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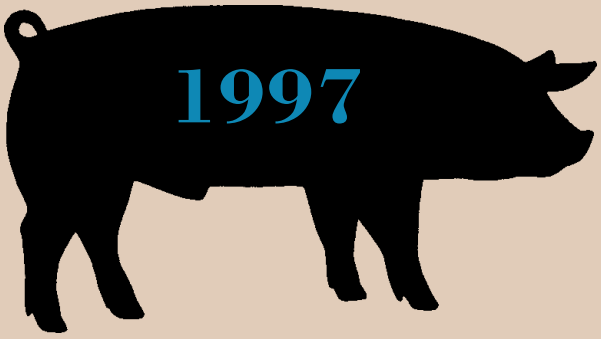

NEBRASKA SWINE REPORT

- Reproduction
- Genetics
- Health
- Nutrition
- Economics
- Housing

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

Cooperative Extension Division
Agricultural Research Division
Institute of Agriculture and Natural Resources
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Cover Art Caption:
Odor emission from swine facilities is a major issue for the pork industry. Here, air samples are taken to determine the impact of reducing dietary crude protein concentration through the use of crystalline amino acids on odor emission into building air.

1997
Nebraska Swine Report

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Method of Detection, Not Type of Housing, Affects Accuracy and Rapidity of Estrus Detection in Gilts

Dwane Zimmerman
Denny Aherin[1]

Summary and Implications

The effects of type of housing (stalls versus pens) and method of heat detection (fence-line boar exposure conducted in-place versus after relocation of gilts to the boar room) on the accuracy and rapidity of estrus detection were evaluated in 24 gilts during two successive estrous periods. Gilts relocated to the boar room showed a higher rate of estrus detection and a more rapid estrous response ($P < .05$) to fence-line boar exposure (81% and 1.7 min, respectively) than gilts provided fence-line boar exposure in-place (67.5% and 2.3 min, respectively). Gilts housed in stalls and pens showed similar rates of estrus detection (68% and 67%, respectively) but the estrous response to fence-line boar exposure tended to occur more rapidly in gilts housed in pens than in stalls (2.0 versus 2.5 min, $P < .1$). Gilts not detected in estrus with fence-line boar exposure were slow to respond to a later heat check with physical boar exposure (3.8 min). Physical boar exposure is required for highly accurate heat detection in gilts. For optimal results, boar stimulation should be provided in an environment removed from the residence of the gilts.

Introduction

Accurate estrus detection is needed to assure proper timing of insemination with both handmating and artificial insemination breeding programs. Recent evidence from our laboratory (1996 Nebraska Swine Report) demonstrated heat detection was less accurate with fence-line boar exposure (FBE) than with physical boar exposure (PBE). Some gilts (16.2%) failed to respond to 15 minutes of FBE but responded to PBE, although slowly (between 5 and 10 min after contact) on the first day of estrus. These gilts were probably in the very early stages of estrus.

Females maintained in individual stalls are difficult to check for estrus and it is time consuming to remove them from individual stalls at each heat check. Also, when females are heat checked in stalls, it is difficult to achieve optimal contact or interaction with the boar. Gilts in estrus or near estrus are attracted to the boar but are unable to pursue and maintain contact with him as he moves away from their stall. The following experiment was designed to compare the accuracy and rapidity of heat detection in gilts heat checked in-place on the fence line, when housed either in stalls or in pens, versus relocating gilts to the boar room for heat detection on the fence-line.

Materials and Methods

Twenty-four gilts with established estrous cycles (two or more) from the Nebraska Gene Pool herd were grouped according to their last estrus into sets of four gilts each. Sets of gilts were assigned randomly to three treatments (two sets or replicates per treatment). Gilts on treatment 1 (S/IP-FBE) were housed in 18 inch-wide gestation stalls (S) and heat checked in-place (IP) with a boar placed in the alleyway directly in front of each set of four stalls. The front of the stalls consisted of vertical bars with 4-inch spacings. Gilts on treatment 2 (P/IP-FBE) were maintained in groups of four in 6 foot x 9 foot pens (P). The 6 foot front gates consisted of vertical bars with 4-inch spacings. These gilts were also heat checked in-place by putting a boar in the alleyway directly in front of each pen. Gilts on treatment 3 (P/R-FBE) were maintained in pens comparable to those used in treatment 2 but were relocated (R) to the boar room for heat detection with FBE. Following completion of estrous observations on all 24 gilts, they were assigned randomly to a different treatment and the gilts were evaluated again at the next estrus using the same procedures.

Heat checks were initiated when the first gilts in each set reached day 17 of the estrous cycle and ended when

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the last estrous gilt was out of estrus. All gilts were housed in the same room and were segregated from boars except during in-place heat checking. Gilts heat checked in-place in stalls or pens were located at opposite ends of the room and were screened from boars during heat detection of the opposite treatment. Gilts relocated to the boar room for heat detection were removed to a neutral room before the heat check boar was brought into the room for IP heat checking. The same boar was used to check gilts on each treatment each day. Gilts relocated to the boar room for heat detection (P/R-FBE) were placed in a heat check pen adjacent to the boar pen. The fence-line separating the boar and gilts consisted of a 10 foot panel with vertical bars separated by 4 inch spacings. Two boars (11 to 12 months old) were used on alternate days to provide 10 minutes of daily (between 7 and 8 a.m.) FBE for each treatment group. In all cases of FBE, efforts were made to keep the boar in close contact with gilts on the fence-line during the 10 minute heat check period. During the heat check period, symptoms of estrus were observed and recorded for each gilt. After heat checking with FBE, each group of gilts was placed in a pen with a different boar and provided PBE for 10 minutes.

Table 1. Mean rate (%) of estrus detection and mean interval to estrus (min) in response to 10 min of fence-line boar exposure

Treatment[a]	Estrus detection rate, %[b]	Mid-estrus detection rate, %[c]	Interval to estrus, min
S/IP-FBE	67	100	2.5[f]
P/IP-FBE	68	100	2.0[g]
P/R-FBE	81[e]	100	1.7[h]

[a]Gilts housed in stalls (S) or pens (P) and heat detected with fence-line boar exposure (FBE) in place (IP) in gilt room or after relocation (R) to boar room.
[b]Detection rate of first and last days of estrus (combined) with FBE.
[c]Detection rate of second day of estrus (mid-estrus) with FBE.
Means in each column with different superscripts differ (e vs others, $P < .05$; h vs f and g, $P < .05$; and f vs g, $P < .1$).

Results and Discussion

During the experiment, two successive estrous periods were detected in all but one gilt. One gilt had an extended estrous cycle (33 days) and controlled estrous observations were terminated before she expressed her second estrus. Detection of the first and last day of estrus with in-place FBE was comparable in gilts housed in pens and stalls (S, 67% versus P, 68%) but the rate of heat detection was higher ($P < .05$) in gilts relocated to the boar room (81%) than in gilts heat detected in-place. All gilts responded to FBE on their second day of estrus (middle estrus) regardless of whether they were housed in stalls or pens or whether they were heat checked in-place or relocated to the boar room for heat detection (Table 1).

Estrous responses (first and last day of estrus combined) occurred more rapidly in gilts relocated to the boar room for heat detection than in gilts heat checked in-place (1.7 min versus 2.3 min, $P < .05$). Gilts housed in pens tended to respond more rapidly to boar exposure than gilts housed in stalls when both groups were heat checked in-place (2.0 min versus 2.5 min, $P < .1$). Gilts not detected in estrus with FBE (28% for first and last days of estrus combined for all three treatments) also tended to be slow to respond to PBE (3.8 min). Gilts in mid-estrus (second day of estrus) not only were able to respond to FBE (100% overall) but 98% also showed estrus within 3 minutes of initiation of FBE.

No differences were detected in duration of estrus between treatment groups. Overall, duration of estrus averaged 52.1 hours. This reflects the average interval of time gilts were actually observed in estrus and makes no correction for the 9 to 15 hour intervals between estrous checks.

Conclusions

Data from this experiment confirm previous observations at Nebraska and elsewhere regarding proper procedures for accurate and efficient heat detection. Relocation of gilts from their home environment to the boar room or a neutral environment to receive contact with boars results in a higher rate of heat detection and a more rapid estrous response to boar exposure than providing boar exposure in-place. Fence-line boar exposure, even under ideal conditions (i.e., when gilts are taken to the boar), is not adequate for accurate detection of estrus in gilts. FBE may be used to quickly screen and identify gilts in solid estrus but the gilts that are not responsive to FBE should be provided PBE in order to find the females that are in early or late stages of estrus and unresponsive to FBE. Housing gilts in stalls versus pens appears to have little influence on the rate of heat detection achieved, as long as the females are properly exposed to boars. The key to achieving accurate and rapid heat detection is to provide gilts with novel stimuli, including physical contact, from a high libido boar(s) at a site other than the gilt's residence.

[1]Dwane R. Zimmerman is a Professor and Denny Aherin is a Research Technologist in the Animal Science Department.

Boar Libido Affects Pubertal Development of Gilts

Dwane Zimmerman
Tom McGargill
Norm Rohda
Matt Anderson
Donald Levis[1]

Summary and Implications

Young boars (10 months) expressing either high (HLB) or low (LLB) libido in standardized mating tests were compared for their ability to stimulate earlier puberty in gilts. Boar exposure was initiated when gilts were either 140 or 160 days old to determine whether the effect of boar libido on attainment of puberty in gilts is influenced by sexual maturation (age) of the gilts. Another group of gilts was isolated from boars (NBE, not boar exposed) and served as controls. Gilts exposed to HLB (10 min/day) reached puberty 8.9 days earlier (P < .06) than gilts exposed to LLB. Gilts exposed to boars, regardless of libido level, reached puberty 21 days earlier (P < .01) than the control gilts. Boar exposure initiated at 140 days induced puberty 11.3 days earlier (P < .06) than when initiated at 160 days. Differences in pubertal responses between HLB and LLB were similar when exposure was initiated at 140 or 160 days. Boar libido is an important component of the boar-stimulating effect on puberty in gilts. Therefore, gilts should be exposed to boars with relatively high libido to achieve optimal pubertal development.

Introduction

Variation in the pubertal response of gilts to boar exposure has been attributed to age of the gilts and boars at initiation of boar exposure, the frequency and duration of boar contact, the nature of the contact between the gilts and boar (e.g., physical vs fenceline contact), and the possible interaction of these factors. In addition, there may be differences between individual boars of similar age in their ability to stimulate gilts. This may result from differences in the quantity or type of pheromone emitted, the level and frequency of their vocalizations during courtship or their ability and willingness to sustain physical interactions with gilts during the period of contact. Data from Australia indicate boar libido significantly affected the pubertal response of gilts to daily boar exposure initiated at 160 days of age. High libido boars (HLB) were more effective than low libido boars (LLB) at inducing earlier puberty in gilts (180 vs 194 days). The objective of this experiment was to compare the effectiveness of HLB versus LLB and determine whether gilt pubertal response to level of boar libido is affected by stage of sexual maturation (age) of gilts at initiation of boar exposure.

Materials and Methods

One-hundred-sixty gilts representing two genetic lines (AP, early puberty; R-LS, average pubertal age) were assigned randomly within genetic line and litter to a replicated (n=4) experiment involving a 2 x 2 + 1 factorial arrangement of treatments. The treatments consisted of exposure of gilts to HLB vs LLB starting at 140 days or 160 days of age. Non-boar exposed (NBE) gilts were maintained in a separate room. Gilts were bled for progesterone analysis 7 to 13 days and one day before treatment to establish ovulatory status; gilts with elevated progesterone were deleted from the study. NBE gilts were bled at approximately 10-day intervals during the course of the experiment. First elevation of progesterone above baseline was used to establish approximate time of first ovulation. Gilts were then checked for estrus after termination of the experiment. Pubertal estrus was back calculated, using a 20-day estrous cycle length, to coincide with the first detected elevation of progesterone.

Thirty-six young boars (10 months) from the White-line population were screened for libido using a standardized 10-minute test with a single estrous female. Six high-rated boars and 6 boars rated low were subjected to repeated testing for their ability and willingness to sustain courtship behaviors and their reaction time to mounting and successful copulation. Boars assigned to the HLB group (n=4) consistently exhibited vigorous courtship behaviors, including vocalization and salivation, sustained vigorous physical interactions and were quick to mount and achieve intromission. Boars selected for the LLB group (n=4) consistently showed only passive interest in the estrous female, made only intermittent, usually non-vigorous, physical contacts with the gilt, exhibited little or no vocalization or salivation, failed or were slow to mount and failed to achieve intromission. Two boars of each category were used on alternate days to stimulate pens of gilts assigned to each type of boar libido. Boar exposure was initiated once daily (10 min duration) as gilts in each replicate reached the target age (140 or 160 days) for boar exposure. Physical contact with boars was provided in a neutral area away from the home-rooms of the gilts and boars. Gilts expressing estrus within the first 5 minutes were recorded and removed from the heat-check pen as soon as observed. Gilts observed in heat after 5 minutes were recorded in estrus between 5 and 10 minutes.

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Results and Discussion

Twenty-five percent of the gilts were deleted from the experiment due to estrous cycles initiated prior to the start of the experiment. Of the 25 percent, most were from the early puberty line and 160-day treatment group. Four gilts (2 HLB and 2 LLB) failed to achieve puberty by termination of the experiment (7 1/2 mo of age). For purposes of statistical analysis, pubertal age in these gilts was considered to be their age at termination of the experiment.

Physical boar exposure, regardless of boar libido level, stimulated earlier puberty in gilts than no boar exposure (HLB, 164.4 and LLB, 173.3 vs NBE, 194.0 days, P < .01, Table 1). Gilts exposed to HLB reached puberty 8.9 days earlier than gilts exposed to LLB (P < .06). No interactions were observed between level of boar libido, age of gilt and genetic line. Genetic line and age of gilt, however, also influenced pubertal response. As expected, gilts from the AP line reached puberty 14 days earlier (P < .003) than R-LS gilts. Gilts exposed to boars starting at 140 days reached puberty 11.3 days earlier (P < .06) than gilts exposed to boars starting at 160 days of age (Table 2).

Table 1. Effect of boar libido on mean age at puberty

Treatment[a]	Pubertal age, days[b]
HLB	164.4[a]
LLB	173.3[b]
NBE	194.0[c]

[a]HLB, high libido boars; LLB, low libido boars; NBE, non-boar exposed.
[b]Means with different superscript differ (a vs b, P < .06; a and b vs c, P < .01).

Table 2. Effect of genetic line and gilt age at initiation of boar exposure on mean age at puberty

	Gilt age, days		
Genetic line[a]	140	160	Combined[b]
AP	158.4	167.2	162.8
R-LS	172.7	180.9	176.8
Combined[c]	165.5	176.8	

[a]AP = early puberty and R-LS = average pubertal age line.
[b]Significant (P < .003) genetic line effect.
[c]Significant (P <.06) gilt age effect.

Conclusion

Boar libido appears to be one important component of the boar-stimulating effect on puberty in gilts. The boar libido effect may be caused by more vigorous physical stimulation, greater pheromonal and/or auditory stimuli emitted by high libido boars or a combination of these factors. Future experiments will attempt to identify the important component(s) of the boar libido effect.

[1]Dwane R. Zimmerman is Professor, Tom McGargill and Norm Rohda are Research Technicians, Matt Anderson is manager and Donald Levis is Professor in the Animal Science Department.

Effect of Early Weaning on Sow Reproductive Performance — A Review

Donald G. Levis[1]

Summary and Implications

A review of literature was conducted to evaluate the effects of lactation length on reproductive performance of sows. As lactation length decreases there is an increase in the weaning-to-estrus interval, a decrease in farrowing rate, a decrease in subsequent litter size and an increase in pigs weaned per sow per year. Because of herd-to-herd differences in the influence of lactation length on reproductive performance, it is advised that each farm conduct a preliminary study to evaluate the effect of the considered lactation length before implementing the "new" weaning age of piglets.

Introduction

Weaning pigs earlier than 21-days of age has become a popular practice in pork production because segregated early weaning has prevented vertical transmission of some diseases pigs encounter from their mothers. Nursery mortality can be less than 1.5% when segregated early weaned pigs are weaned into an off-site, single-stage nursery and provided nutrient-rich, highly palatable diets. In addition, the growth performance of early weaned pigs can be in excess of .44 lb per day during the first week after weaning and over .88 lb per day from weaning to 10 weeks of age. Although performance of pigs is enhanced by using segregated early weaning, reproductive performance may be compromised when sows lactate for less than 21 days.

