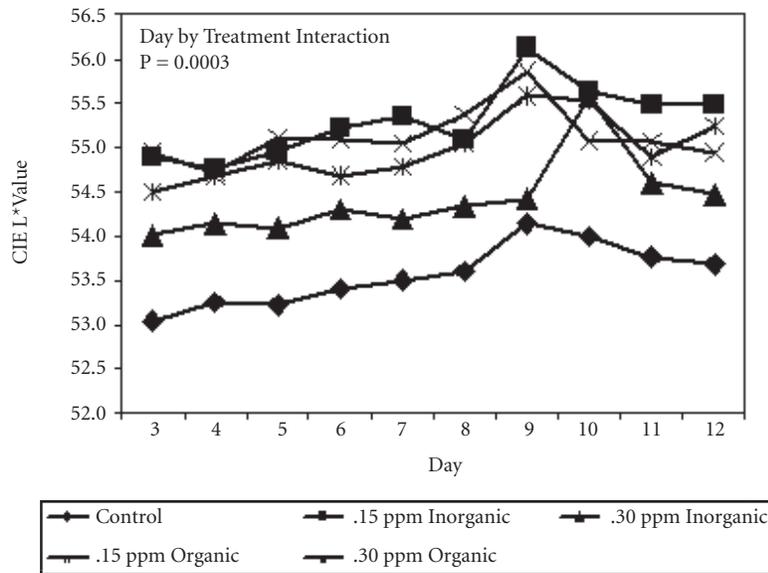
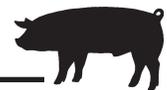


Figure 3. The response of L* value to a 12-day shelf life study.

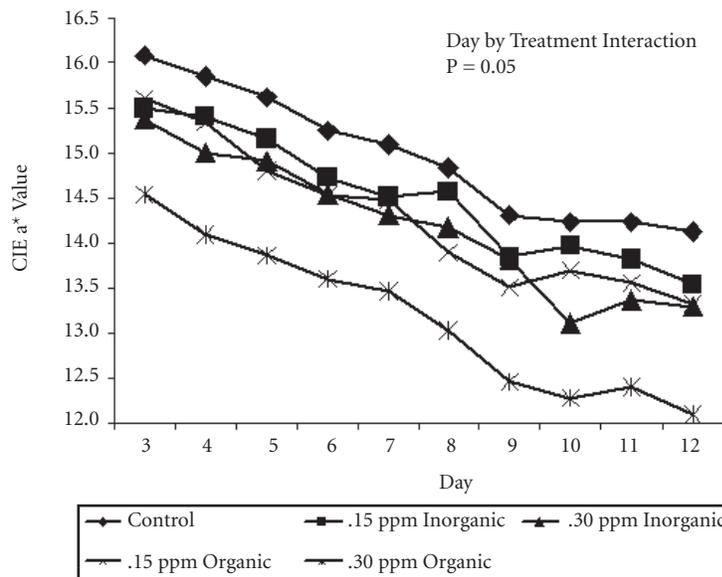


Figure 4. The response of a* value to a 12-day shelf life study.

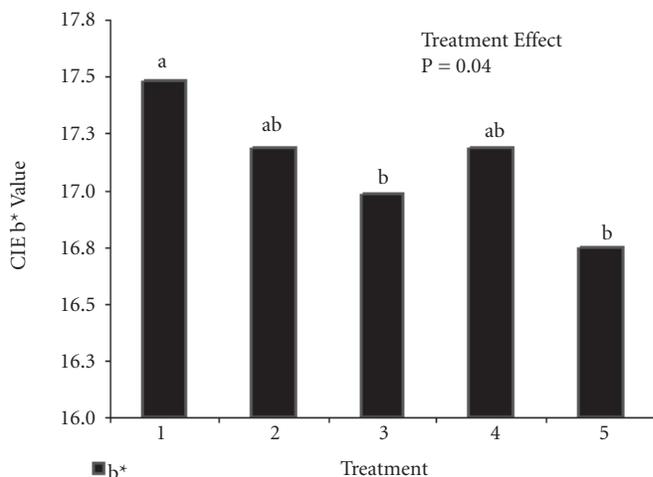


Figure 5. b* Values by treatment: Basal/Control (1), Basal + 0.15 ppm Inorganic Se (2), Basal + 0.30 ppm Inorganic Se (3), Basal + 0.15 ppm Organic Se (4), Basal + 0.30 ppm Organic Se (5).

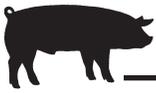
(Figure 4; $P < 0.0001$). The a* values indicate the amount of redness in a sample; therefore, as a* values decrease the product is becoming less red. Antioxidants should prolong the rich, red color in samples. Although Se treatments 1 through 4 began shelf-life at higher values, the rate of decrease was still similar to that of the control samples.

In regards to b* value, supplementation with 0.15 ppm Se were similar to the control (Figure 5). However, diets containing 0.30 ppm Se had lower b* values when compared to the control ($P < 0.05$). Over time, there was a significant decrease in b* value from day 3 to 12, which represents a change from hues of blue to yellow.

Conclusion

Dietary supplementation with Se did not affect carcass weight, fatness, lean quality measures, pH, or proximate analyses; however, the color of chops in retail display was affected. The use of organic Se results in the greatest color differences that persisted throughout the entire shelf-life display. In addition, our results indicate that retail display chops from pigs fed diets supplemented with Se have a lighter, less red, and less yellow longissimus color. While the lighter longissimus lean color observed in this study was acceptable, producers that are targeting production of pork with darker lean colors will need to carefully evaluate the impact of diets supplemented with Se.

¹Karaline A. Poovey, Ashley K. Batie, and Blaine E. Jenschke are graduate students. Dennis E. Burson and Phillip S. Miller are professors in the Animal Science Department.



The Effect of Organic and Inorganic Selenium on Smoked Pork Chop Color

Brian Krause
Roger Mandigo
Dennis Burson¹

Summary and Implications

Selenium fed to growing-finishing pigs had no significant effect on cured meat color in either the organic or inorganic form regardless of amount of selenium. The data clearly confirm the value of vacuum packaging on color protection for 21 days of refrigerated storage compared to oxygen permeable over-wrap packaging technology. Changes in the Longissimus dorsi were found based on location within the muscle and the Psoas major (tenderloin) muscle had the most variable color problem.

Introduction

In the 1960s, selenium deficiencies were reported in some areas of the Midwest. Typical symptoms of selenium deficiency in pigs resemble symptoms of vitamin E deficiency, including muscular dystrophy, pale muscles, small hemorrhages in heart muscle (“mulberry heart”) and necrosis of the liver. In 1974 the U.S. Food and Drug Administration (FDA) approved the addition of 0.1ppm selenium to all swine diets. In 1982, the allowable level increased to 0.3 ppm for young pigs and in 1987 the allowable level was 0.3 ppm for all weights and classes of swine. The benefits of selenium for animal health raised the question — organic or inorganic selenium. The organic form is usually supplied from selenized yeast while the inorganic forms are from sodium selenite. It has been found that different forms of selenium perform differently at different levels in the diet. No differences were detected in the effects of organic or inorganic selenium in pigs when given

at levels below 0.1 ppm in the diet using tissue retention as the criterion. In contrast when the selenium content in the feed exceeds 0.1 ppm, organic forms of selenium are clearly better utilized by the pig.