Weaning-To-Estrus Interval

Seven scientifically controlled experiments indicate the weaning-to-estrus interval (WEI) decreased as lac-

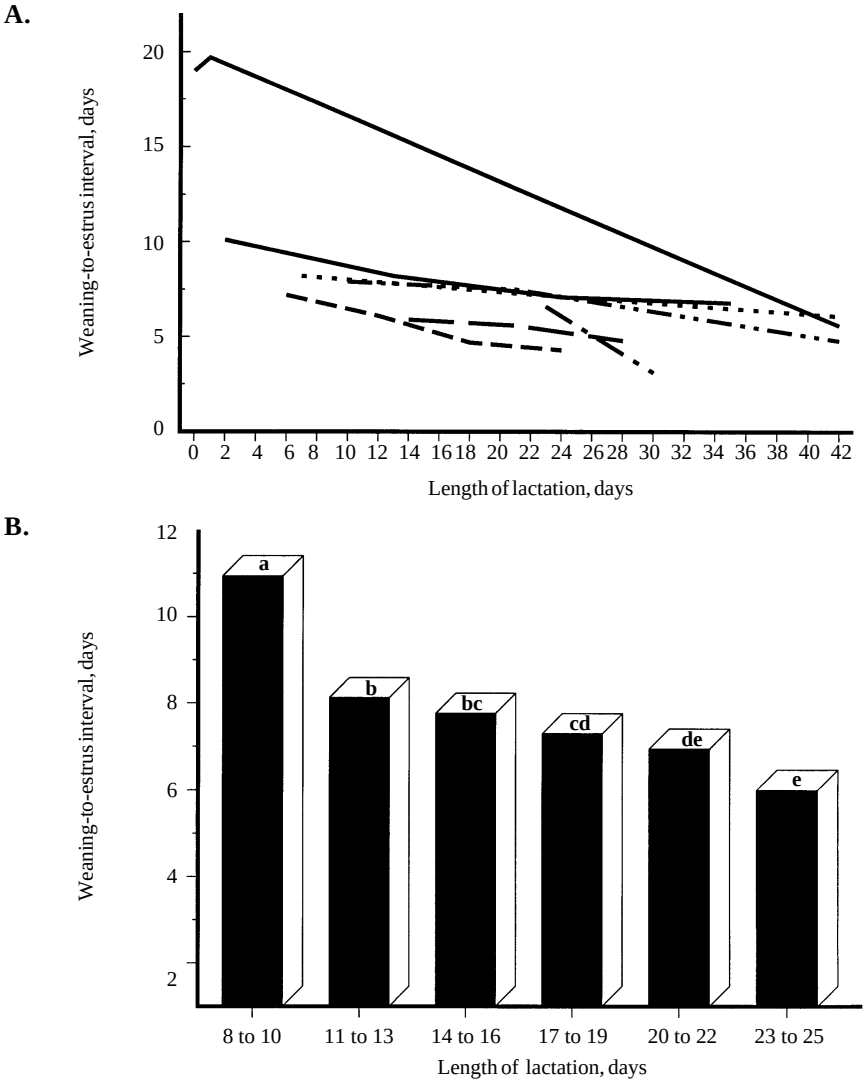

Figure 1. The influence of lactation length on weaning-to-estrus interval (Panel B from Dial et al., 1995, University of Minnesota). Columns with different letters differ (P < .05).

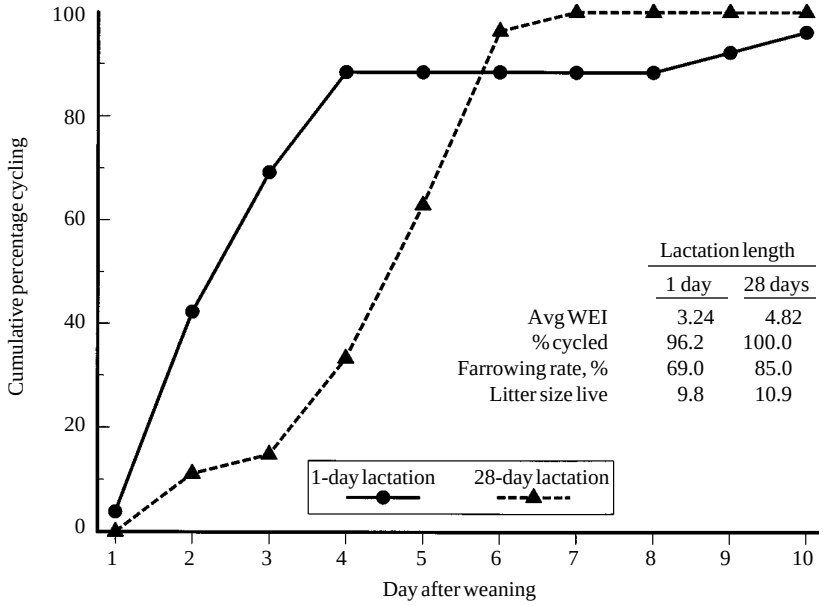

Figure 2. Cumulative percentage of weaned sows cycling after a 1- or 28-day lactation.

tation length increased (Figure 1A). An analysis of PigCHAMP® data found the relationship between lactation length and WEI to be curvilinear when lactation ranges from eight to 25 days (Figure 1B). Sows weaned at eight to 10 days of lactation had a significantly greater WEI than sows weaned at 11 to 25 days lactation. Sows weaned at 14 to 16 days of lactation had a significantly greater WEI than sows weaned at 20 to 25 days of lactation. Some producers wean sows shortly after birth (at birth to two days after birth) to maximize the number of piglets nursing each sow in the farrowing facility. The WEI for multiparous sows weaned within 24 hours after farrowing has ranged from 3.2 to 19.7 days. A problem that has occurred when sows are weaned within 24 hours of farrowing is the formation of cystic follicles. Cystic follicles occur in sows weaned within 24 hours of giving birth because both luteinizing hormone (LH) and follicle stimulating hormone (FSH) have not been suppressed. It takes two to three days of nursing by the litter to suppress LH and FSH. Sows having cystic follicles are characterized by one or more of the following: (1) prolonged and unpredictable return to estrus, (2) constant estrus, (3) prolonged anestrus and (4) irregular estrus. Scientific literature on how parity affects the WEI in sows weaned at less than 2 days of lactation could not be located.

The WEI is influenced by average daily feed intake during lactation. Sows eating an average of less than 9.2 lb of feed per day during a 10- to 19-day lactation have a longer WEI than sows eating an average of 9.2 to 12.5 lb of feed per day. The WEI for lactation lengths of 10 to 19 days is similar when sows eat an average of 12.5 lb or more per day. A scientifically controlled study in Australia indicated lactation feed intake is also important for first-litter sows lactating for 28 days. When first-litter sows consumed an average of 6.6 or 11.0 lb of feed per day during a 28-day lactation, the WEI was 20 and nine days, respectively.

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An analysis of PigCHAMP® data by the University of Minnesota indicated the WEI to increase in a curvil inear manner as lactation length decreased for parities 1, 2, 3 to 6, and 6+. The Minnesota researchers also found that as lactation length decreased the rate of increase in the WEI was greatest for first-litter sows. The delayed WEI for first-litter females may be related to feed intake during lactation. Additional research is needed to clarify how lactation length and lactation feed intake within parity influences the WEI.

The WEI for all evaluated genetic lines increases in a curvilinear fashion with decreasing lactation length. Because the WEI of some genetic lines is less responsive to changes in lactation length than others, it is important for each farm to evaluate the effect of lactation length on the WEI.

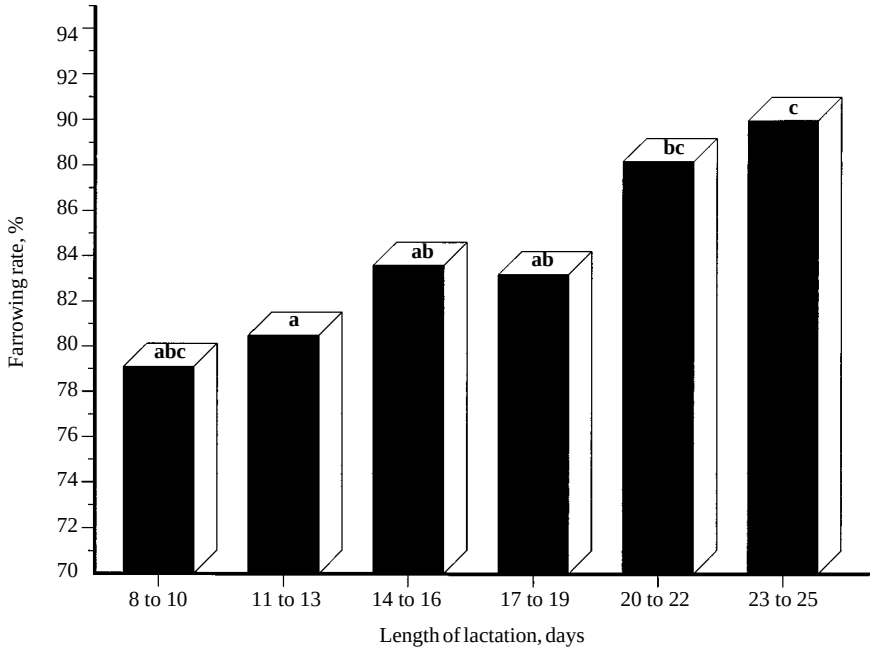

Figure 3. The influence of lactation length on farrowing rate (Dial et al., 1995, University of Minnesota). Columns with different letters differ (P < .05).

Percentage of Sows Cycling after Weaning

It is also important to know what effect lactation length has on the percentage of sows cycling within 10 days after weaning as well as the percentage of sows cycling on each of the first 10 days after weaning. Unfortunately, a scientific study reporting the percentage of sows cycling on each of the first 10 days after weaning for lactation lengths of seven, 14, 21 or 28 days could not be located. Two scientific studies indicated that 91 to 99% of sows weaned at six to 12 days of lactation will cycle within 20 to 30 days after weaning. Figure 2 shows the occurrence of postweaning estrus in sows weaned within 24 hours of parturition or at 28 days of lactation. Although 96.2% of sows weaned within 24 hours of farrowing did cycle within 10 days after weaning, their farrowing rate was 69% as compared to an 85% farrowing rate for sows weaned at 28 days of lactation.

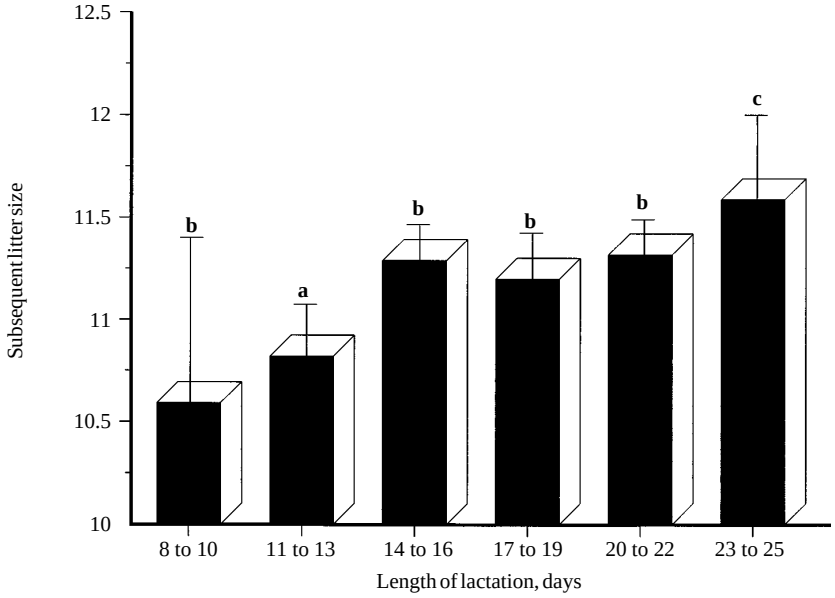

Figure 4. The influence of lactation length on subsequent litter size (Dial et al., 1995, University of Minnesota). Columns with different letters differ (P < .05).

Farrowing Rate

A University of Minnesota study has shown farrowing rate decreases as weaning age decreases (Figure 3). Their

Table 1. Effect of lactation length on farrowing rate

Lactation length, days	Farrowing rate		
	Average	Top 33%[a]	Top 10%[a]
14 to 18	84.9	85.5	86.3
19 to 25	85.2	87.2	88.5
26 to 32	86.0	87.8	88.7

[a]Top 33% and top 10% on the basis of pigs reared per sow per year.

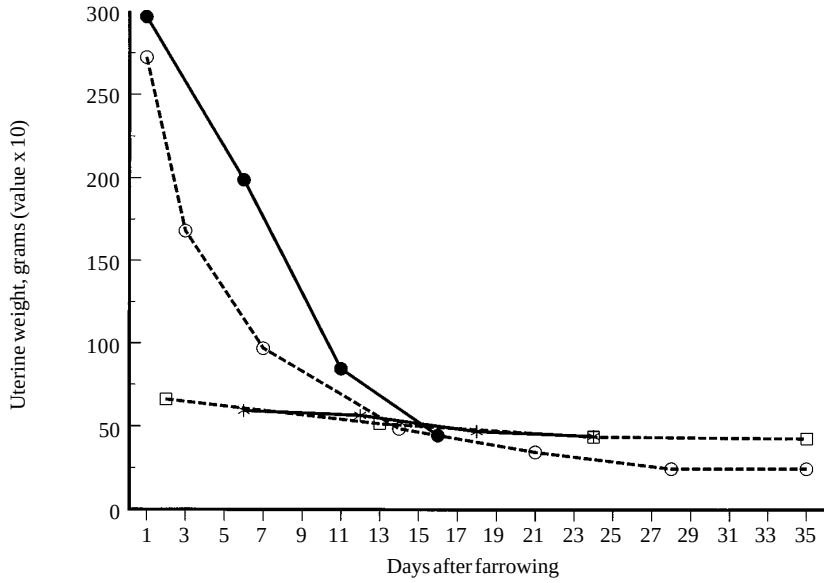

Figure 5. The influence of the number of days after weaning on uterine weight. Data from four studies.

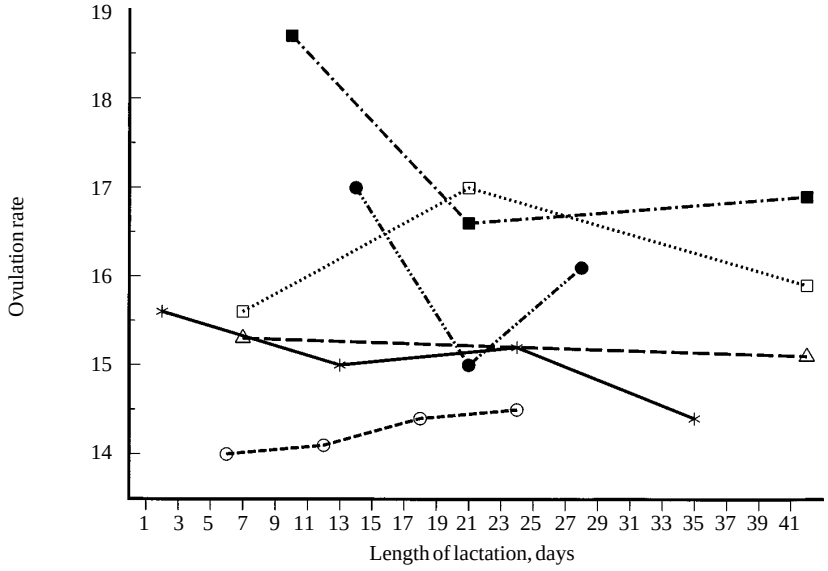

Figure 6. The influence of lactation length on ovulation rate. Data from six studies.

study indicated farrowing rate is significantly lower for lactation lengths of 11 to 19 days as compared to lactation lengths of 23 to 25 days. A substantial amount of variation occurred when sows were weaned at eight to 10 days of lactation; thus, there was not a significant difference when comparing an eight to 10 day lactation period with other lactation periods. Regardless of whether producers are ranked as average, in the top 33% or in the top 10% on the basis of pigs reared per sow per year, data complied from the Meat and Livestock Commission in England indicated a slight decrease in farrowing rate as lactation length decreased from four to two weeks (Table 1). The amount of decrease in farrowing rate will vary between farms because of management factors and the number of days between lactation lengths being compared.

Subsequent Litter Size

A University of Kentucky study indicated subsequent litter size (piglets born live) for sows weaned at six, 12, 18 or 24 days of lactation was 8.8, 9.0, 10.2 and 10.4 pigs, respectively. Subsequent litter size increased ($P < .05$) in a sigmoidal manner. There was a relatively small difference in litter size between sows lactating six or 12 days, a marked increase between sows lactating 12 or 18 days and a plateauing of litter size between sows lactating 18 or 24 days. An analysis of PigCHAMP® data by the University of Minnesota found a curvilinear relationship between lactation length and subsequent litter size born for sows conceiving on first estrus after weaning (Figure 4). A substantial amount of variation was found in subsequent litter size for sows weaned at eight to 10 days of lactation. Subsequent litter size was significantly reduced when sows lactated for 11 to 13 days as compared to lactation lengths of 14 to 25 days. Subsequent litter size was not significantly different between lactation lengths of 14 to 22 days. Subsequent litter size was significantly lower when sows lactated for 14 to 22 days as compared to sows lactating for 23 to 25 days.

Factors that might influence subsequent litter size of early weaned sows are: (1) duration of time needed for the uterus to undergo involution, (2) ovulation rate, (3) fertilization rate of ova and (4) rate of embryo survival.

Uterine involution. The uterus must undergo involution after parturition in order for the sow to breed back satisfactorily. Although the uterus undergoes the greatest weight loss during the first seven days after farrowing, the uterus continues to decrease in weight and length until 21 to 28 days after farrowing (Figure 5). It has been suggested the endometrium of the uterus is capable of receiving and implanting an embryo at 18 days after farrowing.

Ovulation rate. Six scientific studies indicated length of lactation did not

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significantly influence ovulation rate (Figure 6). In contract, a recent study at Kansas State University found that sows weaned at 5 to 11 days of lactation had a lower ovulation rate ($P < .05$) than sows weaned at 23 to 31 days of lactation (15.9 vs 24.0 ova).

Fertilization rate of ova. A University of Kentucky experiment found a linear decrease ($P < .05$) in percentage of ova fertilized when sows were weaned at two (81.9%), 13 (86.3%), 24 (96.5%), and 35 (98.0%) days of lactation. In contrast, a second study at Kentucky did not find a significant decrease in percentage of ova fertilized when sows were weaned at six (90.7%), 12 (94.1%), 18 (95.1%) and 24 (95.1%) days of lactation. However, the percentage of fertilized ova increased numerically as lactation length increased from six to 18 days.

Embryo survival. Five scientific studies have shown embryo survival decreases as lactation length decreases (Figure 7). Therefore, a lower embryonic survival rate of sows with a lactation length less than 21 days may be related to incomplete restoration of the uterine endometrium.