Cured meat color is an important factor that influences consumer buying decisions and affects their perception of the freshness of the product. The problem with cured and smoked pork is that the cured color is unstable when oxygen and ultraviolet light, typical of meat display cases impacts the cured meat color. The chops will fade during distribution due to this oxidation of the color pigments. To prevent this from occurring, greater color and better packaging techniques are desired. In this study two sources of selenium and two types of packaging were studied to evaluate cured pork color. The main factors were:

1. Source of dietary selenium [organic vs. inorganic]
2. Type of packaging [permeable vs. non-permeable]

Materials and Methods

The pork loins used in this project were taken from the pigs used in the selenium (Se) feeding study that was described in the previous paper (Poovey et.al.). Dietary treatments in that study were:

- Diet 1 - No added selenium
- Diet 2 - Same as diet 1 + 0.15 ppm Se from inorganic (selenite) Se
- Diet 3 - Same as diet 1 + 0.30 ppm Se from inorganic (selenite) Se
- Diet 4 - Same as diet 1 + 0.15 ppm Se from organic (selenized yeast) Se
- Diet 5 - Same as diet 1 + 0.30 ppm Se from organic (selenized yeast) Se

Following slaughter and the gathering of carcass data, the 30 remaining pork loins were processed into

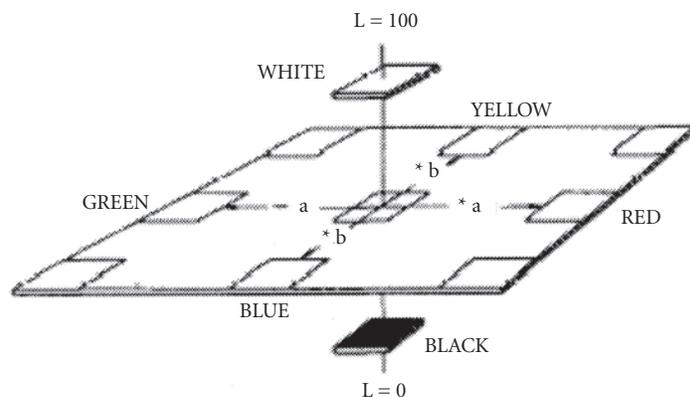
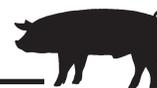
smoked pork chops. The whole loins were trimmed of fat to less than 1/8” and cut into three sections [Section A - RIB, Section B - CENTER LOIN and Section C - SIRLOIN. The sections were injected to 110% of the meat weight with a curing pickle, placed in a cover pickle for four days, a standard curing practice found in the industry for the production of smoked pork loins. The pickle formulations (Table 1) were:

Table 1. Injection pickle and cover pickle formulations.

Ingredient	Injection pickle, lb	Cover pickle, lb
Water	31.36	29.38
Sodium phosphate	1.00	—
Salt	2.6	4.82
Sugar	1.90	3.80
Cure (6.25% nitrite)	0.93	—
Sodium erythorbate	0.21	—
Total weight	38.00	38.00

After the four days for cure equilibration, cooking, smoking and chilling, the loins were cut into 1” smoked pork chops with each of the 90 sections. Two pork chops were randomly selected from each location, placed on a foam tray and wrapped with oxygen permeable film and labeled. The second chop was placed in a vacuum bag, the vacuum drawn and sealed and labeled. The chops were displayed in a refrigerated (34°F cooler and exposed to 300 ft candles of fluorescent light (typical of retail markets) for the duration of the study. The following muscles and locations were the treatments for this phase of the study:

- Treatment 1 - *Longissimus dorsi* in the RIB section
- Treatment 2 - *Longissimus dorsi* in the CENTER LOIN section
- Treatment 3 - *Psoas major* in the CENTER LOIN section



Hunter L a b Color Solid. (Hunter Lab, 1983).

Figure 1. Hunter color L*, a* and b* schematic.

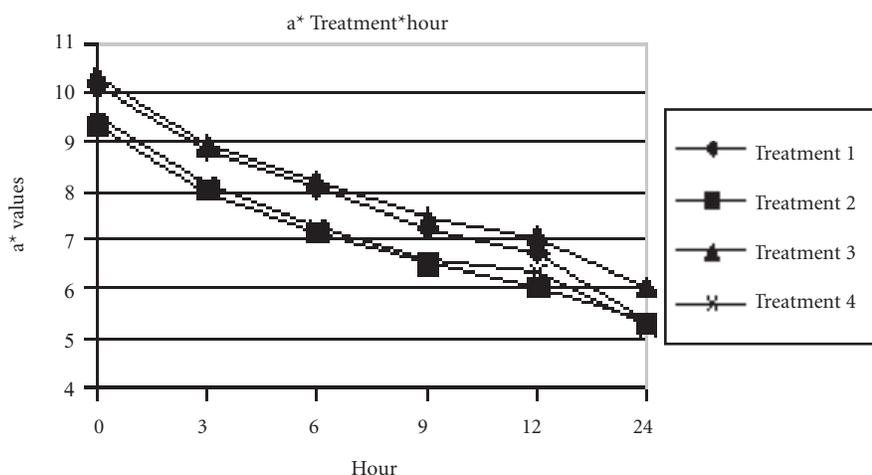


Figure 2. a* color value by treatments — red color

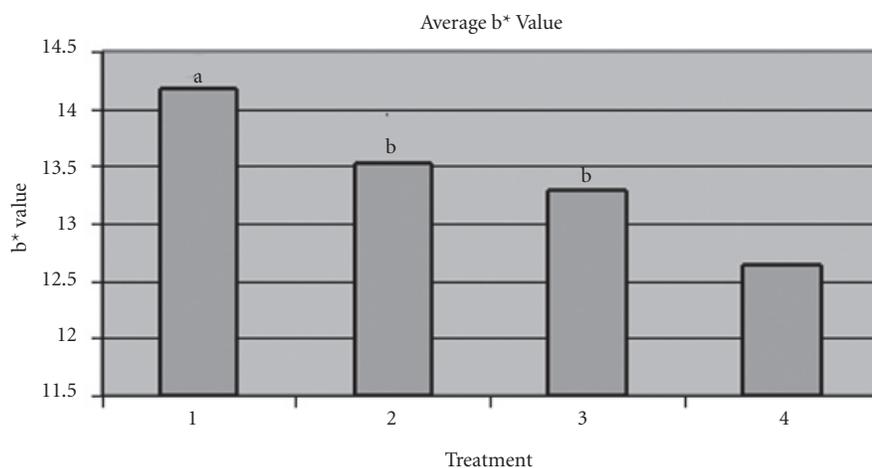


Figure 3. b* color value by treatments — yellow color

Treatment 4 - *Gluteus medius* in the SIRLOIN section

Color Stability— Color was measured using the Hunter L*, a* and b* color measurement system. The overwrapped samples were measured every three hours for the first 12 hours and again at 24 hours to measure the change in color in the presence of oxygen and ultraviolet light. The vacuum packaged pork chops were held in the same environment as the overwrap chops. They were held constantly at 34° Fahrenheit and under 300 foot-candles of light. The Hunter L*, a*, and b* were measured and recorded at day 0, 3, 6, 9, 12, 15, 18, and 21.

The Hunter color classification system (Figure 1) characterized the lightness on the center axis with the “L” value of a “0” as black at the bottom and “100” as white at the top of the axis. The “a” value characterizes the green to red color component of intensity with a “+a” value being red and “-a” being green. A “+b” is yellow and a “-b” is blue. Thus by describing L*, a* and b*, the exact color of the sample can be characterized.

Results and Discussion

The effect of selenium source

Dietary Se had no significant influence on L*, a*, or b* as no differences were detected between the chops from the pigs fed diets with either organic, inorganic, or no Se.

Overwrapped smoked pork chops

The L* for the overwrapped pork chops increased from hour 0 to hour 24. The relationship between the treatment and hour was significant. Treatment 3 (*Psoas Major* or the tenderloin muscle) consistently had the lowest L* color intensity value at all time intervals while Treatment 2 (*Longissimus dorsi*) had the highest average L* value. The a* value for the overwrapped pork chops dropped steadily from hour to hour. Figure 2 shows this trend as the a* value drops significantly with time.

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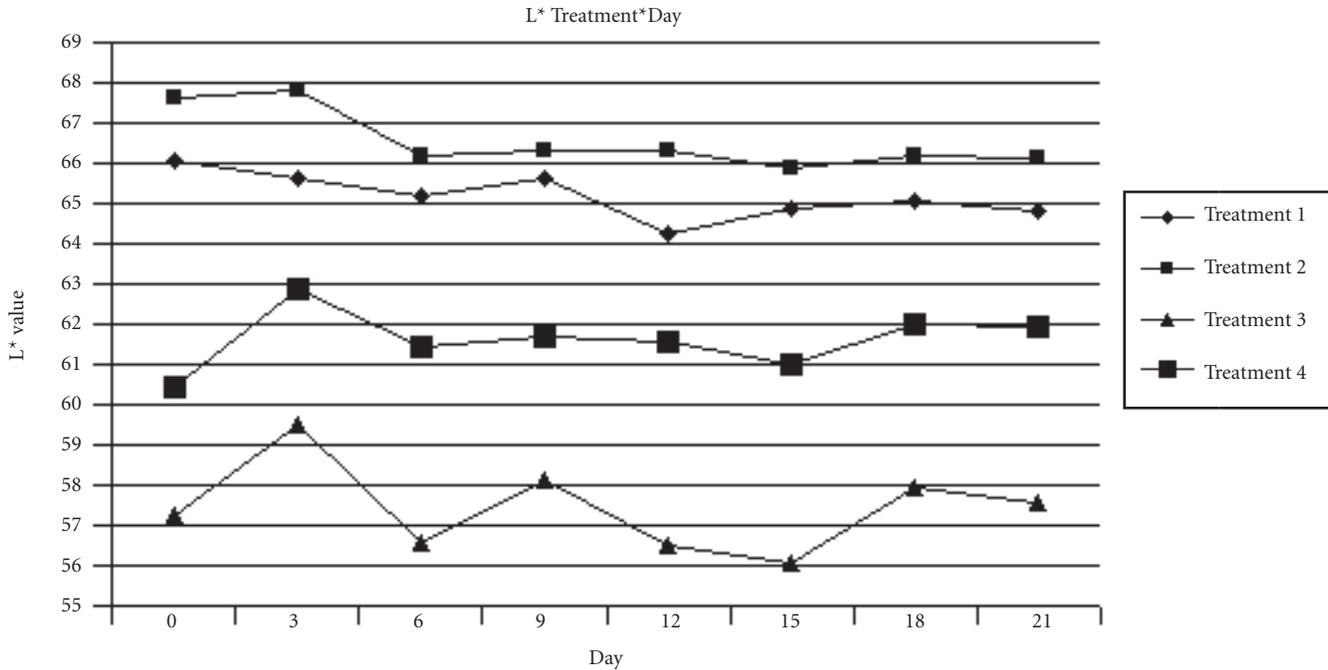
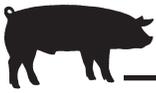


Figure 4. Vacuum packaged smoke pork chops – treatment x day.

The b* value differences shows how the different treatments, not time, affected the b* values (Figure 3).

This suggests that the location of the smoked pork chop in relationship to the whole loin had the effect on b* value in smoked pork chops.

Vacuum packaged smoke pork chops

In the vacuum packaged pork chops the L* values (Figure 4) were consistently highest for Treatment 2 (*Longissimus dorsi*) and consistently lowest for Treatment 3 (*Psoas major*, tenderloin). The data also shows that the two Treatments of the *Longissimus dorsi* had higher L* values than those

of either the *Psoas major* or the *Gluteus medius*. The relationship between Treatment and day was significant.

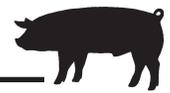
The a* values decreased in the vacuum packaged smoked pork chops. The decrease was significant. The b* values increased (more yellow) over the 21 days in the vacuum packaging. Treatment and day were significant.

Conclusion

The data confirms that vacuum packaging is a good way to preserve color in smoked cured pork chops with the color changing very little in the 21-day period. The type of packaging does affect color as the color faded

faster and more extensively in the oxygen permeable film. Dietary Se had no significant affect on cured meat color in neither the organic or inorganic form regardless of amount of selenium as no significant treatment differences were detected. However, the changes in color were detected within the *Longissimus dorsi* based on the location in the muscle. The *Psoas major* had the biggest problem with color stability as it had the most prevalent change in color.

¹Brian Krause was an undergraduate student; Roger Mandigo and Dennis Burson are professors, of Animal Science, Lincoln.



Genetics Affect Incidence of Porcine Circovirus Associated Disease

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Alan Doster¹

Summary and Implications

Porcine Circovirus Associated Disease (PCVAD) reduces productivity and causes serious economic loss. Genetic variation in resistance to diseases, including PCVAD, is known to exist. In 2002, symptoms of PCVAD in pigs from the University of Nebraska swine population were first observed. Symptoms were limited to five genetic lines that are Landrace/Large White composites: three lines selected for increased litter size and growth rate (Lines 2, 24, and 45), and controls for these selection lines (Lines 16 and 61). PCVAD has not been observed in crossbred pigs from mating the selection lines with other breeds. Generation 24 pigs within these lines were scored for PCVAD based on signs of muscle wasting, rough hair coat, respiratory problems, and growth retardation. Necropsies were performed on a sample of animals expressing symptoms of PCVAD to confirm PCVAD and to determine other infections present in these pigs. Using the foster dam as the maternal genetic effect, direct and maternal heritability estimates were 0.23 ± 0.11 and 0.03 ± 0.06 , respectively, with a common foster litter effect of 0.14 ± 0.06 . Using the birth dam as the maternal genetic effect, direct and maternal heritability estimates were 0.07 ± 0.12 and 0.26 ± 0.14 , respectively. Incidence of PCVAD was greater in selection lines than control lines (18.5 vs. 5.0%; $P = 0.06$). Significant differences between PCVAD- and non-PCVAD-pigs were observed for birth weight (0.21 lb, $P < 0.10$), weaning weight (1.21 lb, $P < 0.05$), 70-day weight (12.6 lb, $P < 0.05$), and 180-day weight (48.5 lb, $P < 0.01$).

*Inbreeding affected incidence of PCVAD in Line 2 ($P < 0.05$), but not in other lines. Incidence also varied between areas of the farm in which pigs were raised ($P < 0.05$). Necropsies confirmed PCVAD in all 21 pigs necropsied, 11 of the 21 pigs also had *Mycoplasma hyopneumoniae* infection. Differences in line, inbreeding, management practices, and exposure to other pathogens influence expression of PCVAD.*

Introduction

Porcine Circovirus Associated Disease (PCVAD) is an emerging disorder characterized by weight loss, muscle wasting, rough hair coat, and internal lesions in multiple organs. Loss of lymphocytes and a high degree of antigen-presenting Giant cells in the infected tissues are typical. Porcine Circovirus 2 (PCV-2) is the main causative agent of PCVAD and Porcine Dermatitis and Nephropathy (PDNS). PCV-2 can solely induce PCVAD expression, but concurrent infection with other pathogens, such as Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) and *Mycoplasma hyopneumoniae*, increase the incidence of PCVAD.