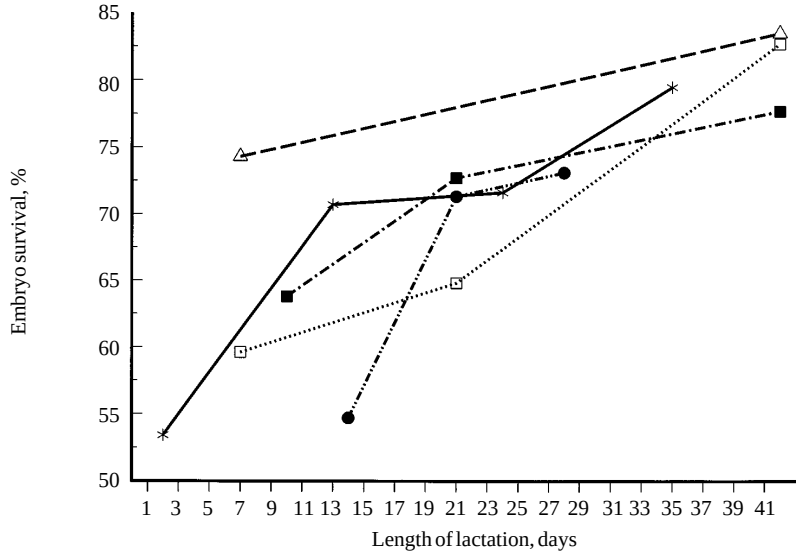

Figure 7. The influence of lactation length on embryo survival. Data from five studies.

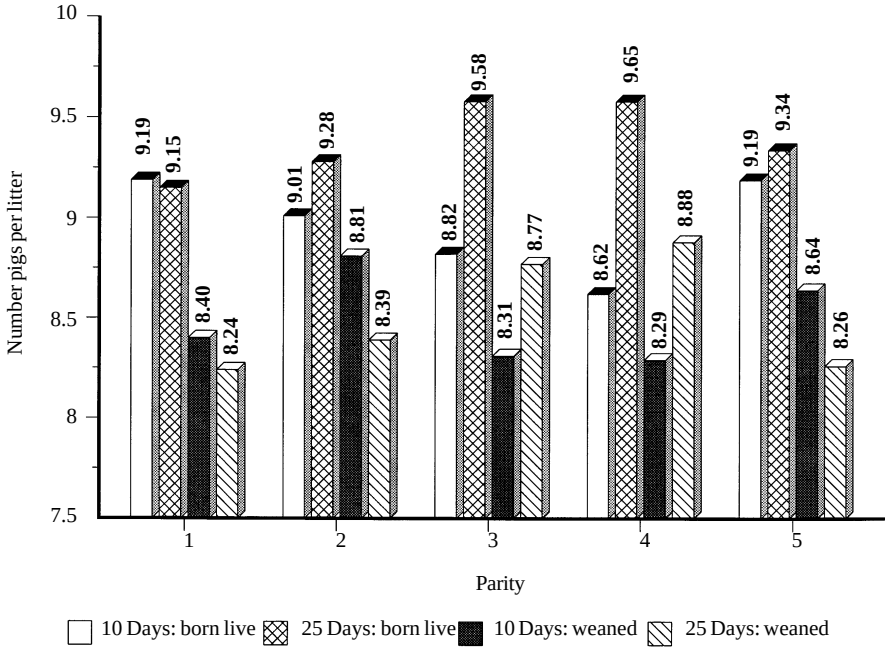

Figure 8. The average number of piglets born live and weaned at each parity of sows weaned after successive lactations of 10 or 25 days.

Longevity

There are two basic arguments about how lactation length may influence sow longevity. One, that sows with short lactation periods would have less body weight loss during lactation, thus they might survive longer because of the reduction of detrimental metabolic effects on vital tissues. The second theory: sows that have short lactation periods would farrow more frequently per year, resulting in higher culling rates due to a greater metabolic demand on their bodies. An analysis of PigCHAMP® data by the University of Minnesota found that average parity at removal and average herd parity are lower for herds using shorter lactation lengths as compared to herds using longer lactation lengths. Additional research is needed to confirm this suggestion.

Pigs Weaned Per Sow Per Year

Since each of the above reproductive traits were detrimentally affected as lactation length decreased, it might be concluded that sows should lactate a minimum of 24 days to optimize the number of pigs weaned per sow per year. However, it must be recognized the number of pigs weaned per sow per year is influenced by litter size born live, percent preweaning mortality and litters per female per year.

British researchers have evaluated the influence of a 10- or 25-day lactation length on number of pigs born live and weaned over five parities (Figure 8). The number of pigs born live per

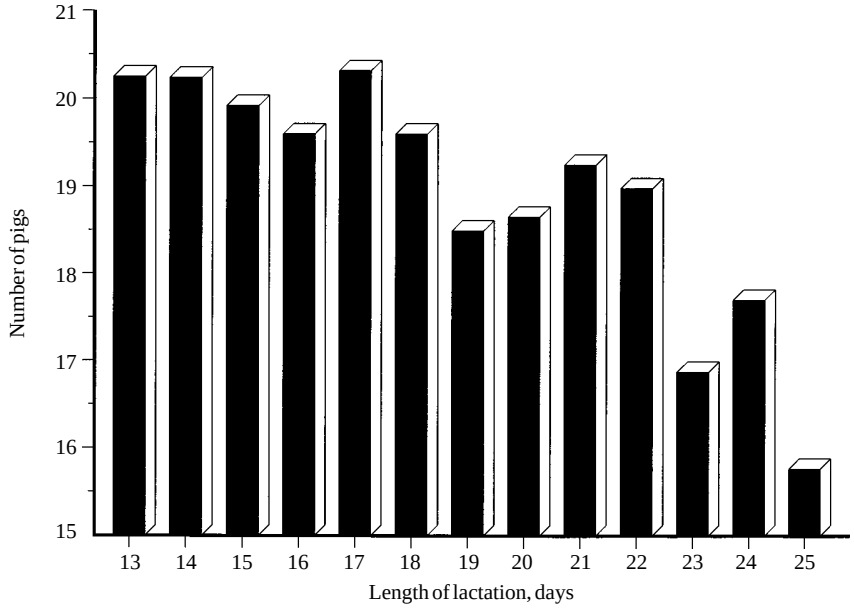

Figure 9. The influence of lactation length on the number of piglets weaned per inventoried female per year (Dial et al., 1995, University of Minnesota).

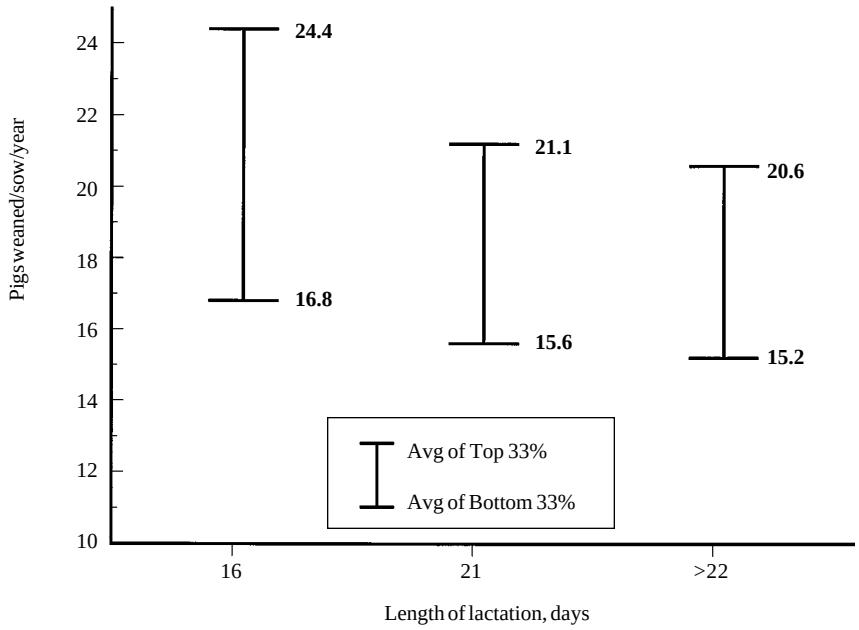

Figure 10. Variation of pigs weaned per sow per year within different lactation lengths.

litter decreased from parity 1 to parity 4 and then increased in parity 5 to the same level as parity 1 for sows weaned at 10 days of lactation. In contrast, sows that were weaned at 25 days of lactation had an increase in number of pigs born live between parity 1 and 3, no increase between parities 3 and 4 and a decrease between parities 4 and 5. When the total number of pigs born live and weaned are summed for parities 1 through 5, sows lactating for 10 days had 2.17 fewer pigs born live than sows lactating 25 days (44.83 vs 47.00). At weaning time, however, sows lactating for 10 days only had .09 less pigs than sows lactating 25 days (42.45 vs 42.54). Preweaning mortality was 5.31% for sows lactating 10 days and 9.49% for sows lactating 25 days. The difference in preweaning mortality is most likely due to the pigs having more days at risk for dying with longer lactation lengths. A farm-level analysis of PigCHAMP® data by the University of Minnesota found that the number of pigs weaned per inventoried female per year increased as lactation length decreased from 25 to 13 days (Figure 9).

It should be remembered a substantial amount of variation exists between farms for number of pigs weaned per sow per year, regardless of the length of lactation. For example, a producer who weans sows at 16 days of lactation and averages 16.8 pigs weaned per sow per year is producing 4.3 less pigs than a producer who weans at 21 days of lactation and averages 21.1 pigs weaned per sow per year (Figure 10).

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Synergism between Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) and *Salmonella choleraesuis*

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Jeffery T. Gray
Tom Stabel
J. J. Zimmerman

Summary and Implications

This study was conducted to investigate the effects of exposure to porcine reproductive and respiratory syndrome virus, Salmonella choleraesuis and stress on young swine. Five-week-old segregated early weaned pigs were randomly assigned to one of eight treatments consisting of all possible combinations of three factors: S. choleraesuis (SC) on day zero, porcine reproductive and respiratory syndrome virus (PRRSV) on day three, and dexamethasone (DEX) on days three to seven. DEX was used as a proxy for stress. Treatment differences were seen in performance parameters, levels and duration of SC shedding, level and distribution of SC in tissues, clinical disease, and mortality. The results of this study provided evidence to support field observations that clinical outbreaks of PRRS are the result of interactions among concurrent infections and stressors.

Introduction

Porcine reproductive and respiratory syndrome virus (PRRSV) and *Salmonella choleraesuis* (SC) are important components of the swine respiratory disease complex. Only recently have both SC as an important and common cause of swine respiratory disease and the emergence of PRRS as a new swine disease been recognized.

Although respiratory disease is a major clinical component of PRRS in field cases, it has been difficult to produce respiratory disease in pigs in the research environment simply by PRRSV exposure. It has been postulated this may be due to low pig density, ideal housing conditions and the absence of concurrent bacterial infections in the research setting.

Pigs subclinically infected with SC are considered the most common source of infection to naïve herds. Like PRRS, it is not clear why and how subclinical infections are triggered to become acute outbreaks of disease. It has been suggested a variety of stressors, including the presence of concurrent viral infections, may lead to clinical outbreaks of salmonellosis. On two Midwestern farms, nursery mortality due to salmonellosis reportedly increased following herd outbreaks of PRRS. This led the authors to suggest that concurrent PRRSV infection may serve to provoke clinical salmonellosis. The work reported here was intended to explore these issues. Specifically, the objective was to investigate the interactive effects of exposure to PRRSV, SC and stress on growth performance and disease in young swine.

Materials and Methods

Experimental animals and design. Two replicate trials were conducted. In each trial, five-week-old segregated, medicated, and early weaned pigs were divided into eight treatment groups. Each treatment group was a different combination of three factors: inoculation with SC on day zero, inoculation with PRRSV on day three, and treatment with dexamethasone (DEX) at a rate of 2 mg/kg on days 3 to 7. DEX was used as a chemical proxy for stress. A three-place acronym was used to denote treatment group. The first letter was either a "P" or "N" to signify inoculation or no inoculation with PRRSV. The second letter was either an "S" or "N" to signify inoculation or no inoculation with SC. The last letter was either "D" or "N" to indicate treatment or no treatment with DEX. For example, treatment group PSN was made up of animals which were inoculated with PRRSV and SC but were not treated with DEX. Use of isolation rooms and strict biosecurity measures, including showering by caretakers and investigators between rooms, were maintained to prevent transmission of infectious agents between groups of pigs.

Bacteria and virus. *S. choleraesuis* strain 3246pp and PRRSV isolate ISU-P (ATCC VR 2402) were used in these experiments. According to the treatment assigned to the group, pigs were intranasally challenged with 1.0 ml of 10^6 CFU/ml of SC and/or 1.0 ml of $10^{6.7}$ $TCID_{50}$/ml PRRSV inoculum.

Biological samples and variables. A single investigator evaluated the health status of the pigs once daily over the course of the experiment. Using minimal restraint, rectal temperatures of the pigs were recorded once daily from day zero through day 14 of the experiment. Body weights of the pigs were determined on days zero and 21 of the trials. Feces, nasal swabs and tonsil swabs were collected on days 0, 3, 7, 10, 14, 17 and 21 for qualitative bacteriological culture. Fecal samples were also submitted for quantitative bacteriological culture. Samples of tonsil, lung, liver, spleen, middle ileum, ileocolic junction, cecum, cecal contents, colon and mesenteric, brachial,

ileocolic and colonic lymph nodes were aseptically collected at necropsy on day 21. Samples from tissues collected from SC inoculated pigs and ileocolic junction samples from non SC inoculated pigs were submitted for qualitative and quantitative bacteriological culture.

Results and Discussion

Clinical evaluations. Pigs which were dually infected with SC and PRRSV exhibited clinical signs of disease. Unthriftiness, rough hair coats, dyspnea and diarrhea were most prevalent. The PSD pigs were the most severely affected; in fact, three of the PSD pigs either died or were euthanized due to the severity of the disease. The PSD death loss was statistically significant (p=0.010).

Body temperature. The proportion of pigs within treatment groups which had fevers was considered a more clinically relevant measure than mean temperature. Temperatures greater than the 97.5 percentile temperature (104.1°F) of all pigs on day zero were considered abnormal (fever). The results indicated the presence of fever was primarily the result of SC infection. Fever, however, was exacerbated by DEX in SC-infected pigs.

Body weight. Both percentage increase in body weight (PIBW) and average daily gain (ADG) were affected by treatment (Table 1). The relatively small numbers in treatment groups, suggested trends, but made it difficult to form conclusions. It should be noted that the pigs which died were excluded from the analysis. At the time of death all three pigs weighed less than their day zero body weight. Therefore, the values for the PSD group were biased upward by the exclusion of the most severely affected pigs. DEX in combination with PRRSV, SC or both had the lowest PIBW and ADG. The overall trends suggested growth performance was most severely affected by pathogens in conjunction with stress; infection alone did not greatly affect growth performance.

Table 1. Percent increase in body weight (PIBW) and average daily gain (ADG) of pigs surviving to day 21. Mean PIBW or ADG values within a column with the same superscript are not significantly different (p>0.05)

Treatment[1]	n	Mean PIBW	Treatment	n	Mean ADG, lb
NSN	7	79.23[a]	NNN	7	0.866[a]
NNN	7	79.04[a]	NND	7	0.860[a]
NND	7	74.00[a]	NSN	7	0.717[a,b]
PNN	7	73.41[a]	PSN	7	0.613[b,c]
PSN	7	66.66[a]	PNN	7	0.575[b,c]
PSD[2]	4	63.43[a,b]	PSD**	4	0.567[b,c]
NSD	6	56.10[a,b]	NSD	6	0.545[b,c]
PND	6	42.01[b]	PND	6	0.390[c]

[1]"P" indicates inoculation with PRRSV; "S" indicates inoculation with *S. choleraesuis*; "D" indicates treatment with dexamethasone; and "N" indicates that factor not given.
[2]Excludes three pigs which died on days 10, 12, and 17.

Table 2. Proportion (%) of pigs within treatment groups which had at least one fecal sample, tonsil swab, or nasal swab positive for S. choleraesuis. Treatments within a column with the same superscript are not significantly different (p>0.008)

Treatment[1]	Day 3	Day 7	Day 10	Day 14	Day 21
PSD	100.00[a]	100.00[a]	100.00[a]	100.00[a]	100.00[a]
NSD	83.33[a]	100.00[a]	100.00[a]	100.00[a]	66.67[a]
PSN	71.43[a]	100.00[a]	100.00[a]	71.43[a]	57.14[a]
NSN	71.43[a]	85.71[a]	85.71[a]	57.14[a]	0.00[b]

[1]"P" indicates inoculation with PRRSV; "S" indicates inoculation with *S. choleraesuis*; "D" indicates treatment with dexamethasone; and "N" indicates that factor not given.

Fecal quantitative bacteriology. Significant differences between treatments (p=0.0099) were shown for repeated measures of SC levels in fecal samples. The level of SC in fecal samples was measured by determining the most probable number (MPN) of SC per gram of feces. The mean of the $\log_{10}$ MPN/g feces of the PSD group was significantly greater (p<0.05) than the NSN group on days seven, 10, 14, and 21; the PSN group on days 10 and 14; and the NSD group on day 10.

Since the clinical severity of salmonellosis is known to be dose-dependent, prolonged and elevated shedding of SC by dual (NSD, PSN) and triple (PSD) treatment groups suggested the possibility that disease outbreaks in the field may be the result of high dose exposures of susceptible pigs from stressed and/or PRRSV-infected herdmates.