Transmission of PCV-2 is not thoroughly understood, but occurs at least by bodily fluids. A striking feature of PCV-2 is that it can remain in a normal, apparently unaffected population for many years. Reasons are not known, but could be due to genetic resistance and/or absence of factors necessary to trigger the onset of PCVAD.

PCVAD is found throughout the world and is an important economic problem within Denmark, Italy, Germany, Southeast Asia, and the United States. Annual estimates of economic loss in Europe from 2000 to 2003 were reported to be in excess of \$755 million. Currently estimates of economic loss in the United States are not

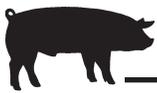
available, but the potential for major economic loss is high.

Genetic variation in resistance to several swine diseases exists, including variation in expression of PCVAD. Use of quantitative models to select for resistance requires estimates of genetic parameters. Incidence of PCVAD was systematically recorded in five University of Nebraska–Lincoln (UNL) selection lines to 1) identify variables, both genetic and environmental, affecting the expression of PCVAD, 2) estimate genetic parameters for incidence of PCVAD, and 3) determine differences in incidence of PCVAD among UNL selection lines.

Materials and Methods

Phenotypic Traits. The UNL selection lines originated from a composite population formed in 1979 by reciprocally mating Large White and Landrace pigs. Currently, three selection (Lines 2, 24, and 45) and two control lines (Lines 16 and 61) exist. Lines 2, 24, and 45 have been selected for increased litter size for 24 generations and increased growth rate and decreased backfat for 4, 6, and 8 generations, respectively. Lines 45 and 61 made up Contemporary Group 1, whereas Lines 2, 16, and 24 made up Contemporary Group 2. Expression of PCVAD was recorded on 1,340 Generation-24 pigs from these lines. Pigs were scored for PCVAD every seven to 10 days from 70 to 160 days of age. After weaning, pigs were in environmentally controlled nurseries until approximately 60 days of age. They were then placed in one of four areas of the farm. Area 1 was an entirely confined, mechanically ventilated, and temperature regulated facility with four rooms of eight pens per room and approximately 10 pigs per pen. Area 2 was a confined building with natural ventilation regulated by thermostatically controlled curtains

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over north and south openings and contained 24 pens with 10 pigs per pen. Area 3 was a confined building with manual control of natural ventilation with 23 pens and 10 pigs per pen. Area 4 consisted of five outside dirt lots. Each lot had a small hoop structure with straw bedding to allow animals resting space and contained five pens with 50 to 60 pigs per pen. Pigs selected for increased litter size, from both contemporary groups, were placed in Area 1. Unselected Contemporary Group 1 pigs were placed in Areas 2 and 3. Unselected Contemporary Group 2 pigs were placed in Area 4.

Scoring and Necropsy. Pigs were scored for symptoms of PCVAD on a scale of 0, 1, or 2. A score of 0 indicated no symptoms of PCVAD, a 1 indicated some symptoms, but not positive diagnosis, and a score of 2 was given to pigs with positive symptoms of PCVAD. Pigs receiving a score of 1 were observed closely in subsequent periods for stronger symptoms of PCVAD. Some of them, but not all of them, subsequently received a score of 2. A pig that was scored as a 2 at any time was considered positive for PCVAD. Necropsies were performed on samples of pigs receiving a score of 2 to confirm the presence of PCV-2 and to determine pathological signs of disease, both macroscopically and microscopically. Twenty-one PCVAD animals between 110 and 160 days of age, 10 from the first contemporary group and 11 from the second contemporary group, were selected for necropsy. Animals were selected to ensure representation from each area. Only one pig per litter was selected for necropsy.

Lung, cervical and mesenteric lymph nodes, tonsils, kidney, and ileal tissue was microscopically examined for lesions suggestive of PCVAD. RT-PCR in lung, lymph node, and tonsil was used to confirm presence of PCV-2; all 21 pigs tested were positive for PCV-2. Nasal swabs for RT-PCR testing were also taken on five pigs from Contemporary Group 2. Two of these pigs had no internal macroscopic signs of PCVAD infection. Necropsies and RT-PCR procedures were performed at the UNL Veterinary Diagnostics Cen-

Table 1. Numbers and percentages (%) of pigs with PCVAD and mortality in pigs with PCVAD in each line at Generation 24.

Trait ^a	Contemporary Group 1		Contemporary Group 2		
	Line 45 ^b	Line 61 ^c	Line 16 ^c	Line 2 ^b	Line 24 ^b
PCVAD	55 (14.00) ^d	9 (2.91)	18 (7.50)	53 (28.04)	43 (18.30)
Mortality	3 (6.67)	0 (0)	3 (16.67)	13 (24.53)	5 (11.63)

^aPCVAD = total number of pigs considered positive for the PCVAD, Mortality = number of positive pigs that died.

^bLines selected for increased number born, increased growth rate and increased longissimus muscle area.

^cControl lines.

^dNumber in parentheses is the percentage of cases out of the total number possible.

Table 2. Differences in probability of score of 2 for PCVAD between lines, areas of the farm, and sex from combined genetic analysis considering all relationships among individuals.

Line	PCVAD difference	Standard error	P-value
Line 2 vs. Line 16	0.13	0.11	0.14
Line 24 vs. Line 16	0.13	0.09	0.11
Line 45 vs. Line 61	0.13	0.07	0.09
Select lines vs. Control lines	0.14	0.08	0.06
Area 1 vs. Outside Lots	-0.11	0.03	0.02
Areas 1, 2, & 3 vs. Outside Lots	-0.04	0.02	0.05
Area 1 vs. Areas 2, Area 3, & Outside Lots	-0.03	0.01	0.04
Female vs. Male	-0.04	0.02	0.14

ter. Antibodies for PRRSV determined by ELISA were also estimated in all 21 pigs selected for necropsy.

PCVAD is a disorder that affects multiple organ systems. Therefore, multiple pathological signs may be present in some pigs but not others. The presence of PCV-2 in RT-PCR, followed by pathological signs present in most, if not all cases of PCVAD, including lymphoid tissue depletion (lymphoid hyperplasia), the presence of multinucleated cells, such as Giant cells, and enlargement of lymph nodes, were used to confirm the expression of PCVAD.

Statistical Analyses. Genetic analyses were done with a pedigree file containing 61,270 animals tracing back to the base generation. Analyses for PCVAD, birth weight, weaning weight, 70-day weight, and 180-day weight were performed in MTDFREML, a program designed to partition variation into genetic and environmental components. Analyses of birth weight, weaning weight, 70-day weight, and 180-day weight were used to estimate the differences in weight for pigs with and without PCVAD. The analyses of PCVAD included two models, one in

which the foster dam was used as the maternal genetic effect, and the other in which the birth dam was used as the maternal genetic effect. These two models determine whether maternal genes expressed while pigs are in the uterus (birth dam) or while nursing (foster dam) play a role in expression of PCVAD in progeny or litter being nursed. Analyses compared the selection and control lines for incidence of PCVAD. If they differ, evidence for genetic variation exists. Analyses also produced estimates of direct and maternal heritability. Direct heritability indicates the degree to which a pig's genes influence expression, maternal heritability measures the dam's (birth and foster) contribution.