Fecal, tonsil, nasal qualitative bacteriology. Qualitative bacteriology results were consolidated to determine if there were differences among groups in duration of SC shedding. The proportion of pigs within treatment groups that had at least one positive SC sample, either fecal, nasal swab or tonsil swab, are given in Table 2. The proportion of shedders in the NSD, PSN and PSD groups were all significantly greater (p<0.008) than in the NSN group on day 21. The results indicated that although the PSD group had the most pronounced effect, there were also significant SC-PRRSV and SC-DEX interactions.

Postmortem tissue bacteriology. Significant differences were seen among treatment groups in the proportion of pigs which were SC positive for particular postmortem tissues. Tissues assayed included mediastinal lymph node, cecal contents, middle ileum, and lung. Although the proportions of positive pigs among treatment groups varied among these four tissues and differences were not always significant, the relative order of the treatment groups remained constant. When all

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tissues sampled at postmortem were considered, a similar pattern was seen. PSD had a significantly greater ($p<0.008$) proportion than the other groups. The NSD and PSN groups were intermediate and similar to each other. The NSN group had the smallest proportion of positive tissues. Further, the mean $\log_{10}$ MPN/g of cecal contents of PSD pigs was significantly greater ($p<0.05$) than the other groups. Once again, the results indicate the PSD pigs, and to a lesser degree the NSD and PSN pigs, were less able to respond to SC infection resulting in a greater distribution and level of SC in tissues.

Summary

Treatment differences were seen on ADG, PIBW, levels and duration of SC shedding, level and distribution of SC in tissues, morbidity and mortality. Although the number of pigs per group limited our ability to statistically differentiate treatment effects for some traits, a consistent pattern was seen. Pigs in the PSD treatment group were the most adversely affected, indicating a high degree of synergism among these three factors. Pigs in 2-factor treatment groups (PSN, NSD) were affected, but to a lesser extent. The results of this study provided evidence to support field observations that clinical outbreaks of PRRS are the result of interactions among concurrent infections and stressors.

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The Effects of Reducing Dietary Crude Protein Concentration on Odor in Swine Facilities

Claudia Obrock H.
Phillip S. Miller
Austin J. Lewis

Summary and Implications

The effect of dietary manipulation on odor emission in a research pig facility was evaluated with 26 finishing gilts (initial weight 161 lb). The two diets were formulated to contain 13% crude protein or 9% crude protein supplemented with crystalline amino acids. Two environmental chambers were used and each housed a group of four or five gilts for 21 days. Relative humidity, temperature and air exchange were maintained throughout the experiment. Samples of feces and air were taken on days 4, 7, 11, 14, 18 and 21 of the experiment. Aerial ammonia and hydrogen sulphide concentrations were measured using detector tubes. Air samples were collected in 25 L Tedlar bags and analyzed within 24 hours, by an olfactometer and a trained panel at Iowa State University. Hydrogen sulphide concentration was < .25 ppm for both treatments. Ammonia concentration was significantly higher when the 13% crude protein diet was provided (P < .01). Odor levels measured by the olfactometer were not different between treatments. These results suggest one method by which the odors produced by swine units can be decreased to potentially benefit both animal and human health.

Introduction

Odor emission from swine facilities is a major pork industry issue. Producers are facing stricter federal, state and local regulations, and lawsuits concerning odor issues are becoming more frequent. The study of odor is complex, both in terms of identifying the combinations of odor-causing compounds and quantifying the odor. Several compounds (e.g., hydrogen sulphide, ammonia, indole phenol, p-cresol and skatole) and measuring techniques have been used to assess odor. Most identified compounds are related to the degradation of excess amino acids commonly found in swine diets. Although new odor control products and techniques appear regularly, a different approach to reduce odor emission is to manipulate the pig's diets.

The objective of this experiment was to reduce total crude protein intake through the use of crystalline amino acids in the diet and examine the effect of the reduced protein intake on odor and ammonia emission into building air.

Materials and Methods

Twenty-six finishing gilts (initial weight 161 lb) were divided into six groups and kept in two environmental chambers (five gilts/chamber for replicate one and four gilts/chamber for replicates two or three) for 21 days (the experiment was replicated three times). Each group was housed in a completely slotted floor pen, raised 18 inches above a solid concrete floor. Manure and urine remained undisturbed in the chamber until the gilts were removed. In both chambers, humidity (maintained at 74%) , temperature (maintained at 70°F) and air exchange (74 ft^3/min) were computer controlled throughout each of the three experimental replications. The chambers were vacant for one week between replicates and cleaned thoroughly with a chlorine solution to avoid odor carryover.

Table 1. Diet composition (as-fed basis)

Ingredient, %	Control diet	Treatment diet
Corn	82.00	92.78
Soybean meal, 46.5% CP	13.75	2.25
Tallow	2.00	2.00
L-lysine HCl	.00	.35
L-tryptophan	.00	.06
L-threonine	.00	.09
DL-methionine	.00	.02
Dicalcium phosphate	.80	1.05
Limestone	.40	.35
Vitamin premix	.70	.70
Trace mineral mix	.10	.10
Salt	.25	.25
Formulated composition:		
Metabolizable energy, Mcal/lb	1.55	1.54
Crude protein, %	13.60	9.40
Lysine, %	.64 (.48)[a]	.59 (.48)
Tryptophan, %	.14	.13 (.10)
Threonine, %	.52	.42 (.34)
Methionine + cystine, %	.51	.40 (.34)
Calcium, %	.55	.56
Phosphorus, %	.45	.45

[a]Values in parenthesis are on an available basis.

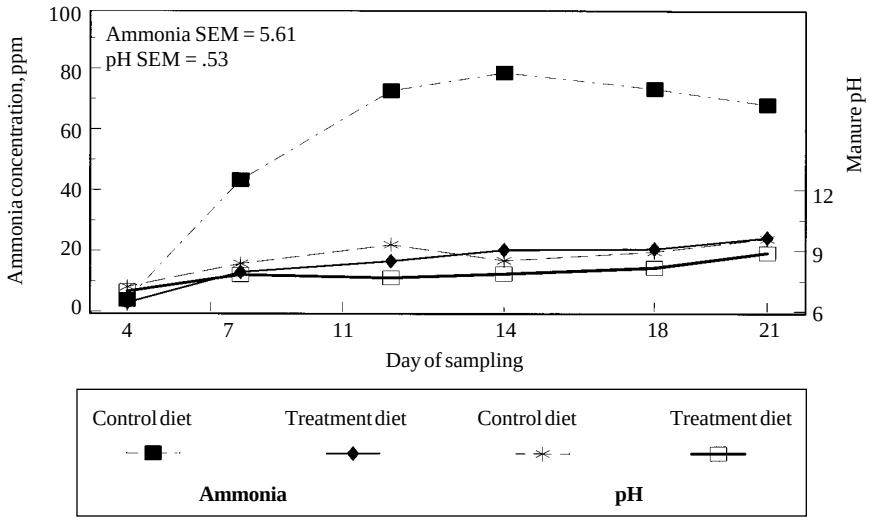

Figure 1. The effect of reducing dietary crude protein on aerial ammonia concentration and manure pH. Control diet = 13% CP and treatment diet = 9% CP.

One of two dietary treatments (Table 1) were randomly assigned to each chamber. The control diet was corn-soybean-meal based and was formulated to meet or exceed nutrient requirements for finishing gilts (NRC, 1988). The treatment diet was formulated by reducing the crude protein concentration and supplementing crystalline amino acids for the first four limiting amino acids (Table 1). Both diets were formulated to contain .48% available lysine. The ratios (available basis) of tryptophan, threonine and methionine + cystine to lysine were set at .20, .70 and .70, respectively. All pigs had ad libitum access to feed and water throughout the experiment.

Manure and air samples were taken on days 4, 7, 11, 14, 18 and 21. An electronic pH meter was used to determine pH in manure. Aerial ammonia was measured using low and mid-range detector tubes and low-range detector tubes were used to determine aerial hydrogen sulfide concentration. For the sensory analysis, air samples were collected directly into 25-L Tedlar bags by creating a negative pressure in a cylinder containing the Tedlar bag. Air samples were transported to Iowa State University and analyzed within 24 hours. The sensory analysis consisted of an olfactometer through which a trained odor panel was presented with various concentrations of odorous air samples. The trained panel smelled the air samples to determine the lowest concentration at which odor was detectable.

Results and Discussion

Temperature, relative humidity and air exchange were similar in both chambers throughout this study. Aerial ammonia concentration was affected by diets ($P < .01$, Figure 1). The average ammonia concentration in air from chambers housing pigs fed the control diet was 56.6 ppm. In the chambers housing pigs consuming the treatment diet, the average ammonia concentration was 16.3 ppm. Ammonia concentration reached a plateau after day 11 ($P < .01$). Hydrogen sulphide concentration for both treatments was < .25 ppm, below the minimum range detectable with commercially available detector tubes.

Manure pH increased significantly throughout the 21 days of experiment ($P < .05$) but did not differ between diets (Figure 1). A plateau in pH was observed on day seven ($P < .01$). The average pH for the control diet and treatment diets were 8.66 and 7.91, respectively. Because pH did not differ between treatments, the difference in ammonia concentration was attributed to the difference between diets.

Sensory analysis results are shown in Figure 2. Although the odor threshold between treatments were not statistically different, odor unit threshold was greater in control pigs on days 11, 14, 18 and 21. Order units threshold is

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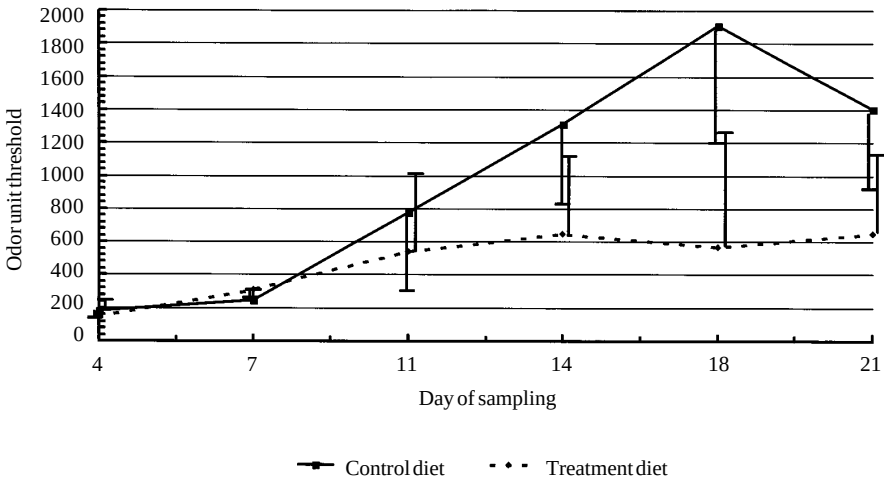

Figure 2. Effect of crude protein reduction on odor unit threshold. Control diet = 13% CP and Treatment diet = 9% CP. Odor unit threshold is defined as the dilution ratio (odor-free air: odorous air) at which 50% of the test subjects cannot detect the odor.

defined as the dilution ratio (odor-free air:odorous air) at which 50% of the test subjects cannot detect the odor. Larger odor threshold units indicate a greater odor concentration in the air sample. Threshold results suggest more replications are necessary to confirm the numerical differences observed in this study.

Conclusions

Reducing dietary crude protein by 4% and formulating the diet to meet the requirements for the first four limiting amino acids decreased aerial ammonia concentration by 29%. Although odor units thresholds were not statistically different, the numerical differences present an indication that there is a reduction of odor emission when feeding a 9% crude protein diet supplemented with crystalline amino acids to gilts in the finishing phase.

These results suggest one method by which the odors produced by pig units can be reduced. A decrease in ammonia concentration within buildings should benefit both animal and human health.

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Segregated Early Weaning of Pigs: Dietary Challenges and Opportunities

Stacy L. Norin
Duane E. Reese
Austin J. Lewis[1]

Summary and Implications

Segregated early weaning (SEW) technology is being adopted by many producers in the pork industry. With the implementation of this technology come many challenges and opportunities to exploit the lean-growth potential and health status of the SEW pig. This review provides insight into some of the reasons for these challenges and discusses some possible ways of utilizing the unique characteristics of the SEW pig to reduce production costs.

Early weaning technology (typically at 10 to 16 days of age) is becoming increasingly common in the pork industry. At this age, the immune status of the pigs is still high because of the antibodies received from sow colostrum and milk. If they are then separated from older pigs, the combination of segregation and early weaning offers substantial protection against disease infection. Segregated early weaning is being used to help control infectious diseases in swine herds while minimizing medication and vaccine use. By reducing the disease challenge to pigs, their genetic potential for growth can be realized in the growing-finishing phases.

However, SEW presents several new environmental and nutrition challenges because of the stress of weaning at a young age. This review will describe some of the dietary challenges and opportunities of SEW. Advances in nutrition have helped increase success in herds implementing SEW by developing diets that facilitate the transition from a milk diet to a solid nursery diet.

Digestive Tract Developments

Diets for SEW pigs must be highly digestible and contain specialty ingredients (i.e., milk products, etc.) be-

cause specific digestive enzymes are present only at low levels in pigs less than three weeks of age. These pigs have the enzyme needed to digest milk sugar (lactase) but limited amounts of enzymes needed to digest proteins (proteases) and starches (amylase and maltase). To increase digestibility and acceptability, diets for SEW pigs are pelleted.

Digestion of diets by SEW pigs is also affected by changes in gut morphology that occur at weaning. The small intestine, the primary site of digestion and absorption of nutrients, contains numerous finger-like projections called villi. These villi create a large and efficient surface area for nutrient absorption. However when the pig is weaned, the villi become much shorter and absorptive and secretory area of the intestine is reduced. Any dietary modifications that help to maintain the villus height should improve nutrient digestibility and absorption.

Disruption of the intestinal tract can be compounded by certain feedstuffs such as soybean meal, which contain factors antigenic to young pigs. These antigenic factors cause an inflammatory response in the intestinal mucosa of the early weaned pig impairing nutrient absorption. Exposure to antigens also activates the pig's immune system and may disrupt growth processes.

Dietary Opportunities

Because anorexia (low feed intake) is a leading cause of morbidity and mortality in SEW pigs, stimulating their feed intake is crucial. Feed intake has been shown to be increased with decreased immune challenge. This results in increased dietary protein consumption and increased efficiency of protein utilization. Certain feed ingredients, such as spray-dried porcine plasma also exert positive effects on feed intake of weanling pigs.

Because of the biological changes in enzymatic activity, gut morphology and the influence of immune challenge on the SEW pig, intensive management is crucial. However, along with the management challenges involved in SEW operations, some new advantages of early weaning suggest there may be more opportunities than originally thought to exploit the lean growth potential and high-health status of SEW pigs.

It has been suggested SEW pigs have the ability to utilize diets containing lower proportions of milk products and other expensive ingredients than previously believed possible. Feed companies are beginning to offer specialized feeding programs specific to SEW and conventionally-raised pigs exploiting this theory.

Although there is a lack of conclusive evidence as to why a less complex diet may be adequate for SEW pigs, there are some possible explanations. One theory is that although the transition to a more simple diet may be stressful, a drastic change in the diet may force the pig's digestive system to develop more rapidly than would occur otherwise. The digestive system is highly adaptable and will alter enzymatic secretions with changing diet composition. Therefore, somewhat less digestible diets may promote development of the intestinal tract. A simple diet may also ease the transition from the early nursery diet to a subsequent simple, corn-soybean meal diet. It is possible these impacts on the digestive system, facilitated by a less complex diet, may be more pronounced in SEW pigs due to their high health status.

Current Research Thrust

Research at the University of Nebraska is currently exploring the elimination or reduction of antigenic factors in feedstuffs to better suit them for incorporation into SEW diets. Extrusion of soybeans is one example. The antigenic factors, glycinin and b-conglycinin, present in soybean meal limit its use in the diets of young pigs. These antigenic factors cause an inflammatory response, resulting in decreased gains and feed efficiency. However, with extrusion of soybeans these antigenic factors can be lessened to levels that cause reduced allergic responses in young pigs versus that seen with soybean meal. This research offers one possibility for reducing the cost of SEW diets by substituting plant protein sources for more expensive animal protein sources in the SEW diet.

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The Effect of Infusion of Urea into the Jugular Vein on Feed Intake of Finishing Gilts

Hsin-Yi Chen
Austin J. Lewis
Phillip S. Miller[1]

Summary and Implications

Previous research suggested feed intake was reduced in growing-finishing pigs consuming corn-soybean meal diets high in crude protein. Because urea is the primary end product of the breakdown of excess dietary protein intake, the effect of intravenous infusion of urea solution on feed intake was evaluated. Daily infusions of 24 and 30 g of urea were used to mimic plasma urea concentration of pigs receiving a 25% crude protein (CP) diet. Blood samples were obtained and feed intakes were measured daily to determine plasma urea concentration and average daily feed intake (ADFI). Average daily feed intake was reduced 4% as daily infusion of urea was increased from zero to 30 grams. The data suggest that plasma urea concentration is involved in regulating feed intake in the finishing gilts consuming excess protein.

Introduction

In the 1996 Nebraska Swine Report, we described an experiment in which diets with five protein levels (13, 16, 19, 22 and 25% CP) were fed to finishing barrows and gilts. We found increasing dietary protein concentration from 16 to 25% reduced average daily feed intake (ADFI) in gilts. We also found plasma urea concentration increased with each incremental increase in dietary protein concentration up to the 22% CP treatment. Because of the apparent correlation between ADFI and the response of plasma urea concentration, we hypothesized plasma urea concentration may have a role in regulating feed intake. Therefore, three experiments were conducted to evaluate the relationship between ADFI and plasma urea concentration.