Results

Numbers and percentages of pigs scored as 2 for PCVAD and mortality of pigs with PCVAD for each genetic line are in Table 1. Summaries of differences in probabilities of score 2 for PCVAD due to line, area, and sex are in Table 2. Line 2 had the greatest percentage of PCVAD (28.04%), whereas Line 61 had the least (2.91%).

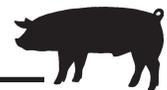


Table 3. Differences in birth weight (BWT), weaning weight (WWT), 70-day weight (70-d Wt), and 180-day weight (180-d Wt) for pigs without (-) and with (+) PCVAD.

Trait	PCVAD (-) ^a - PCVAD (+) ^b	SE	P-value
BWT, lb	0.22	0.04	0.06
WWT, lb	1.21	0.15	0.04
70-d Wt, lb	12.6	0.99	0.02
180-d Wt, lb	48.5	2.09	0.01

^aPigs scored as 0 or 1 for PCVAD expression.

^bPigs scored as 2 for PCVAD expression.

Table 4. Estimates of genetic parameters for incidence of PCVAD and pig weights.

Trait ^a	h^2_a	h^2_m	r_{am}	e^2	c^2_{dam}
PCVAD ¹	0.22 ± 0.11	0.03 ± 0.06	-0.95 ± 0.98	0.69 ± 0.07	0.14 ± 0.06
PCVAD ²	0.07 ± 0.12	0.26 ± 0.14	-0.14 ± 0.98	0.69 ± 0.07	—
BWT	0.09 ± 0.15	0.12 ± 0.15	1.00 ± 2.25	0.53 ± 0.09	0.02 ± 0.08
WWT	0.02 ± 0.15	0.30 ± 0.20	-1.00 ± 3.71	0.64 ± 0.09	0.10 ± 0.05
70-d Wt	0.63 ± 0.17	0.07 ± 0.08	-0.05 ± 0.38	0.29 ± 0.12	0.00 ± 0.05
180-d Wt	0.48 ± 0.07	—	—	0.52 ± 0.07	—

h^2_a = direct heritability; h^2_m = maternal heritability; r_{am} = correlation between direct and maternal genetic effects; e^2 = variance due to residual effects as a proportion of total variance; c^2_{lit} = variance due to common environmental effects due to litter as a proportion of total variance.

^a PCVAD = pigs scored 2 for the expression of PCVAD; BWT = birth weight; WWT = weaning weight; 70-d = 70-d weight; 180-d Wt = 180-day weight.

¹Model with foster dam as the maternal genetic effect.

²Model with birth dam as the maternal genetic effect.

Average inbreeding coefficients for Lines 2, 16, 24, 45, and 61 were 0.26, 0.16, 0.20, 0.15, and 0.14, respectively. Within line estimates of effects of inbreeding on expression of PCVAD were significant for Line 2 ($P = 0.04$), indicating greater susceptibility to PCVAD with increasing inbreeding in that line. Effects of inbreeding were not significant in other lines.

Pigs in outside lots had greater incidence of PCVAD than those in confinement (Table 2). Differences in incidence of PCVAD existed between Area 1 vs. outside lots ($P = 0.02$), Area 1 vs. Areas 2, 3, and outside lots ($P = 0.04$), and for all barns vs. outside lots ($P = 0.05$). Differences in weight between pigs with and without PCVAD are in Table 3. Pigs with scores of 2 for PCVAD weighed less at birth ($P = 0.06$), weaning ($P = 0.04$), 70 days ($P = 0.02$), and 180 d ($P = 0.01$).

Estimates of heritability for PCVAD, birth weight, weaning weight, 70-day weight, and 180-day weight are in Table 4. Estimates of direct and maternal heritability with the foster dam in the model to account for the maternal genetic effect were 0.22 ± 0.11 and 0.03 ± 0.06 , respectively. Estimates of

direct and maternal heritability with the birth dam contributing the maternal genetic effect were 0.07 ± 0.12 and 0.26 ± 0.14 , respectively. The fraction of variance accounted for by the common litter effect was 0.14 ± 0.06 . These variance components indicate genes of the pig and the genetic dam play a role in susceptibility to PCVAD. Genes of the foster dam are less important, but the common preweaning environment shared by littermates affects degree of susceptibility.

Necropsy Results. Necropsy findings varied among pigs. All pigs were negative for antibodies against PRRSV. Twenty-one out of 21 pigs necropsied tested positive for PCV-2. All pigs necropsied had severe wasting, weight loss, and a rough hair coat. Prominent and consistent gross lesions within animals positive for PCV-2 included enlarged mesenteric lymph nodes, pneumonia, and chronic colitis. Microscopic lesions included lymphoid hyperplasia within lymph nodes, and the presence of Giant cells in lymphoid follicles, splenic follicles, and Peyer's Patches. Thymus elimination due to lymphocyte depletion was evident. Co-infection with *Mycoplasma hyo-*

pneumoniae was evident in 12 of 21 animals. *Lawsonia intracellularis* was noted in one animal. Scarring of the liver due to ascarid migration was present in pigs from the outside lots.

Based on these findings, similar results would be expected for other pigs scored as a 2 but not selected for necropsy. It is possible that some pigs scored as 1 also had these conditions. They showed some phenotypic symptoms of PCVAD, but never fully expressed the condition.

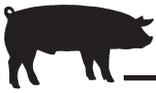
Discussion

Lines formed from the same base but selected differently differed in incidence of PCVAD, indicating genetic variation exists. Lines with greater incidence were selected primarily for reproduction; however, these data are insufficient to conclude that selection for increased reproduction results in greater susceptibility to PCVAD. These results suggest that some breeds may be more resistant to causes of PCVAD than others. Heterosis may reduce the incidence of PCVAD in crossbred pigs, as PCVAD has not been observed in crosses of UNL lines with commercial lines (data not shown). Mortality rates of PCVAD pigs in each line were relatively low.

A possible explanation for greater incidence of PCVAD in lines selected for reproduction is that an increase in litter size without accompanying changes in uterine capacity, nutritional supplementation, metabolic efficiency, and other maternal components important for pig health may lead to physical stress within newborns both *in utero* and while nursing and result in young pigs more susceptible to effects of pathogens. Stress is known to decrease the immune response of the host during viral infection.

Inbreeding may also increase susceptibility. Antibodies are formed through combinations of gene fragments. Inbreeding decreases heterozygosity and could have a profound effect on antibody genes. An increase in homozygosity would decrease the number of gene combinations possible

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and decrease the number of antibodies produced within the pig and the dam.

Differences in expression of PCVAD between areas of the farm existed and there are many possible reasons. Incidence was least in Area 1 where temperature and ventilation were regulated. Incidence was greatest in pigs housed outside (Area 4) where temperatures varied from -10°F to 100°F , depending on the time of year. Environmental stress is known to affect the immune response. Outside lots were also the only area with direct exposure to soil; therefore pigs were more likely to be exposed to more pathogens, especially ascarids, and possibly bacteria and other viruses. Differences of 0.22 lb, 1.21 lb, 12.6 lb, and 48.5 lb, for birth weight, weaning weight, 70-day weight, and 180-day weight, respectively, occurred between PCVAD positive and normal pigs. The birth weight, weaning weight, and 70-day weights were taken prior to scoring for PCVAD. The 180-day weight was taken to measure the ultimate effect on weight of pigs having PCVAD. These weight differences indicate that pigs with PCVAD may have been exposed to the PCV-2 virus, and

other agents necessary to induce the disease, prior to birth, and that the effects of the virus occurred early and continued during the growing period.

Differences in expression of PCVAD in these lines may reflect differences in exposure to the virus and not differences in genetic resistance. However, this hypothesis is unlikely. Onset of the disease, in many cases, occurred several weeks after separation from littermates. Once onset of PCVAD had occurred, most animals within the same pen or the same room of the infected individual appeared to be unaffected, whereas many littermates at other locations expressed PCVAD concurrently, suggesting PCV-2 latency or that another factor was needed for expression of PCVAD.

Estimates of direct heritability for expression of PCVAD were 0.22 with the foster dam as the maternal genetic effect and 0.07 with the birth dam as the maternal genetic effect. These values indicate genetic variation among pigs in response to PCV-2 and that direct selection for resistance is possible. However, these estimates were obtained from a small data set and more data are needed to confirm these values.

The positive variance component for litters indicates greater susceptibility of littermates to PCVAD independent of their genetic relationship. Competition effects may play a role in the common environmental component due to limitations of resources of the foster dam, including a finite number of antibodies, relative to the number of pigs nursing. This limitation could also explain differences between lines selected for increased litter size versus control lines.

Management issues, including cleanliness and removal of pigs with PCVAD upon onset of the disease, may decrease the incidence of the infection. Because antibody production from the dam may play a role in PCVAD resistance in offspring, increasing age at weaning may also decrease incidence of the disease. The positive heritability indicates that selection for resistance is possible, but application requires careful monitoring and scoring for accurate selection.

¹Jared S. Bates is a graduate student in Animal Science, Matt Anderson is manager of the ARDC swine herd, Rodger K. Johnson is Professor of Animal Science, Alan Doster is Professor of Veterinary Biomedical Science.

The Effect of Sodium Lactate and Sodium Citrate Solutions on the Quality Characteristics of Restructured Hams

Nicholas Brown
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Dennis Burson

Harshavardhan Thippareddi¹

Summary and Implications

Food safety issues are the number one concern of food processors who make ready-to-eat meat products. Organic acids are being added to meat formulations to add an additional

hurdle in the fight against food borne pathogens. This research evaluates the quality and palatability of restructured hams utilizing consumer taste panels, color changes under light exposure, shear-force values, cooking loss, pH, and packaged purge. It provides additional results of research to utilize organic acids in ham production. When these acids are applied to meat to help extend shelf-life, concern with the possible changes in palatability, productivity, and overall quality of the meat product must be

studied. Results showed no flavor differences were detected by consumer panelists, however, decreases in juiciness and texture values were observed. Color differences between hams were also observed, but the differences were slight and consumers would not likely be able to detect them. No differences in smokehouse yields were observed between the treatments. Percent purge, pH, and shear force differences were observed.

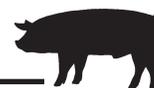


Table 1. Least square means of smokehouse yield loss percent, pH, purge, shear force (kgf = kilogram of force) by treatment and day effect.

Effect	Smokehouse yield loss, % ^d	pH	Purge, % ^e	Shear force, kg ^f
Treatment				
Control	10.22	6.41 ^a	1.12 ^b	107.77 ^c
Ional LC	10.34	6.26 ^c	1.49 ^a	119.76 ^b
OptiForm SD4	10.21	6.38 ^b	1.63 ^a	138.09 ^a
SE ^g	0.14	0.04	0.21	1.97
P-Value	0.6417	0.0414	<0.0001	<0.0001
Day				
0		6.21 ^b		
28		6.41 ^a	1.33 ^b	
56		6.38 ^a	1.45 ^a	
84		6.40 ^a	1.46 ^a	
SE ^g		0.05	0.21	
P-Value		0.0495	0.0215	

^{abc}Means within the same column and within a main effect without a common superscript differ (P<0.05).

^dSmokehouse yield loss, % = (pre-cooked weight – cooked chilled weight)/pre-cooked weight x 100.

^ePurge % = ((weight of ham slice + package weight + weight of purge) – (weight of ham slice + package weight))/(weight of ham slice + package weight + weight of purge) x 100.

^fkgf = kilograms of force.

^gSE = Standard Error.

Table 2. Least square means for consumer sensory panel by treatment for juiciness, flavor, and texture.

Effect	Juiciness	Flavor	Texture
Treatment			
Control	8.08 ^a	8.35	8.55 ^a
Ional LC	7.59 ^{ab}	8.25	7.60 ^b
OptiForm SD4	7.21 ^b	8.30	7.43 ^b
SE	0.37	0.30	0.30
P-Value	0.0023	0.9371	0.0004

^{ab}Means within the same column and within a main effect without a common superscript differ (P<0.05).

Table 3. Least square means for colorimeter values in L*, a*, and b*

Effect	L* ¹	a* ²	b* ³
Treatment			
Control	53.79	15.93	12.30
OptiForm SD4	52.83	16.45	11.07
Ional LC	54.36	15.92	10.64
SE	0.25	0.25	0.12
P-Value	<0.0001	<0.0001	<0.0001

¹L* = Lightness (white = 0; black = 100).

²a* = Redness (higher value the redder).

³b* = Yellowness (higher value the more yellow)

Introduction

Each year thousands of people become ill due to food-borne bacteria. *Listeria monocytogenes* is the bacteria of greatest concern for processors because it is ubiquitous in nature, and will grow at refrigeration temperatures and in vacuum packaging. The type of

illness caused by *L. monocytogenes* is known as listeriosis, which appears in about 2,500 cases in the United States annually. It has one of the highest mortality rates of all food-borne illnesses at nearly 30%, therefore, a Zero Tolerance regulation for *L. monocytogenes* by the USDA has been issued in ready-to-eat foods.

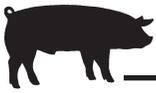
Enhancing food safety and increasing shelf-life with the addition of various organic acid salts to ready-to-eat meat products has been growing rapidly over recent years. Some common organic acid salts added to meat products are sodium lactate, sodium citrate, and sodium diacetate. Although much work has been done with the organic acid salts ability to decrease microbial growth, little work has been done to test the palatability and overall quality of the meat products.

Materials and Methods

Boneless pork shoulder picnic cushion meat (IMPS #405A) was purchased and cut into approximately 1-1.5 in cubes. The meat was randomly assigned to three treatments: (A) Control, (B) 1.3% buffered sodium citrate supplemented with sodium diacetate (Ional LC, World Technology Ingredients, Jefferson, Ga.) and (C) 2.4% buffered sodium lactate supplemented with sodium diacetate (Opti-Form SD4, 60% syrup, Purasal, PURAC America, Lincolnshire, IL). The cushion meat was cured by tumbling in a brine solution containing water, sodium phosphate, salt, sugar, sodium nitrite (cure), sodium erythorbate, the control and either (B) 1.3% Ional LC, or (C) 2.4% OptiForm SD4. The OptiForm SD4 was adjusted for moisture content. The brine solution was added to the cushion meat to obtain a 112% green weight, tumbled for 45 minutes and allowed to rest 24 hours for cure equilibration. The meat was then retumbled for an additional 15 minutes prior to stuffing. The cushion meat was stuffed into 6 in fibrous casings, weighed, pressed into molds, and placed on smokehouse trucks prior to thermal processing. The hams were cooked to 165°F internal temperature and chilled at ≤ 37°F overnight.

Hams were weighed to determine smokehouse yield, sliced, vacuum packaged, and stored at 37°F. The ham slices consisted of four 2 in

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slices for microbial testing at the University of Nebraska Food Science and Technology Department, one 1 in slice for sensory analysis, and the remaining ham was cut into 0.5” slices for color evaluation, pH, purge, and Lee-Kramer shear-force.