Procedures

Experiment 1. This experiment was a preliminary study conducted to investigate the effects of intravenous infusion of urea solution on plasma urea concentrations in finishing gilts. The objective was to determine the concentration of urea that would mimic the plasma urea concentration of pigs receiving a 25% CP diet. Six gilts (average body weight 117 lb) were used in a 5×5 + 1 Latin Square design. Catheters were placed into the vena cava of each pig via the external jugular veins (both left and right sides). Catheters were passed subcutaneously through a cannula to the back and exteriorized. Pigs were individually housed in stainless steel metabolism crates in a temperature-controlled room (72 to 74°F) and allowed five days to recover from the catheterization and to adapt to the metabolism crates.

Five gilts were fed a 16% CP corn-soybean meal diet and were infused with either saline or one of four concentrations of urea. The urea solution was infused at a constant rate of 6, 12, 18 and 24 grams of urea daily. Each of the five pigs received the five treatments. One treatment was administered on each of five periods (12 hour/period). Between periods, infusions were stopped for 36 hours to avoid carryover effects. The sixth pig received a 25% CP diet and was infused with saline

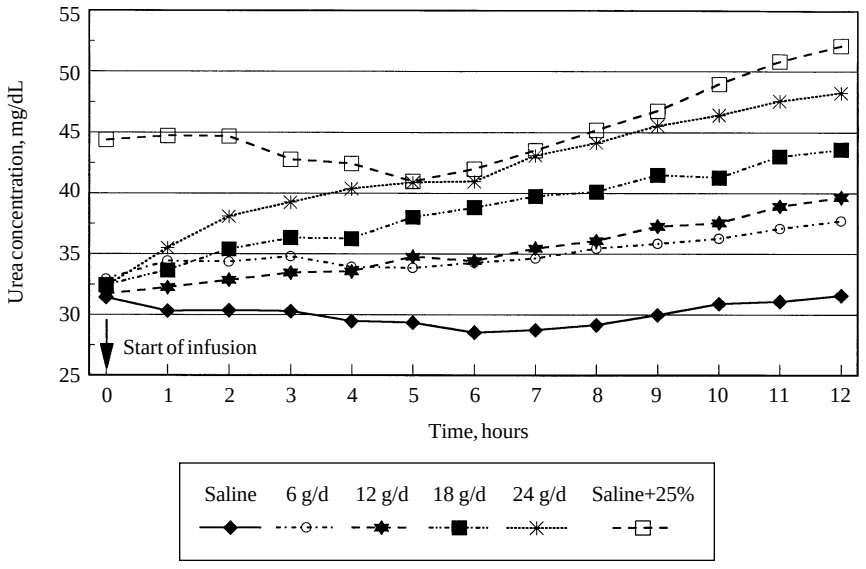
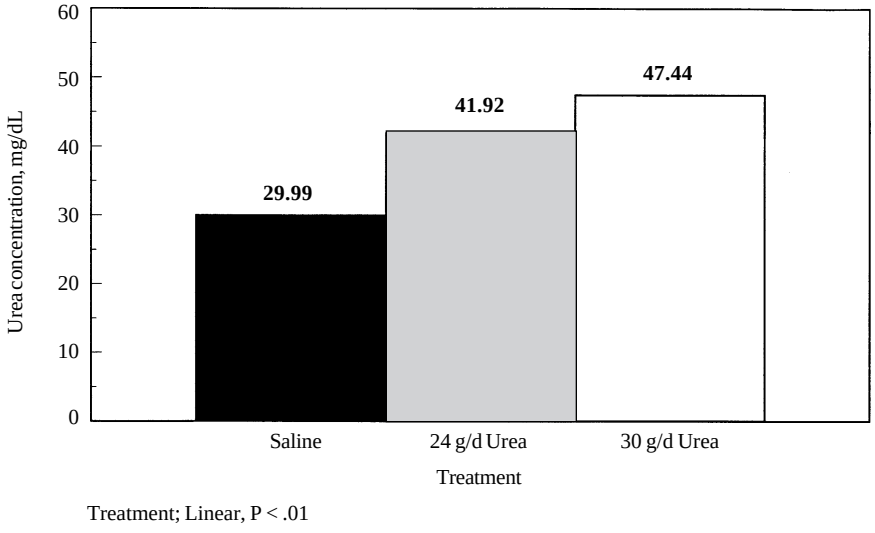
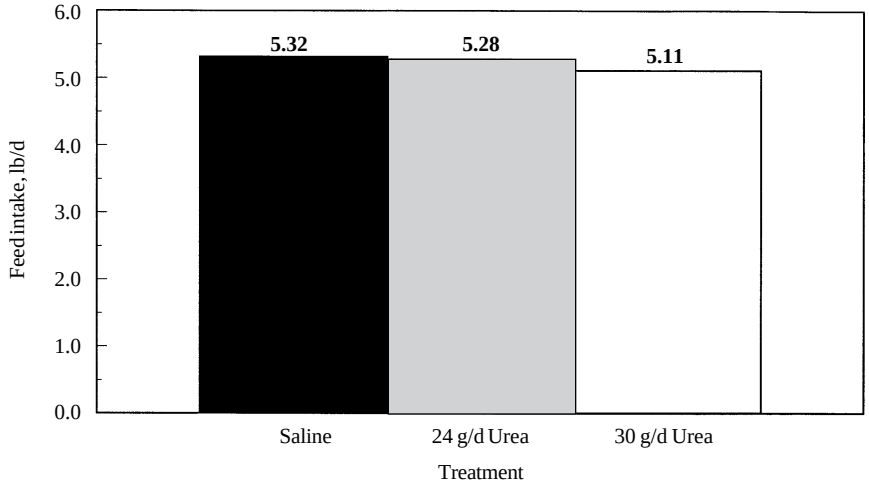


Figure 1. Effect of intravenous infusion of urea or saline on the pattern of plasma urea concentrations in gilts (Experiment 1).



Treatment; Linear, P < .01

Figure 2. Effect of intravenous infusion of urea or saline on the pattern of plasma urea concentrations in gilts (Experiments 2 & 3).



Treatment, P < .1; Trt 0 vs 30, P < .05

Figure 3. Effect of intravenous infusion of urea or saline on feed intake in gilts (Experiments 2 & 3).

throughout the experimental period. Venous blood samples were obtained at 1-hour intervals starting 1 hour before infusion. Plasma was separated and analyzed for urea concentration. Pigs and feeders were weighed before and after each infusion period to determine weight gain and ADFI.

Experiment 2. Three treatments were selected based on the results of Experiment 1 (0, 24 and 30 g/d of urea). Twelve gilts (average body weight 132 lb) were used in a crossover design. The catheterization procedures were similar to those used in Experiment 1. Pigs received a 16% CP diet and a different treatment in each of three infusion periods. Each infusion period lasted for two weeks. Infusions were stopped for two days between periods. Blood samples were obtained before infusion and daily after infusions started. Feeders were weighed daily to determine ADFI. Pigs were weighed before and after each infusion period.

Experiment 3. This experiment was very similar to Experiment 2 except only two treatments (0 and 30 g/d of urea infused) were used.

Results and Discussion

Experiment 1. The results of Experiment 1 are presented in Figure 1. Plasma urea concentration increased with increasing amount of urea infused. When pigs received a daily infusion of 24 grams of urea, plasma urea reached a concentration similar to the pig receiving the 25% CP diet and saline infusion. This concentration (approximately 50 mg/dL) was also similar to that of pigs fed a 25% CP diet in our previous research. However, we assumed a higher concentration of urea solution (30 g/d) may elevate plasma urea concentration even closer to that of pigs receiving the 25% CP and saline infusion. Therefore, daily infusions of zero (saline), 24 and 30 grams of urea were used in Experiment 2 and daily infusions of saline and 30 grams of urea in Experiment 3.

Experiments 2 and 3. Data from both experiments were combined for statistical analysis. The data for plasma urea concentration are shown in Figure 2. Plasma urea concentration increased linearly (P < .01) with increasing concentration of urea solution. The data for ADFI are presented in Figure 3. There was a trend (P < .1) for urea infusion to decrease ADFI. Average daily feed intake was reduced 4% (P < .05) as daily infusion of urea increased from zero to 30 grams. Although the reduction in feed intake was less than we observed previously in gilts fed 25 vs 16% CP, these data do suggest that plasma urea concentration may have a role in regulating feed intake in gilts consuming excessive protein. However, further research is required to elucidate the mechanism(s) whereby plasma urea affects feed intake in finishing pigs.

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Growth Performance and Digestive and Metabolic Responses of Finishing Gilts Penned Individually or in Groups

Sergio Gómez-Rosales
Phillip S. Miller
Austin J. Lewis[1]

Summary and Implications

An experiment was conducted using one or four finishing gilts/pen to identify factors related to the lower performance of pigs penned in groups. Feed intake, daily gain and final weight were greater in pigs penned individually. There was a trend for greater loin weight and primal cut percentage for pigs penned individually. Apparent digestibilities of dry matter, crude protein and gross energy and the plasma concentrations of urea, glucose and nonesterified fatty acids were similar for both individually and group-penned pigs. These results suggest the lower performance of group-penned pigs is related neither to changes in digestive processes nor plasma metabolite concentrations.

Introduction

Pigs raised in commercial conditions are normally penned in groups. In nutrition and other experimental studies, however, they are frequently penned individually. Researchers often pen pigs individually to increase the number of times a treatment can be replicated in an experiment. Increasing the number of replicates/treatment reduces experimental error.

Previous research indicates growth performance is improved when pigs are penned individually compared to when they are grouped. Both competition and aggressive behavior are related to reductions in feed intake and weight gain in group-penned pigs. However, little is known about the changes in body composition or digestive and metabolic responses arising from the social interactions in group-penned pigs compared with those individually-penned. These differences should be investigated to not only refine nutritional recommendations but also to identify conditions in group pens which limit productivity. The present experiment was conducted to identify factors involved in the lower performance of pigs housed in groups.

Procedures

Sixty crossbred gilts with an initial body weight of 100 pounds were allotted to a randomized complete block experiment with two treatments. Two housing treatments were used; one versus four pigs per pen. There were 12 pens with individual pigs and 12 pens with four pigs per pen. One feeder (with one feeding space), one waterer and the same space allowance was offered to each pig, regardless of the number of pigs per pen. The diet was corn-soybean meal-based and fortified with vitamins and minerals to meet or exceed the NRC requirements for 110 to 240-pound pigs (Table 1).

Table 1. Diet composition (as-fed basis)

Ingredients	Percentage
Corn	72.9
Soybean meal, 46.5% CP	21.5
Tallow	3.0
Dicalcium phosphate	1.1
Salt	.3
Limestone	.4
Vitamin mix	.7
Trace mineral mix	.1
Formulated composition:	
Metabolizable energy, Mcal/lb	1.44
Crude protein, %	16.00
Lysine, %	.80
Calcium, %	.65
Phosphorus, %	.55

Pigs were housed in an environmentally regulated facility and had ad libitum access to feed and water throughout the experiment. Pigs were weighed and feed intakes were measured weekly to determine average daily gain (ADG), average daily feed intake (ADFI) and the ratio of gain:feed (ADG/ADFI). Pigs remained on the study for 77 days.

Blood samples were taken from each pig at the start of the trial, after the first week and at two-week intervals throughout the experiment. Plasma was obtained and analyzed for urea, glucose and nonesterified fatty acids

Table 2. Growth performance, digestive and metabolic responses of finishing gilts housed individually or in groups[a]

Item [bc]	Individual	Group
No. of pigs	12	48
Growth performance		
Initial wt, lb	99.7 ± .97	100.3 ± .85
Final wt, lb [d]	264.5 ± 3.80	254.0 ± 3.36
ADFI, lb [d]	6.03 ± .13	5.70 ± .12
ADG, lb [e]	2.15 ± .05	2.01 ± .04
ADG/ADFI	.36 ± .01	.35 ± .01
Carcass characteristics		
Carcass wt, lb	198.2 ± 3.3	191.5 ± 2.6
Ham wt, lb	23.5 ± .55	22.2 ± .43
Loin wt, lb [d]	27.2 ± .36	26.0 ± .28
Shoulder wt, lb	28.0 ± .57	26.4 ± .45
Primal cut wt/carcass wt, % [d]	40.1 ± .54	38.8 ± .41
Lean, % of carcass wt	51.5 ± .61	51.0 ± .46
Digestibility, %		
Dry matter	87.8 ± .31	87.7 ± .27
Crude protein	84.1 ± .48	83.8 ± .42
Energy	87.2 ± .33	87.2 ± .29

[a]Individual= one gilt/pen; Group= four gilts/pen.
[b]ADFI= average daily feed intake; ADG= average daily gain; and gain/feed= feed efficiency.
[c]± standard error of the mean.
[d]P < .10.
[e]P < .05.

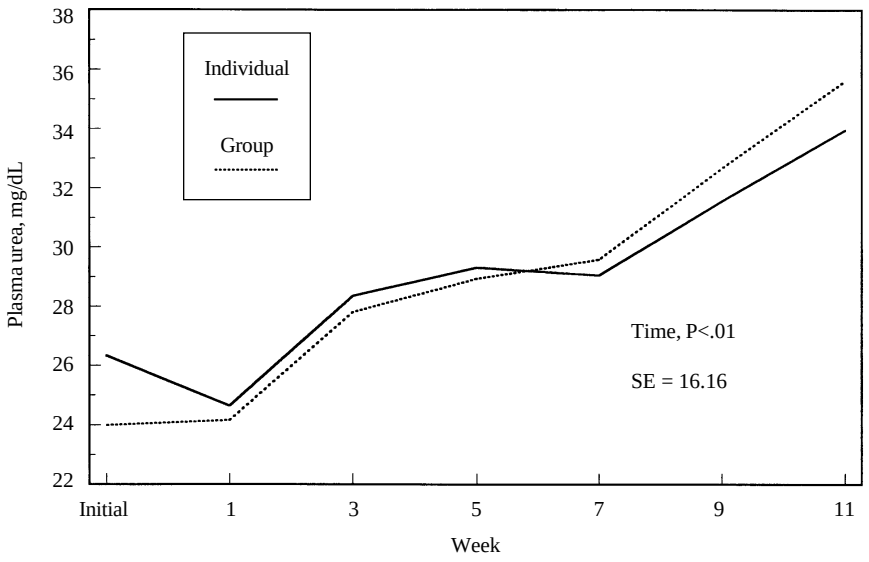

Figure 1. Plasma urea concentration vs time in pigs penned individually or in groups.

(NEFA) . The response of each of these metabolites versus week of the study was examined.

During week 6, .25% of chromium oxide (Cr_2O_3) was added to the diet as an indigestible marker and fecal samples from each gilt were collected daily for three consecutive days. Dry matter (DM), crude protein (CP), gross energy (E) and chromium concentration were determined in feed and fecal samples to calculate apparent digestibility of DM, CP and E.

At the end of the experiment, the pigs were shipped to a packer in northwestern Iowa where carcass characteristics were acquired from relationships derived using Total Body Electrical Conductivity (TOBEC). These included ham, loin and shoulder weights, primal cut percentage and carcass lean percentage (5%-fat basis).

Results and Discussion

Results of growth performance, carcass characteristics and apparent digestibility are presented in Table 2. Average daily gain was greater (P<.05) and there was a trend for greater final weight and ADFI (P<.10) for individually penned pigs. Reduction of feed intake and weight gain in pigs penned in groups is attributed to fighting and aggressive behavior to maintain dominance hierarchy, especially when pigs are eating. Competition during eating periods can distract some pigs from eating, whereas other pigs may be displaced from the feeder by dominant pigs. We assume pigs penned individually ate more and grew faster because of lack of competition at the feeder.

Carcass weight was statistically standardized (used as a covariate) to analyze carcass characteristics. There was a trend (P<.10) for higher loin weight and primal cut percentage in pigs penned individually.

Apparent digestibilities of DM, CP and E were similar in both treatments. Because the efficiency of digestion and absorption were similar,

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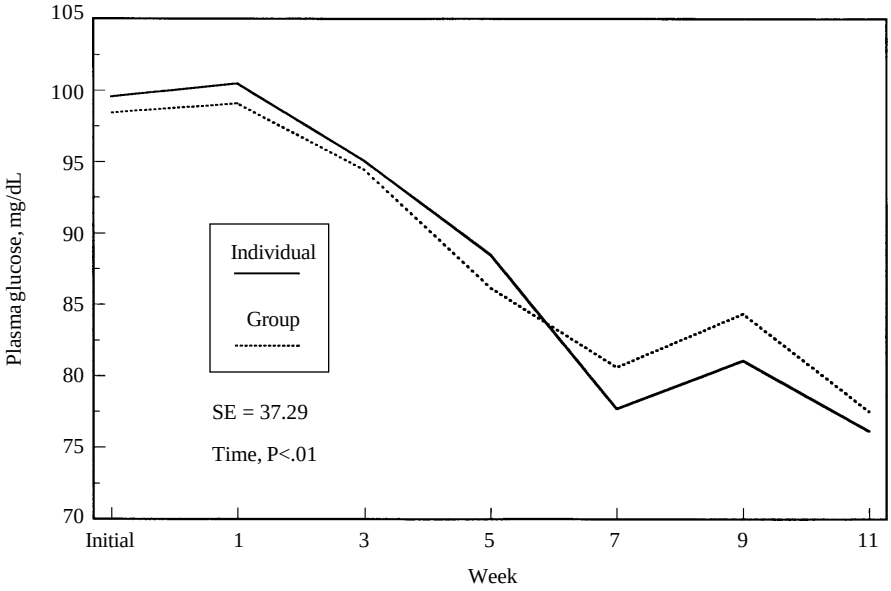

Figure 2. Plasma glucose concentration vs time in pigs penned individually or in groups.