Color evaluation was taken at times 0, 2, 4, 6, and 8 hours post light exposure on 0, 28, 56, and 84 days postslicing using Hunter Lab Mini-Scan for color measurements. Purge and pH were also taken on 0, 28, 56, and 84 days postslicing. A consumer sensory panel and Lee-Kramer shearforce data was collected 28 days postslicing.

Results and Discussion

No significant differences were observed in the percent smokehouse yield loss (Table 1) with yield losses ranging from 10.22% for the control, to 10.21% in the OptiForm SD4 treated hams, and 10.34% in the Ional LC treated hams.

All three treatments showed significant differences between pH values with the control at 6.41, Ional LC at 6.26, and the OptiForm SD4 at 6.38. There were significant differences in pH between all three treatments (Table 1). Also, there was a pH by day interaction between all three treatments with significant differences shown between 0 and 28 days post slicing, but not between 28, 56, and 84 days post slicing. The lower pH of the Ional LC treated hams is probably due to the lower pH of Ional LC at approximately 5.6 compared to

OptiForm SD4 pH at approximately 8.0.

There were no differences in purge between the Ional LC and the OptiForm SD4 hams (Table 1) at 1.49% and 1.63%, respectively. However, the control hams had significantly less purge at 1.12%. All three treatments had significant day effects on percent purge between 28 and 56 days post slicing, but not between 56 and 84 days post slicing. The higher purge in the Ional LC hams could be attributed to the lower pH of the hams which causes the meat to be closer to its isoelectric point thus lowering the meats water holding capacity. Previous research has shown that sodium lactate decreases percent purge; however, the results observed in this study showed an increase in percent purge with the addition of sodium lactate. The percent purge differences observed between days post sliced can be attributed to muscle protein breakdown causing free water to easily escape from within the muscle structure.

All three treatments showed significant differences between shear force values with the control at 107.77 kgf, Ional LC at 119.76 kgf, and the OptiForm SD4 at 138.09 kgf. The control was more tender than both the Ional LC and OptiForm SD4 treated hams. The possible cause for this would be tighter muscle to muscle binding in the OptiForm SD4 versus the Ional LC and the control hams.

No differences were observed for ham flavor between all three treatments. However, the control

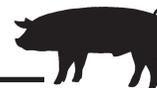
ham had higher scores for juiciness and texture with no difference between acid treatments (Table 2). No significant differences in juiciness and texture between Ional LC and OptiForm SD4 were shown.

There were no differences shown within all three treatments pooled together over time, with the Ional LC having the highest L* value (lightest), the OptiForm SD4 having the lowest L* value (darkest), and the control was intermediate between the Ional LC and the OptiForm SD4 (Table 3). OptiForm SD4 had the highest a* value (reddest) and the control had the highest b* value (yellowest). Even though slight differences were observed between treatments these differences are small enough that the average consumer will not likely be able to distinguish between hams with the various treatments.

Conclusion

Ional LC and Optiform SD4 are both effective in controlling bacterial growth. Both products lowered pH and this may be the cause for the slight increase in shear force, and reduction in juiciness and texture as measured by taste panels. These differences are minor and of far less importance than the safety advantage obtained from using the acids in products.

¹Nicholas Brown is a graduate student, and Roger Mandigo and Dennis Burson are professors in the Animal Science Department. Harshavardhan Thippareddi is a professor in the Department of Food Science and Technology.



Corn Prices, Ethanol and Feed Price Outlook

Allen Prosch¹

Summary and Implications

Livestock feeders, and pork producers in particular, need to be concerned about the impact of corn ethanol demand on corn prices. There is a great deal of uncertainty on the amount of ethanol that will be produced. Using the Chicago Board of Trade, the Chicago Mercantile Exchange and a basic diet that simulates the average ingredient needs across a farrow to finish production system, we compared corn and soybean prices as forecast by futures markets to calculate their effect on a production system's breakeven. Producers with high productivity will be better positioned to deal with rising corn prices. Producers have more control over their production efficiency than their ability to offset higher corn cost.

Ethanol Production

Ethanol is one fuel alternative that is enjoying considerable support from both the private and public sector. In Nebraska there are enough plants being considered or under construction that if completed, along with Nebraska's current capacity, would produce nearly (85%) as much ethanol in Nebraska alone as is currently produced in the entire United States. Ethanol plants will have an impact on the users of corn in Nebraska.

Several companies have multiple proposals in Nebraska, as well as in other states. It appears that some of these plants will not be built. Plants that are built first will have an advantage over those that come later; therefore, some plants may not be completed. Those plants that offer best locations and best supply of raw product, along with potential use of co-products, will likely get built first. Already, some plans to fund new plants using the sale of stock have been withdrawn due to market conditions. However, even if ethanol is not

as profitable as this summer's price spike might have suggested, if oil stays above the \$50 per barrel range, ethanol plants will remain profitable. Currently, crude oil futures through 2012 are above \$60 per barrel.

The bigger problem facing the ethanol industry as it grows, is transporting the fuel to areas of demand. One suggestion is that the ethanol industry will not develop to become a significant alternative fuel until feedstocks for the plants can be grown locally or regionally. Bio-mass plants using everything from wood chips to switchgrass and sugar cane are being considered.

Alternatives to corn based ethanol

Honda Motors along with the Japanese Research Institute for the Earth has perfected a process for extracting ethanol from alternate bio-mass that has much improved efficiencies. Purdue Research Foundation has licensed a technology to Bio Processing Technology, Inc. for the development of a new environmentally friendly method to produce ethanol that also costs less than current methods and also produces biodegradable byproducts that could be safely consumed. How long it takes to perfect and adopt such technologies will depend on the political and economic pressures to do so and they appear to be growing. Before these technologies are commercialized, corn-based ethanol plants that bring new capacity will have an advantage.

Today, the amount of ethanol mandated to be produced annually by the Renewal Fuels Standard, under the Energy Policy Act of 2005, is 7.5 billion gallons. That is the current goal thru 2012. It appears from plants now expanding or being built that this goal will be exceeded by the end of 2008. How much production will increase beyond that mandated is an open question. At least 15 billion gallons of corn based production is planned annually.

Corn use in Nebraska

Currently, Nebraska uses 239 million bushels of corn to produce ethanol each year. By the end of 2008, when current plants complete expansions and those under construction are producing, Nebraska will produce about 990 million gallons of ethanol using about 366 million bushels of corn. Nebraska also uses 19% of its corn crop to feed beef, 6% to feed hogs, 1% to feed poultry, and 0.46% for other feeds. Also, approximately 6% of Nebraska's corn is used for processing plants other than ethanol. Forty-five percent of Nebraska's corn is exported out of the state. Nebraska ethanol plants could use the export share or nearly 479 million bushels of corn to supply expansion. The export recipients will be the first competitor for these bushels and if transportation costs are high, they may be at a disadvantage.

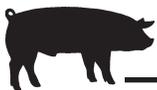
Actions that reduce ethanol impact on corn prices

There are several actions that could affect ethanol prices, profitability and final competition for corn. The U.S. could reduce or eliminate the 54-cents-a-gallon tariff on imported ethanol and make more Brazilian product available.

Producers may increase corn acreage in response to better prices thus increasing available supplies. Some think as many as five million acres of corn (nationwide) will be added next year and more by 2008.

Livestock feeders may cut use of corn by substituting cheaper ingredients. The cattle and dairy industry would be best able to do that with hogs and poultry less able to replace corn with ethanol co-products. Nebraska livestock feeding accounts for about 26.5% (279 million bushels) of corn. If all substitutions of ethanol co-products currently suggested as sound were used, livestock feeding

(Continued on next page)



could cut use of corn to approximately 188 bushels of corn or about 68% of current use. This would free up about 91 million bushels of corn.