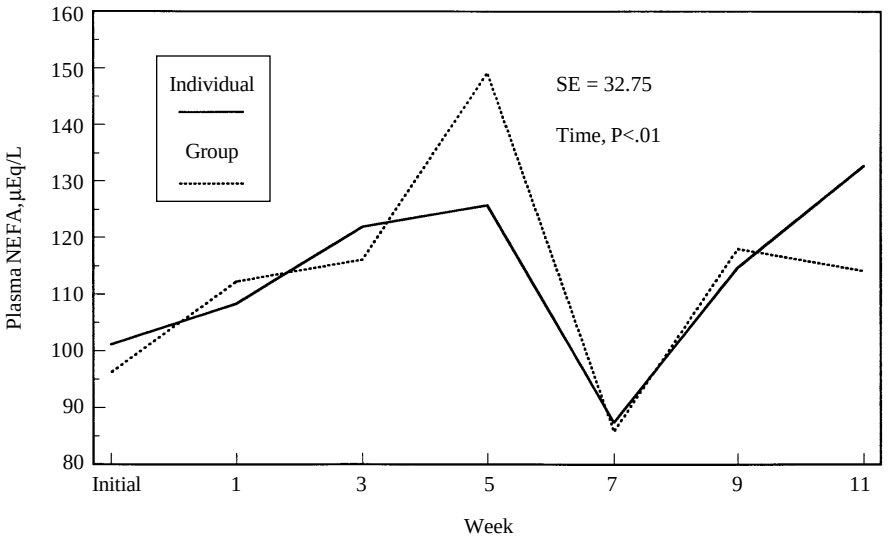

Figure 3. Plasma nonesterified fatty acids (NEFA) concentration vs time in pigs penned individually or in groups.

changes in digestive processes related to housing conditions do not seem to be associated with the lower performance of pigs housed in groups. However, because feed intake was greater for pigs penned individually, more nutrients were absorbed and potentially utilized for tissue accretion.

Increased concentrations of urea, glucose and NEFA in pigs are often symptoms of stressful situations. Stress responses can be triggered by competition and aggressive behavior in pigs penned in groups. However, this is not supported by the responses of plasma urea, glucose and NEFA concentration observed in this study (Figure 1, 2, and 3 respectively). Pigs penned individually or in groups showed similar patterns of plasma urea, glucose and NEFA concentration throughout the experiment.

Conclusions

Growth performance was greater in pigs penned individually than in those pigs penned in groups. The lower performance of pigs penned in groups is not related to changes in apparent digestibility of DM, CP or E or to changes in plasma concentrations of urea, glucose, or NEFA. These observations suggest measurements of feed intake and growth performance data derived from pigs penned individually should be adjusted if they are to be applied to commercial situations or research conditions where pigs are penned in groups.

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Dietary Fiber in Sow Gestation Diets — A Review

Duane E. Reese[1]

Summary and Implications

Gestation sows are well suited to utilize high-fiber, low-density diets. They utilize fiber better than growing pigs and during gestation have a high feed intake capacity relative to their energy requirement. When research results from several studies were pooled and weighted according to the number of litters produced, sows fed additional fiber during gestation farrowed and weaned more pigs/litter than sows fed control diets. Feeding fiber during gestation also improved lactation feed intake, but reduced sow weight gain during pregnancy and pig birth weight. Sows fed fibrous diets also exhibit less stereotypic behavior (i.e., bar-biting), which may be an indication of improved welfare. It is likely there are several factors influencing the response to extra fiber in the sow diet, but it appears the amount of neutral detergent fiber consumed and the source of fiber are important. The metabolizable energy content of fibrous feed ingredients for sows is greater than that for growing pigs. There are limitations to feeding high-fiber diets related to the physical nature of fibrous feed ingredients and the greater volume of manure produced. Potential opportunities exist for pork producers to lower gestation sow feeding costs and/or improve sow reproductive performance by using fibrous feed ingredients during gestation.

Introduction

Gestating sows are excellent candidates for high-fiber diets. Limit-fed gestating sows derive more energy from fibrous feedstuffs than growing pigs allowed ad libitum access to feed. Because of their low feed intake and resulting slow rate of passage, sows have a higher fermentation capacity in the hindgut. Also, sows can consume more of a concentrate diet than necessary to meet their energy requirement during gestation. This excess feed intake capacity can be exploited by offering sows low energy feeds.

There may be certain situations that justify using fibrous feed ingredients in sow gestation diets. However, before decisions can be made it is important to examine the role and feasibility of added fiber in sow gestation diets.

Overall Effects on Reproductive Performance

Results from over 30 years of research are mixed on the effects of added fiber in gestation diets on sow and litter performance. Because of this, it is difficult for producers and nutritionists to decide whether to add fiber to sow gestation diets. Part of the reason for the mixed results is the large variation often observed in reproductive data. Until recently there was no study reported where the number of litters evaluated was sufficient to detect significant differences in performance of sows fed a control or a high-fiber diet.

That study involved feeding gestation sows a fortified corn-soybean meal diet at 4 pounds/day or the same diet (4 lb/d) plus ground wheat straw (.7 lb/d). Wheat straw is a fairly nonfermentable fiber source and was assumed to contribute no nutrients to the diet. It was ground to a fiber length of .25 to .5 inches. All sows were allowed ad libitum access to a corn-soybean meal diet during lactation. Treatments continued for three consecutive reproductive cycles.

The results of the study showed no significant effects of diet on any sow performance traits except lactation feed intake. Sows fed wheat straw during gestation consumed .3 pounds/day more feed during lactation. There was significant diet x parity interaction for litter size born alive, because sows fed wheat straw farrowed more pigs than control sows in cycles 2 (10.5 vs 9.0) and 3 (10.6 vs 10, $P < .015$) but not in cycle 1 (9.9 vs 10.4). Sows fed wheat straw also weaned significantly more (.7) pigs than control sows. Other litter traits were not affected by wheat straw.

Besides having a more adequate number of sows/diet than previous experiments, the following unique features about this study strongly supports the idea that fiber *per se* improved reproductive performance in gestation sows.

- Energy and nutrient intake during gestation were not confounded with the effect of fiber.
- Both diets were supplemented with folic acid and biotin which are known to increase litter size.

To further understand the role fiber has in gestation diets, careful study of previous research is warranted. An analysis of multiple studies was conducted to gain an overall perspective on how added fiber affects sow and litter performance. Mean responses for sow and litter performance were weighted according to the number of litters represented by each mean.

A summary of the net effects of feeding fiber seen in the wheat straw study, as well as, those observed in previous studies is shown in Table 1. In general, the net effect of fiber fed during gestation is similar between the two data sets for most traits. However, the effect of fiber on the number of pigs weaned per litter was over twice as high for sows fed wheat straw. Moreover, there appears to be disagreement on the effect of fiber on the percentage of sows completing the experiment

Table 1. A summary of changes in sow and litter performance due to added fiber observed in a wheat straw study and previous studies

	Study	
	Wheat straw[a]	Previous[b]
Sow traits		
ME/d, Mcal[c]	0	-0.1
Gestation wt. gain, lb	-9	-6
Lactation wt. loss, lb	0	-3
Lactation feed/d, lb	+0.3	+0.6
% completion[d]	0	+10
Litter traits		
Pigs born alive	+0.5	+0.3
Pigs weaned	+0.7	+0.3
Pig birth wt, lb	-0.1	-0.2
Pig weaning wt, lb	-0.7	+0.9

[a]Ewan et al.,1996.
[b]Data from 20 references representing 14 fiber sources and over 1,113 litters produced from sows fed control and high-fiber diets during gestation.
[c]Metabolizable energy intake.
[d]% completion = number of females that completed the study/number assigned to each treatment.

(i.e., sow longevity) and pig weaning weight. These results suggest at least a portion of the responses observed in previous studies was due to fiber intake *per se*, not other factors such as differences in sow nutrient intake.

Effect of Fiber Source on Performance

Knowing if there are fiber source effects on sow and litter performance will enable producers and nutritionists to make better decisions about feeding gestation sows. Unfortunately, few studies have directly compared different fiber sources. Comparisons that have been made include wheat straw to soybean hulls, alfalfa hay to prairie hay, alfalfa hay to alfalfa meal and alfalfa meal to corn cobs. These studies do not provide conclusive evidence that sow and litter performance is affected by fiber source, because no study evaluated more than 18 litters per diet. Thus, the data from previous studies (described in Table 1) were sorted according to fiber source. In an attempt to reduce bias from the analysis, only data from fiber sources evaluated at more than one location were selected and summarized. Daily neutral detergent fiber (NDF) intake during gestation for sows fed control and fibrous diets was calculated. Means were weighted according to the number of litters evaluated for each fiber source.

Table 2 shows the average change in the number of pigs born alive and weaned according to the fiber source given to the sow during gestation. It appears negative responses occurred when alfalfa meal and distillers grains were fed during gestation. The decrease in litter size observed with alfalfa meal is due to results from one of the three evaluated studies. Negative responses also were observed in both studies where distillers grains were evaluated. In contrast, alfalfa hay/haylage, corn gluten feed, oat hull/oats and wheat straw gave positive responses. The largest response in litter size born alive occurred when oat hulls/oats was fed; however, those sows consumed at least 54% more NDF/day than sows fed the other fiber sources. In addition, pigs from sows fed oat hull/oats had the lowest preweaning survival rate. Interestingly, feeding alfalfa hay/haylage, corn gluten feed, or wheat straw increased the number of pigs born alive similarly (.5, .7, and .5 pigs/litter, respectively). A similar increase in the number of pigs weaned was also observed when alfalfa hay/haylage, oat hulls/oats or wheat straw were provided (.8, .7, and .7 pigs/litter, respectively).

Additional research is necessary to provide conclusive evidence that fiber source influences sow reproductive performance. It is possible a fiber source x NDF intake interaction exists, suggesting the amount of NDF necessary to elicit an increase in litter size may depend on the source of NDF. Supporting evidence for this can be observed in Table 2. Sows fed wheat straw consumed about 50% less NDF/d than sows fed alfalfa hay/haylage, but the improvement in litter size was similar.

Response in Sow and Litter Performance in Relation to Fiber Intake

Better decisions regarding feeding fiber to gestation sows are possible if the response in sow and litter performance for each unit of additional fiber consumed is known. Unfortunately, few dose titration studies have been conducted with fiber in gestation diets.

Despite these limitations, it is possible to use existing data to help decide how much fiber gestation sows should consume to ensure a response. It appears that when feeding alfalfa haylage sows should consume about 450 grams of NDF/day to maximize the response in litter size at weaning. The same recommendation may also apply to alfalfa meal and hay, although that has not been critically evaluated. When oat hulls were fed to provide sows 515 grams of NDF/day, litter size was improved, but not maximized. Providing up to 380 grams of NDF/day when feeding corn gluten feed may optimize litter size. Although a dose titration study was not conducted with wheat

Table 2. Average change in litter size according to source of dietary fiber fed to the sow during gestation

Fiber source	Daily NDF intake, g[a]		No. pigs born alive	No. pigs weaned	No. litter[b]	No. references
	Control	Fiber				
Alfalfa meal	264	381	-0.4	-0.7	269	3
Alfalfa hay/haylage	246	721	+0.5	+0.8	647	6
Corn gluten feed	166	794	+0.7	+0.4	229	2
Distillers grains	139	418	-0.3	-0.4	118	2
Oat hulls/oats	260	1221	+1.8	+0.7	96	3
Wheat straw	150	368	+0.5	+0.7	699	1

[a]Average neutral detergent fiber intake by the sow consuming control and fibrous diets during gestation.
[b]Total number litters produced by sows fed control and fibrous diets.

Table 3. Estimated neutral detergent fiber (NDF) intake (g/d) by sows fed diets containing various levels of fibrous feedstuffs[a]

	Dietary level,%		
Fiber source	10	20	30
Alfalfa hay or meal	220	315	415
Corn gluten feed	185	235	295
Oats	185	235	285
Sugar beet pulp	200	265	335
Soybean hulls	235	340	455
Wheat middlings	185	230	280

[a]Alfalfa hay/meal, corn gluten feed, oats, sugar beet pulp, soybean hulls and wheat middlings assumed to contain 49, 33, 31, 40, 58 and 32% NDF, respectively. Sow ME intake = 6 Mcal/d.

straw, litter size at weaning was improved when the sows consumed 368 grams of NDF/day (Table 2). Table 3 provides estimates on the amount of NDF sows would consume if their diet contained various levels of fibrous feedstuffs.

Effect of Fiber on Sow Behavior

Recently a significant amount of attention has been given to stereotypic behavior in sows. Stereotypic behavior is repeated behavior having no apparent purpose. It is thought that stereotypic behavior is an indicator of reduced welfare of sows in individual housing systems.

Common types of stereotypic behavior observed in sows are bar-biting, sham-chewing and excessive adjunctive drinking. There are thought to be certain biological consequences to stereotypic behavior in sows including increased metabolic rate and poorer feed conversion. In addition, these sows are more prone to thin sow syndrome. It is possible that sow reproductive performance is impaired in sows prone to, or exhibiting, stereotypic behavior during gestation.

Researchers in Scotland have linked feed restriction to the development of stereotypic behavior in gestating sows. In practice, gestating sows are given quantities of feed much lower than they are capable of consuming. This leaves sows with a heightened feeding motivation which they deal with through performing stereotypic behavior.

Nutritionists may have an important role in designing feeding programs for pregnant sows to reduce the incidence of stereotypic behavior. Researchers have investigated the effect of feeding diets containing unmolassed sugar beet pulp on stereotypic behavior exhibited by gilts during the first 1.5 hours after feeding. One group of sows was fed a control diet at 4.4 pounds/day a second group was fed a diet containing 50% unmolassed sugar beet pulp at 5.1 pounds/day and a third group had ad libitum access to the 50% beet pulp diet. Results indicate the amount of time the sows spent licking the floor or trough, bar-biting or sham-chewing was reduced when the beet pulp was fed (Table 4). These results show feeding sugar beet pulp promoted satiety in gilts and reduced the incidence of stereotypies. The 50% sugar beet pulp diet fed at 5.1 pounds/day seemed as effective at reducing the incidence of stereotypies as providing gilts ad libitum access to that diet.

Table 4. Effect of dietary fiber on the incidence of oral behaviors in sows[a,b]

	Time (min) spent on[c]		
Treatment	Licking	Sham-chewing	Bar-biting
Control (4.4 lb/d)	28.1	12.1	8.8
Restricted SBP (5.1 lb/d)	6.1	0.9	0.1
Ad libitum SBP	2.6	0.0	0.3
	P < 0.03	P < 0.08	P < 0.05

[a]Brouns et al., 1994.
[b]SBP = unmolassed sugar beet pulp.
[c]During first 1.5 hr after feeding.

Diet Formulation and Feeding Management

Using fibrous feeds in sow gestation diets requires attention to some important details. A summary of key points is presented below.

- Evaluate the economics of feeding fibrous feeds by calculating **total** feed cost/sow/year (cost of feed/ton x tons/sow/year), not just feed cost/ton.
- Sows fed high-fiber diets must eat more feed to meet their energy requirements.
- Digestion coefficients for high-fiber ingredients are greater than those obtained with growing pigs.
- Dry matter, gross energy and fiber utilization of alfalfa hay is increased when particle size is reduced from .5 to 25 inches.
- Sows fed restricted quantities of a bulky diet require more time to eat their ration.

Possible Limitations to Feeding Sows Fiber

In addition to direct economic considerations, other factors may limit the ability of producers to use fibrous feeds in gestation sow diets. These include:

- Some feed mixing and handling equipment can not physically handle fibrous feed ingredients.
- Grinding certain ingredients is time consuming and dusty.
- High-fiber diets are bulky (fewer lb/ft^3) and may bridge in bulk bins and feeders.
- Costs associated with manure handling may increase due to the larger volume of solids produced.
- Handling liquid manure may be more difficult because of larger, undigested feed particles and less liquid present due to sows drinking less water.

[1]Duane E. Reese is Extension Swine Specialist and Associate Professor in the Animal Science Department. References available upon request from the author.

Addition of Fat to Diets of Lactating Sows: I. Effects on Lactation Performance and Pig Composition

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Paul M. Ermer[1]

Summary and Implications

An experiment was conducted with 30 lactating sows to determine the effects of high fat lactation diets on the body composition of suckling pigs and sow backfat composition. Sows were provided a lactation diet containing either zero or 10% tallow on an ad libitum basis for a 21-day lactation. No differences in feed intake during lactation were observed, although sows fed tallow consumed more metabolizable energy per day than control sows. Composition of backfat samples taken at weaning from sows suggested an increase in the amount of fatty acid synthesis in adipose tissue of control sows. Sows fed tallow weaned heavier litters, however, body composition of these pigs indicated this increased weight was almost exclusively fat. Additional research is required to determine the effects of this change in body composition in pigs at weaning on their subsequent performance and body composition.

Introduction

The addition of fat to the diet of the lactating sow has been examined by numerous researchers as a potential method to increase energy intake. Typically, these experiments find sows fed high concentrations of fat (ten percent or more) decrease feed intake slightly. However, because of the increased energy density of these diets, energy intake is increased by approximately 1.5 Mcal of metabolizable energy/day. This increase in energy intake by the sow is reflected in small improvements in the growth performance of her offspring. In addition, we reported an increase in the energy content of the milk from sows fed diets with added fat in the 1995 Nebraska Swine Report. The effects of this change in milk composition on the composition of the suckling pig, however, are unknown.

Because of these reasons, an experiment was designed with the primary objective of determining the effects of feeding a lactation diet high in fat on the body composition of pigs at weaning. A secondary objective was to determine whether differences in the fatty acid composition of the sow's backfat occur due to dietary fat intake during lactation.

Procedures

Thirty first-parity crossbred sows were fed 4 pounds/day of a standard corn-soybean meal diet throughout gestation. Sows were housed in gestation crates until day 110 of gestation, at which time they were moved to farrowing crates. Three farrowing rooms were used for this study and each room contained 10 sows. Each farrowing room was blocked by the predicted farrowing date of the sow. Five sows per room were randomly assigned to receive a corn-soybean meal diet and five were assigned to a similar diet containing 10% tallow (Table 1). Diets were formulated to contain 1% lysine. Concentrations of other nutrients were included at 110% of NRC requirements. Sows had ad libitum access to diets, starting immediately after farrowing. Farrowing room temperature was maintained at approximately 70˚F, except for four days during the final week of the study, when daily high temperatures reached between 80 and 90°F. Continuous lighting was provided.

Table 1. Composition of diets (as-fed basis)

Ingredient, %	Control	Tallow
Corn	67.9	56.80
Soybean meal, 46.5% CP	28.00	29.00
Tallow	0.00	10.00
Dicalcium phosphate	2.10	2.30
Vitamin premix	1.00	1.00
Salt	.50	.50
Limestone	.40	.30
Trace mineral premix	.10	.10
Formulated composition:		
Metabolizable energy, Mcal/lb	1.42	1.63
Protein, %	19.00	18.50
Lysine, %	1.00	1.00
Calcium, %	.90	.90
Phosphorus, %	.75	.75
Analyzed composition:		
Gross energy, Mcal/lb	1.72	1.98
Protein, %	17.90	17.23
Dry matter, %	88.1	89.6
Ether extract, %	2.09	10.94
Calcium, %	.96	.95
Phosphorus,%	.78	.79

Table 2. Fatty acid composition of the diets[a]

Fatty acid, %	Control	Tallow
Myristic (C14:0)	N.D.[b]	1.36
Palmitic (C16:0)	13.86	23.65
Palmitoleic (C16:1)	N.D.	2.01
Stearic (C18:0)	20.59	13.15
Oleic (C18:1)	1.12	37.84
Linoleic (C18:2)	61.72	20.89
Linolenic (C18:3)	2.71	1.11

[a]Data are presented as a percentage of the total of these fatty acids present in the sample, but do not reflect differences in the amount of fat in the diet.
[b]N.D. = not detectable.

Table 3. Effect of 0 or 10% tallow in the sow lactation diet on the fatty acid composition of sow backfat at weaning[a]

Fatty acid, %	Control	Tallow	P <
Myristic (C14:0)	1.12	1.02	.05
Palmitic (C16:0)	23.39	23.33	N.S.[b]
Palmitoleic (C16:1)	2.18	2.13	N.S.
Stearic (C18:0)	13.12	13.03	N.S.
Oleic (C18:1)	47.38	47.63	N.S.
Linoleic (C18:2)	12.43	12.49	N.S.
Linolenic (C18:3)	.37	.36	N.S.

[a]Data are presented as a percentage of the total of these fatty acids present in the sample. The number of sows per treatment was 15.
[b]N.S. = not significant, P > .10.

Table 4. Effect of 0 or 10% tallow in the sow lactation diet on sow and pig performance

Criteria	Control	Tallow	P <
No. of sows	15	15	
Feed intake, lb/d			
d 0 to 7	8.60	8.38	N.S.[a]
d 7 to 14	12.67	12.76	N.S.
d 14 to 21	11.99	11.64	N.S.
Average	11.09	10.93	N.S.
Metabolizable energy intake, Mcal/d			
d 0 to 7	12.77	14.19	N.S.
d 7 to 14	18.77	21.57	.05
d 14 to 21	17.75	19.70	.10
Average	16.43	18.49	.05
Sow weight change, lb			
d 0 to 7	1.56	3.76	N.S.
d 7 to 14	1.56	7.48	N.S.
d 14 to 21	-15.71	-14.30	N.S.
Overall	-12.58	-3.06	N.S.
Litter weight, lb			
d 0	32.91	31.86	N.S.
d 7	57.09	57.20	N.S.
d 14	93.48	97.17	N.S.
d 21	128.02	136.27	.05

[a]N.S. = not significant, P > .10.

Table 5. Effect of 0 or 10% tallow in the sow lactation diet on body weight and composition of 21-d old pigs

Criteria	Control	Tallow	P <
No. of pigs	30	30	
Live weight, lb	12.76	13.35	.10
Carcass weight[a], lb	11.88	12.52	.05
Fat, %	10.41	13.68	.05
Protein, %	15.35	14.70	.05
Ash, %	2.70	2.69	N.S.[b]
Dry matter, %	30.47	32.93	.05
Water, %	69.53	67.07	.05

[a]Carcass weight is the weight of the frozen animal after gastrointestinal contents were removed. All percentage data are expressed as a percentage of carcass weight.
[b]N.S. = not significant, P > .10.

Table 6. Effect of 0 or 10% tallow in the sow lactation diet on the weight of carcass components of 21-d old pigs[a]

Criteria	Control	Tallow	P <
No. of pigs	30	30	
Fat, lb	1.241	1.711	.05
Protein, lb	1.825	1.842	N.S.[b]
Ash, lb	.320	.337	N.S.
Dry matter, lb	3.628	4.122	.05
Moisture, lb	8.261	8.397	N.S.

[a]All data are calculated from carcass weight and percentage data.
[b]N.S. = not significant, P > .10.

Sow and litter weights and feed intake were recorded weekly, from day zero (within 24 hours post-farrowing) to day 21. Litter size was standardized to 10 pigs per litter within 48 hours after farrowing using pigs from a separate group of sows managed similar to experimental sows during gestation. At weaning, a backfat sample was taken from the last rib region of each sow for fatty acid analysis. A barrow and gilt from each litter was selected for determination of body composition. These pigs (n = 60) were euthanized and gastrointestinal contents were removed. Diets and carcasses were analyzed for dry matter, protein, fat and ash content. Data were analyzed as a randomized complete block experiment with gilts blocked by farrowing room.

Results and Discussion

Analyzed nutrient content of the diets were similar to predicted values (Table 1), but protein concentration tended to be lower than formulated concentration. However, values for all nutrients exceeded the NRC requirements. Fatty acid composition of the diets is provided in Table 2.

Fatty acid composition of sow backfat samples was similar between treatments (Table 3), with the exception of a higher proportion of myristic acid in control sows. Because myristic acid was not present in the control diet, this would indicate net synthesis in adipose tissue of these sows. This hypothesis is further supported by the slight, but nonsignificant, increases in the proportions of palmitic and palmitoleic in backfat samples from these sows; these fatty acids are present in concentrations greater than would be predicted by diet composition. For sows fed tallow, myristic acid was present in adipose tissue in lower concentrations than in the diet.

Feed intake did not differ between dietary treatments (P > .10; Table 4). However, sows fed the high-fat diet consumed more metabolizable energy than did control sows on weeks two and three of lactation, as well as for the entire lactation. This result is supported by numerous studies have reported slight decreases in feed intake, but increases in energy intake during lactation by adding fat to the diet. No significant differences were observed in sow weight change, although overall control sows lost 9.5 pounds more than sows fed tallow.

No differences in litter weight were observed on days zero, 7 or 14. However, litters from sows fed tallow were heavier (P < .05) at day 21 than litters from control sows. A majority of previous studies where high-fat lactation diets have been fed have also reported heavier litter weights at weaning.

Pigs chosen for body composition analysis from sows fed 10% tallow were heavier than controls, both on a live weight (P < .10) and a carcass (P < .05) basis (Table 5). Composition of pigs from sows fed tallow differed from that of control pigs. Pigs from sows fed tallow were higher (P < .05) in dry matter percentage and lower (P < .05) in percentage water than control pigs (Table 5). This increase in the dry matter percentage was due to an increase (P < .05) in the percentage fat of these pigs. Percentage protein was lower in pigs from sows fed tallow, although the total pounds of protein did not differ between treatments (Table 6). Pounds of fat and dry matter in carcasses of pigs from sows fed tallow were increased (P < .05) in comparison to pigs from the control-fed sows.

Lactating sows fed diets high in tallow tended to have slightly reduced feed intakes and increased metabolizable energy intakes during lactation. This increase in energy intake resulted in an increase in the milk fat percentage in previous experiments and it has now been shown to affect carcass composition of the suckling pig. Pigs nursing sows fed tallow were heavier at 21 days than control pigs; however, most of the difference in weight was attributed to the increased fat in the carcass. Additional research is required to assess the effects of these compositional changes on subsequent performance of pigs from sows fed tallow during lactation.

[1]Scott L. Tilton and Paul M. Ermer are graduate students, Austin J. Lewis is a Professor and Phillip S. Miller is an Associate Professor, Department of Animal Science.

Addition of Fat to Diets of Lactating Sows: II. Effects on Energy Mobilization and Hormone-Sensitive Lipase Activity

Scott L. Tilton
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Phillip S. Miller
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Summary and Implications

The effect of dietary fat intake on the ability of the lactating sow to mobilize energy from adipose tissue fat was examined. Sows had ad libitum access to diets formulated to contained 1% lysine and either zero or 10% tallow. Data from two epinephrine challenges indicated sows fed tallow tended to have higher baseline concentrations of nonesterified fatty acids (NEFA) and lower stimulated release of NEFA in response to epinephrine than did control sows. Because baseline glycerol values did not differ between treatments, we interpreted this to suggest control sows tended to re-esterify (recycle) a greater portion of the fatty acids during unstimulated (no epinephrine treatment) conditions. This is in agreement with the finding that dietary fat did not affect hormone-sensitive lipase activity on day 21 of lactation.

Introduction

The addition of fat to the diet of the lactating sow typically results in a slight increase in energy intake. There is also an increase in the energy (fat) content of milk and an increase in energy intake by suckling pigs. During lactation, the rates of lipid synthesis and esterification in adipose tissue are increased, compared to rates during gestation. However, little is known about the in vivo and in vitro ability of the lactating sow to mobilize energy from adipose tissue and the affect of dietary fat on this ability.

The objectives of the following experiments were to measure changes in the mobilization of nonesterified fatty acids (NEFA), glycerol and glucose due to epinephrine stimulation. Hormone-sensitive lipase activity was also determined because this enzyme catalyzes the rate-limiting step in the release of energy from adipose tissue.

Procedures

Experiment 1. Seventeen first-parity crossbred sows were used to examine the effect of feeding a 10% tallow lactation diet on epinephrine-stimulated energy mobilization and hormone-sensitive lipase activity. Sows received approximately 4 pounds/day of a standard corn-soybean meal based gestation diet until farrowing. On day 110 of gestation, sows were moved to farrowing crates. Sows were randomly allotted within room to receive either a corn-soybean meal (n = 9) or a corn-soybean meal with 10% tallow (n = 8) diet (Table 1). Diets were formulated to contain 1% lysine and contained 110% of the NRC requirements for other nutrients. Farrowing room temperature was maintained at 70°F and there was continuous lighting. Pigs were cross-fostered within 48 hours after birth to standardize litter size. Sow and litter weights were recorded on a weekly basis. Sow feed disappearance was recorded daily.

On day 3 of lactation, sows were fitted with two jugular catheters. Catheters consisted of sterile medical-grade tubing inserted through an ear vein.

Sows received an epinephrine challenge on day 6 and 20 of lactation. Epinephrine acts to stimulate the processes of fatty acid breakdown from triacylglycerol in adipose tissue. Dosage of epinephrine used was .73 mg /lb of body weight. This dosage was chosen because a linear response up to this dosage was reported in the 1996 Nebraska Swine Report. Blood samples were collected 15 and 5 minutes before epinephrine administration and zero, 2, 4, 6, 8, 10, 15, 20, 25, 30, 45, 60 and 120 minutes after administration of epinephrine.

Plasma was separated and analyzed for glucose, NEFA and glycerol. Baseline, peak height adjusted peak height, and area under the curve were calculated for each sow. Peak height consisted of the average of the 8, 10 and 15 minute samples, whereas adjusted peak height was corrected for differences in baseline concentrations of the metabolite (i.e., peak concentration - baseline concentration). Baseline concentration was the average of the two samples collected before epinephrine administration. Response area was calculated from zero to 45 minutes after epinephrine infusion, by averaging the values obtained from consecutive time points and multiplying the average by the time elapsed between the two data points. Data were then summed over the 45-minute period.

Adipose tissue samples were collected at weaning (d 21) from anesthe-

Table 1. Composition lactation of diets

Ingredient, %	Control	Tallow
Corn	67.9	56.80
Soybean meal, 46.5% CP	28.00	29.00
Tallow	0.00	10.00
Dicalcium phosphate	2.10	2.30
Limestone	.40	.30
Salt	.50	.50
Vitamin premix	1.00	1.00
Trace mineral premix	.10	.10
Formulated composition:		
Metabolizable energy, Mcal/lb	1.42	1.63
Protein, %	19.00	18.50
Lysine, %	1.00	1.00
Calcium, %	.90	.90
Phosphorus, %	.75	.75
Analyzed composition:		
Protein, %	19.17	18.68
Dry matter, %	91.46	91.83
Ether extract, %	3.00	11.35
Calcium, %	1.09	1.07
Phosphorus, %	.89	.89

Table 2. Effects of an epinephrine challenge during d 6 and 20 of lactation on plasma metabolite concentrations in sows fed either a corn-soybean meal diet or a similar diet with 10% tallow (Experiment 1)

	Treatment[a]		Collection time		P <	
Criteria	Control	Tallow	d 6	d 20	Trt	Period
Nonesterified fatty acids						
Baseline,μEq/L	135.8	261.7	232.2	165.4	N.S.[b]	N.S.
Peak,μEq/L	208.2	274.3	275.0	207.5	N.S.	N.S.
Adjusted Peak,μEq/L	72.3	12.6	42.8	42.2	N.S.	N.S.
Response area,μEq*L^{-} *min^{-1}	3738	1760	3370	2128	N.S.	N.S.
Glycerol						
Baseline,μmol/L	66.1	70.7	79.9	56.9	N.S.	N.S.
Peak,μmol/L	101.0	95.7	108.4	88.3	N.S.	N.S.
Adjusted peak,μmol/L	34.9	25.0	28.5	31.4	N.S.	N.S.
Response area,μmol*L^{-} *min^{-1}	1067.0	943.2	1069.3	940.9	N.S.	N.S.
Glucose						
Baseline, mg/dL	89.5	86.5	82.3	93.6	N.S.	.05
Peak, mg/dL	98.27	95.44	90.8	103.0	N.S.	N.S.
Adjusted peak, mg/dL	8.64	9.25	8.52	9.37	N.S.	N.S.
Response area, mg*dL^{-} *min^{-1}	362.8	250.9	246.9	366.8	N.S.	N.S.
NEFA:glycerol ratio						
Baseline	1.70	4.24	2.92	3.02	.09	N.S.
Peak	1.61	2.63	2.29	1.96	.06	N.S.

[a]Litter weight gain and sow weight loss were used as covariates in this analysis. The number of sows fed control and tallow diets was 9 and 8, respectively.
[b]Not significant, P > .10.

Table 3. Effect of diet on hormone-sensitive lipase (HSL) activity in sows on d 21 of lactation[a]

Criteria	Control	Tallow	P <
Experiment 1			
No. of sows	9	8	
nmol FFA[b] released, nmol/mL	334.50	315.98	N.S.[c]
nmol FFA released/mg protein	125.17	128.56	N.S.
nmol FFA released/g of tissue	669.00	631.95	N.S.
HSL, IU/g of tissue	11.15	10.53	N.S.
Experiment 2			
No. of sows	15	15	
nmol FFA released/mL	316.8	322.4	N.S.
nmol FFA released/mg protein	106.8	108.8	N.S.
nmol FFA released/g of tissue	633.6	644.7	N.S.
HSL, IU/g of tissue	10.56	10.75	N.S.

[a]Litter weight gain and sow weight loss were used as covariates in this analysis.
[b]FFA = free fatty acid.
[c]Not significant, P > .10.

tized sows. Samples were flash-frozen using liquid nitrogen and stored until analyzed for hormone-sensitive lipase activity. Hormone-sensitive lipase is the enzyme in adipose tissue assumed to be the rate-limiting step in fatty acid breakdown from triacylglycerol (lipolysis). Diets were analyzed for dry matter, protein, fat, calcium and phosphorus.

Experiment 2. Thirty sows were used to determine further the effect of dietary fat during lactation on hormone-sensitive lipase activity. Sows were managed as reported in the previous experiment. Biopsies were taken at weaning (d 21) and treated as in Experiment 1.

Results and Discussion

Formulated and analyzed nutrient levels for diets are presented in Table 1. In general, formulated and analyzed values agreed; however, calcium and phosphorus percentages analyzed between .1 and .2% greater than formulated values.

Sows fed tallow tended to have higher baseline concentrations of NEFA (Table 2). This led to decreases in the adjusted peak concentration of NEFA and the NEFA response (to epinephrine) area in sows fed tallow . However, these differences were not statistically significant. Because the NEFA:glycerol ratio in control sows was lower (P<.10) both at baseline and peak concentrations, we believe control sows may be re-esterifying more NEFA during stimulated and nonstimulated conditions. In addition, control sows seemed to be more sensitive to epinephrine than were tallow sows (higher adjusted NEFA peak and NEFA response area). Because there were no differences due to treatment in either glycerol and glucose parameters, it would suggest rate of lipolysis and glucose utilization were not affected by dietary treatment. The lack of differences in hormone-sensitive lipase activity from either Experiment 1 or 2 (Table 3) further supports the conclusion that no difference exists for the rate of lipolysis in sow adipose tissue due to the addition of fat to the lactation diet.

Plasma glucose concentration was greater (P < .05) on day 20 than day 6 of lactation. This glucose response is likely due to the increase in feed intake as lactation progressed (observed in the previous report). Although not significant, peak height and response areas for these metabolites follow similar trends, with NEFA and glycerol values decreasing and glucose values increasing as lactation progresses.