The price relationship between crude oil, corn and ethanol will affect the continued expansion of ethanol. Table 1 shows the relationship between oil, gasoline and ethanol. Table 2 shows the relationship between corn and ethanol. Ethanol has a limited ability to buy corn away from feedstock use. Current ethanol futures put a gallon of ethanol near \$1.80 (December 2007). Ethanol at \$1.80 per gallon would suggest buying power of about \$3.50 per bushel for corn.

Corn prices staying in the \$2.90 to \$3.50 range in the foreseeable future is likely. There is a potential for upside price rises over \$4.00. The most critical year may be 2008 as the current spurt of ethanol plant construction will be completed and added corn acres and other alternatives may not have affected the supply of corn or the buying power of the ethanol industry. And, a drought situation would create a supply problem and probably result in a price spike well over any previous level.

Corn Prices and Pork Production

Corn has averaged near \$2.00 per bushel for some years. How future

Table 1. The relationship of refiner's cost of petroleum and wholesale gasoline and ethanol.

Petroleum, \$/barrel	Gasoline, \$/gallon	Ethanol, \$/gallon
40.00	1.20	1.30
50.00	1.49	1.59
60.00	1.78	1.88
70.00	2.07	2.17
80.00	2.36	2.46

Table 2. Cost per gallon of ethanol compared to price per bushel of corn.

Corn, \$/bushel	Ethanol, \$/gallon
2.00	1.27
2.50	1.45
3.00	1.63
3.50	1.80
4.00	1.98
4.50	2.16
5.00	2.34

Table 3. Effect of corn price on carcass breakeven prices (\$/cwt) for various sow reproductive rates^a.

Corn price		No. pigs marketed per sow per year		
		20	19	18
\$/bushel	\$/ cwt	Group 1	Group 2 ^b	Group 3
2.00	3.57	47.39	48.81	49.88
2.20	3.93	48.61	50.04	51.12
2.40	4.29	49.84	51.27	52.36
2.60	4.64	51.03	52.47	53.57
2.80	5.00	52.26	53.70	54.81
3.00	5.36	53.47	54.95	56.05
3.20	5.71	54.72	56.15	57.27
3.40	6.07	55.89	57.38	58.50
3.60	6.43	57.11	58.61	59.74
3.80	6.79	58.34	59.84	60.99
4.00	7.14	59.53	61.04	62.19

^aCarcass breakevens generated using Pig Net spreadsheet, University of Minnesota; farrow-to-finish system assuming market weight = 265 lb with 1% shrink, soybean meal price = \$186/ton (approximate 1 year futures average on October 19, 2002).

^bAverage reproductive rate according to PigChamp®, 2005.

Table 4. Ability to purchase corn and breakeven.

Contract date	Carcass futures prices, \$/cwt ^a	
	Value	Can pay per bushel of corn, \$
December 2006	64.52	4.13
February 2007	67.77	4.66
April 2007	69.22	4.90
May 2007	72.40	5.42
June 2007	74.15	5.71
July 2007	72.10	5.37
August 2007	70.00	5.03
October 2007	63.25	3.92
December 2007	62.32	3.77

^aOn November 6, 2006.

corn price could affect pork breakevens is shown in Table 3. The Group 2 farms represent average productivity as found in Pig Champ® data with benchmarks of 20 pigs weaned per sow per year with 5% postweaning death loss. Therefore, these farms would market 19 pigs per sow per year.

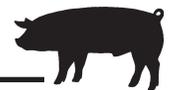
The power of ethanol to purchase corn was shown in Table 2. The buying power of the Group 2 producers to purchase corn, based on November 6, 2006, lean hog futures with a -\$2.70 basis, is shown in Table 4. Pork producers will be competitive purchasers of corn as long as market prices remain supportive.

Conclusion

During 2007 and 2008, the increases in ethanol production will

increase corn prices. Unless some action or event modifies the current outlook, this increase will result in corn prices averaging nearer \$3.00 over the two years, rather than near \$2.00 as has been common in the past. Current hog futures prices suggest pork producers will remain competitive in the corn market, but will see much of their profitability eroded. Individual productivity will have a large impact on a producer's ability to compete. Producers who have to purchase corn will have a limited ability to offset rising corn prices. Their production improvements are likely to be the factor they can most control to offset rising costs.

¹Allen Prosch is the Pork Central coordinator at the University of Nebraska-Lincoln.



Explanation of Statistics Used in This Report

Pigs treated alike vary in performance due to their different genetic makeup and to environmental effect we cannot completely control. When a group of pigs is randomly allotted to treatments it is nearly impossible to get an "equal" group of pigs on each treatment. The natural variability among pigs and the number of pigs per treatment determine the expected variation among treatment groups due to random sampling.

At the end of an experiment, the experimenter must decide whether observed treatment differences are due to "real" effects of the treatments or to random differences due to the sample of pigs assigned to each treatment. Statistics are a tool used to aid in this decision. They are used to calculate the probability that observed differences between treatments were caused by the luck of the draw when pigs were assigned to treatments. The lower this probability, the greater confidence we have that "real" treatment effects exist. In fact when this probability is less than .05 (denoted $P < .05$ in the articles), there is less than a 5% chance (less than 1 in 20) that observed treatment differences were due to random sampling. The conclusion then is that the treatment effects are "real" and caused different performance for pigs on each treatment. But bear in mind that if the experimenter obtained this result in each of 100 experiments, 5 differences would be declared to be "real" when they were really due to chance. Sometimes the probability value calcu-



lated from a statistical analysis is $P < .01$. Now the chance that random sampling of pigs caused observed treatment differences is less than 1 in 100. Evidence for real treatment differences is very strong.

It is commonplace to say differences are significant when $P < .05$, and highly significant when $P < .01$. However, P values can range anywhere between 0 and 1. Some researchers say that there is a tendency that real treatment differences exist when the value of P is between .05 and .10. Tendency is used because we are not as confident that differences are real. The chance that random sampling caused the observed differences is between 1 in 10 and 1 in 20.

Sometimes researchers report **standard errors of means (SEM)** or **standard errors (SE)**. These are calculated from the measure

of variability and the number of pigs in the treatment. A treatment mean may be given as $11 \pm .8$. The 11 is the mean and the .8 is the SEM. The SEM or SE is added and subtracted from the treatment mean to give a range. If the same treatments were applied to an unlimited number of animals the probability is .68 (1 = complete certainty) that their mean would be in this range. In the example the range is 10.2 to 11.8.

Some researchers report **linear (L)** and **quadratic (Q)** responses to treatments. These effects are tested when the experimenter used increasing increments of a factor as treatments. Examples are increasing amounts of dietary lysine or energy, or increasing ages or weights when measurements are made. The L and Q terms describe the shape of a line drawn to describe treatment means. A straight line is linear and a curved line is quadratic. For example, if finishing pigs were fed diets containing .6, .7, and .8% lysine gained 1.6, 1.8 and 2.0 lb/day, respectively we would describe the response to lysine as linear. In contrast, if the daily gains were 1.6, 1.8, and 1.8 lb/day the response to increasing dietary lysine would be quadratic. Probabilities for tests of these effects have the same interpretation as described above. Probabilities always measure the chance that random sampling caused the observed response. Therefore, if $P < .01$ for the Q effect was found, there is less than a 1% chance that random differences between pigs on the treatments caused the observed response. 

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