Conclusions

The lactating sow is able to increase energy mobilization from adipose in response to epinephrine. It seems likely adipose tissues (fat) in lactating sows consuming diets with a high concentration of tallow are less responsive to signals (epinephrine) stimulating lipolysis. In addition, fatty acids seem to be re-esterified (recycled) to a lesser extent after lipolysis in sows consuming tallow.

[1]Scott L. Tilton and Paul M. Ermer are graduate students, Austin J. Lewis is a Professor and Phillip S. Miller is an Associate Professor, Department of Animal Science.

Retention of Selected Nutrients in Grilled Boneless Pork Chops

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Summary and Implications

Fresh pork Canadian Backs, cut into boneless pork chops, were cooked to 160°F internal temperature by grilling at one of the following temperatures: 200, 250, 300, 350, or 400°F. Significantly longer cooking times were observed for chops grilled at 200°F than for those grilled at the higher temperatures. The yields, as well as the moisture and crude fat content of the chops in the different treatments, were similar. Retention values for selenium were similar for all treatment groups. Chops grilled at 400°F had significantly lower retention values for vitamin E and thiamin and a tendency for lower retention values for vitamin B-6. To optimize cooking time and nutrient retention, the most desirable temperatures for grilling boneless pork chops are 250, 300, or 350°F.

Introduction

Nebraskans and other Americans select pork as a meat choice about 24% of the time. Pork cuts are sources of many essential nutrients, including vitamin B-6, vitamin E and selenium. These nutrients are a potential public health issue in our country. Many Americans consume less than adequate quantities of vitamin B-6 and vitamin E and selenium have been implicated as possible protective factors with regard to the incidence of cancer and coronary heart disease. Little is known, however, about the content of these two nutrients in most foods, including pork cuts. Thiamin, the most heat labile nutrient found in meat, was measured as an index nutrient.

Cooking methods affect retention values for many nutrients. Previous studies in our laboratory indicated retention values for vitamin B-6 were significantly higher in Chef's Prime$_{TM}$ pork loin roasts cooked in a bag than those roasted, while those roasted were significantly higher in B-6 retention than those braised. Also, retention values for thiamin were significantly higher in roasts cooked in a bag and roasted than in those braised. Significantly more vitamin B-6, thiamin, iron, magnesium and zinc also were retained in pork strips cooked by stir-frying than by broiling or microwaving.

The purpose of the present study was to determine the retention of selenium, vitamin E, vitamin B-6 and thiamin in boneless pork chops prepared on a commercial grill set at five different temperatures, but brought to the same internal temperature of 160°F.

Methods

Fresh pork Canadian Backs were cut into boneless pork chops (1 in thick, .1 in fat trim, mean of 140 g). Chops were vacuum packaged and held at -30°F for less than 30 days before refrigerator defrosting and grilling. For the grilling, a commercial grill was set at the following temperatures: 200, 250, 300, 350 and 400°F. The chops were turned when an internal temperature of 97°F was reached. All chops were cooked to 160°F internal temperature. Each cooking occasion was replicated five times. Cooking times and yields were determined.

Samples of all chops, including a raw chop for each cooking occasion, were taken for chemical analyses. Moisture, crude fat, selenium, vitamin E, vitamin B-6 and thiamin content of all samples were determined and true retention values calculated for the vitamins and selenium. True retention was calculated as the nutrient content of the chop cooked, divided by its content before cooking multiplied by 100.

Results and Discussion

The cooking times for the chops, expressed as minutes per gram, are given in Table 1. Significantly longer ($P<.05$) cooking times were observed for chops grilled at 200°F than for those grilled at the higher temperatures. Yield values for chops in the different treatment groups were similar.

Higher equipment temperatures have greater impact on internal color than on external color. The internal color of the cooked chops was significantly more ($P<.05$) red when chops were grilled at 200°F than when grilled at temperatures of 300, 350 or 400°F. External color of the cooked chops was not influenced by grill temperature.

The moisture content of cooked chops in the different treatment groups was also similar (mean $\pm$ standard deviation = 59.8 $\pm$ 3.1 g/100 g); the same was true with regard to crude fat content (10.0 $\pm$ 3.6 g/100 g). Values for moisture were similar to USDA Handbook values, but those for crude fat were lower. This may be due to swine production practices which have produced leaner pigs in recent years.

True retention values for selenium were similar for all treatment groups and were close to 100%. True retention values for the selected vitamins in the cooked pork chops are given in Figure 1. Chops grilled at 400°F had significantly lower ($P<.05$) retention values for vitamin E and thiamin than those grilled at lower temperatures. Chops grilled at 400°F tended to have lower retention values for vitamin B-6 than those grilled at lower temperatures; however, these differences were

Table 1. Effect of grill temperature on yield and cooking times for boneless pork chops[1]

Grill temperature, °F	Yield (%)	Cooking time (min/g)
200°F	76.88 ± 3.90	0.21 ± 0.05[2]
250°F	78.29 ± 4.61	0.14 ± 0.03
300°F	77.57 ± 4.84	0.13 ± 0.02
350°F	77.63 ± 3.98	0.11 ± 0.02
400°F	76.01 ± 6.25	0.10 ± 0.01

[1]Values given as mean ± standard deviation.
[2]Significantly higher (P<.05) than cooking times of other groups.

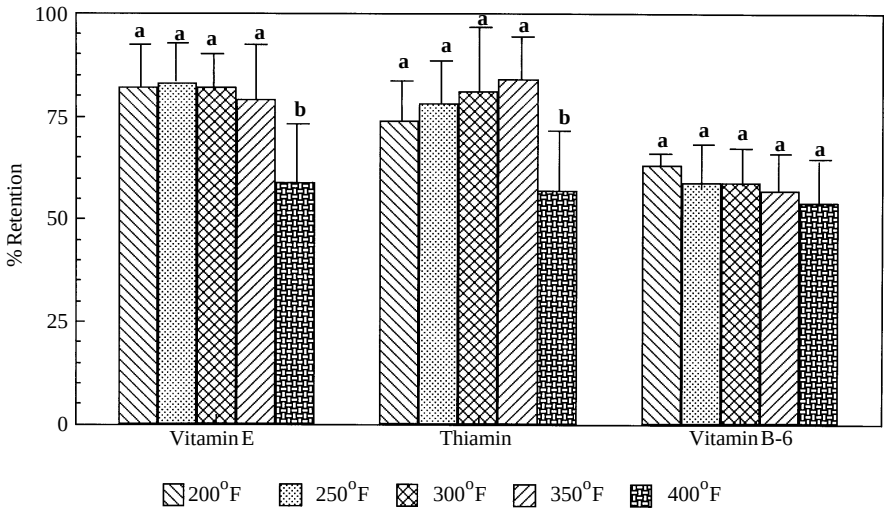

Figure 1. True retention of selected vitamins in boneless pork chops grilled at various temperatures. Values represent means ± standard deviations. Values for each nutrient not sharing a common superscript are significantly different at P<.05.

not significant.

Cooked pork chops (3.5 ounces) were found to contain approximately 96 to 144% of the selenium, 3 to 5% of the vitamin E, 14 to 20% of the vitamin B-6 and 18 to 42% of the thiamin needed to meet the daily Recommended Dietary Allowances of adults.

Conclusions and Implications

To optimize cooking time and nutrient retention, the most desirable temperatures for grilling boneless pork chops were 250, 300 and 350°F. Retention values for nutrients were higher when chops were cooked on grills set at lower temperatures. The cooking time was longer at the lowest grill temperature. Boneless pork chops are rich sources of selenium and good to rich sources of thiamin and vitamin B-6, nutrients which Americans frequently consume in low amounts. The chops also provide some vitamin E.

[1]Judy A. Driskell is a Professor, Fayrene L. Hamouz, an Assistant Professor, Sharon L. Davis and Jidong Sun, graduate students and David W. Giraud, a Research Technologist in the Department of Nutritional Science and Dietetics, University of Nebraska-Lincoln.

Pork Quality Assurance...Dollars and Sense

Angela Baysinger[1]

Summary and Implications

*Is there any reason a pork producer would **not** want to reduce production cost or improve management skills? With the pork industry becoming more consumer driven, should producers take an active role in producing a quality pork product? The Pork Quality Assurance (PQA) Program, developed by the National Pork Producers Council on behalf of the pork industry, is available to help pork producers answer these questions and ensure future success.*

Why Worry?

Producers need to be conscious of the effect of swine health on pork quality. Packers have switched to more carcass buying, placing more responsibility on producers to provide them a quality pig. Producers must withstand the loss for pigs condemned for health reasons. The Pork Quality Assurance (PQA) program helps producers, through an analysis of their herd health protocol and management techniques, to produce better quality pork.

The PQA program is based on the Hazard Analysis and Critical Control Points (HACCP) process. This is an evaluation program routinely used by the Food Safety and Inspection Service (FSIS) to monitor slaughter and processing facilities. The PQA program helps producers in evaluating the following critical control points.

- Establish an efficient and effective herd health management plan.
- Establish a valid veterinarian/client/patient relationship.
- Store all drugs correctly.
- Use only FDA approved over-the-counter or prescription drugs with professional assistance.
- Administer all injectable drugs and oral medications properly.

(Continued on next page)

- Follow label instructions when using feed additives.
- Maintain proper treatment records and adequate identification of all treated animals.
- Use drug residue tests when appropriate.
- Implement employee/family awareness of proper drug usage.
- Complete quality assurance checklist annually.

Benefits

The following are benefits for producers of becoming PQA certified.

- An objective professional assessment of their pork production practices (ie. people/pig flow, biosecurity, processing, etc.)
- Examine the production process for possible cost saving areas (ie. vaccine, antibiotic or feed-additive usage).
- Discuss newly available animal health care products with a veterinarian.
- Review and update facility design and repair needs.
- Learn new technology and developments to improve the production system, nutrition program and swine health. For example, producers can gain insight into segregated early weaning, all-in/all-out, the latest dietary lysine recommendations or the most recent reports on Porcine Reproductive and Respiratory Syndrome (PRRS).

Producers can certify by a one-on-one consultation with their veterinarian, local extension educator, vocational agricultural teacher or through statewide certification meetings. To maintain Level III status, producers must re-certify every other year. For more information about the Pork Quality Assurance Program, contact the Nebraska Pork Producers Association, Inc., at (402) 472-2563.

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Space Allocation Decisions for Barrows and Gilts

Mike Brumm
Jim Dahlquist[1]

Summary and Implications

An experiment was conducted to determine if barrow and gilt performance could be modified by varying pen space allocation for each sex and whether performance of barrows given less space per pig could be enhanced with a more nutrient-dense diet. Barrows given 6 ft^2 of pen space per pig consumed less feed and grew slower with no effect on lean gain compared to barrows provided 7 ft^2 of pen space per pig. Increasing diet nutrient density by feeding the diet sequence recommended for gilts to barrows had no effect on performance for barrows at 6 ft^2 per pig. No differences in performance or carcass measurements were found when space allocation for gilts was increased from 7 to 8 ft^2 per pig. These results suggest that instead of stocking all-in/all-out (AIAO) managed grow-finish facilities at 7 ft^2 per pig for both barrows and gilts, growth rate of barrows can be restricted to match that of gilts if barrows are given 6 ft^2 and gilts 8 ft^2 of pen space per pig. For producers with barns of 500 head capacity managed AIAO, this manipulation of barrow growth results in increased numbers of barrows and gilts of the same weight at the same time, thus increasing producer marketing options.

Introduction

A frustration for many pork producers utilizing all-in/all-out (AIAO) management in growing-finishing facilities is that barrows generally grow faster than littermate gilts. This faster daily gain results in facilities which may have up to 50% of the pens empty one to two weeks while waiting for the slower growing gilts to achieve similar market weight. In many smaller facilities, this differential in growth rate results in the inability of producers to market load lots of pigs, resulting in market access restrictions due to transportation costs. The purpose of the following experiment was to see if barrow and gilt performance could be modified by varying the space allocation and if performance of barrows given less space per pig could be enhanced with a more nutrient-dense diet.

Methods

Terminal-cross pigs of high lean gain potential were allotted to various floor space and dietary treatments (Table 1). Treatment 3 was included to determine the effect of feeding a gilt diet (higher in lysine and other essential amino acids beginning at 80 pounds liveweight) to barrows given less floor space.

The experiment was conducted at the University of Nebraska's Northeast Research and Extension Center at Concord from November - March 1996. The facility was a fully slatted, double wide, naturally ventilated barn with fresh water under slat flushing for manure removal. Pen size was 7 ft x 8 ft with the experimental space allocations achieved by varying the number of pigs per pen. In the event of pig removal for poor performance, pen size was adjusted to maintain the desired stocking density. There was one nipple drinker per pen and one two-hole self feeder.

Diets were formulated with corn and soybean meal according the University of Nebraska recommendations for barrows or gilts of high lean gain potential. Diets were switched on the week pens of pigs averaged 80, 130 and 190 pounds. The lysine sequence

Table 1. Dietary and floor space treatments

Treatment	No. of pens	Floor space, ft ^{2}/pig	Sex	Diet provided
1	6	7	Barrow	Barrow
2	6	6	Barrow	Barrow
3	6	6	Barrow	Gilt
4	6	7	Gilt	Gilt
5	6	8	Gilt	Gilt

Table 2. Effect of space allocation on sex-fed growing-finishing pigs

	Barrows			Gilts		Contrasts			
Space (ft^2/pig):	7	6	6	7	8	1	2	4	1+4
Diet[a]:	B	B	G	G	G	vs	vs	vs	vs
Treatment:	1	2	3	4	5	2	3	5	2+5
No. pens	6	6	6	6	6				
Pig weight, lb									
Initial	50.0	50.2	50.1	49.0	49.0				
Final	255.8	253.9	253.3	251.6	254.2				
Average daily gain, lb	1.88	1.79	1.79	1.72	1.78	P<.05	NS[b]	NS	NS
Average daily feed, lb	5.98	5.80	5.76	5.48	5.52	P<.075	NS	NS	NS
Feed:gain	3.18	3.23	3.23	3.18	3.10	NS	NS	NS	NS
Carcass % lean[c]	49.6	49.9	50.0	52.0	51.6	NS	NS	NS	NS
Lean gain, lb/d[c]	.78	.79	.78	.83	.82	NS	NS	NS	NS

[a]B = diet designed for barrows and G = diet designed for gilts.
[b]Not significant.
[c]Containing 5% fat.

for the gilt diets was 1.00, .93, .88, and .69%. For the barrow diets, the lysine sequence was 1.00, .88, .73, and .60%.

Individually identified pigs were removed for slaughter on the week they weighed 240 pounds or greater. Carcass lean percentage was estimated using total body electrical conductivity (TOBEC) on the individually identified carcass at SiouxPreme Packing Co, Sioux Center, IA.

Results and Discussion

Reducing space allocation for barrows from 7 to 6 ft^2 per pig resulted in a reduction in daily feed intake and daily gain, with no effect on feed efficiency, carcass lean or lean gain (Table 2). While not significant, there was a slight increase in daily gain for gilts at 8 ft^2 vs 7 ft^2 of pen space per pig. Providing barrows housed at 6 ft^2 per pig a diet sequence designed for the lower feed intake of gilts did not improve daily gain, feed conversion efficiency, carcass lean or lean gain compared to barrows fed the recommended diet sequence.

In this experiment, providing barrows 6 ft^2 and gilts 8 ft^2 of pen space per pig resulted in similar rates of gain from purchase to slaughter. However, carcasses from barrows still had a lower percent lean than those from gilts and increasing dietary nutrient density to crowded barrows by feeding diets intended for gilts did not improve their performance.

Conclusion

These results suggest performance of barrows in AIAO managed grow-finish facilities can be altered such that their daily gain is similar to gilts if barrows are provided 6 ft^2 and gilts 8 ft^2 of pen space per pig. There is no effect on either performance or carcass measurements if barrows, which are restricted to 6 ft^2 of pen space per pig and have lower daily feed intake than those given 7 ft^2 of pen space per pig, are given a diet sequence higher in lysine and other amino acids beginning at 80 pounds liveweight.

[1]Mike Brumm is a Professor of Animal Science and an Extension Swine Specialist and Jim Dahlquist was a Research Technologist, Animal Science at the Northeast Research and Extension Center, Concord.

Impact of Feeder and Drinker Designs on Pig Performance, Water Use and Manure Production

Mike Brumm
Jim Dahlquist[1]

Summary and Implications

Two experiments were conducted to examine the impact of feeder and drinker designs on pig performance, water use and manure volume. In the first experiment, pigs with access to a Crystal Springs® wet/dry feeder grew faster, but had a poorer feed conversion and similar carcass merit as pigs using dry feeders with wall-mounted nipple drinkers. Water use was reduced 25.6% in the combined winter and summer trials and manure volume reduced 28.9% in the summer trial for the wet/dry feeder system versus the dry feeder and wall-mounted nipple drinker system. In the second experiment, there was no difference in pig performance or carcass merit for pigs using Trojan WaterSwing® drinkers versus gate mounted Trojan nipple drinkers. There was an 11.1% reduction in water use and a 16.2% reduction in manure volume for pigs using the swinging waterer. The reduction in manure volume for both systems compared to a conventional dry feeder and gate-mounted nipple drinker system has implications for designing manure storage devices and estimates of time necessary for manure removal. While the volume needed to store 180 days of manure production decreases with either the wet/dry feeders or swinging nipple drinker, the estimated acres of cropland to utilize the stored manure as a fertilizer resource does not change. It appears the difference in volume is due to a reduction in water wastage only. The total pounds of nutrients (N, P, K, etc) in the stored manure do not change, only their concentration per 1,000 gallons.

Introduction

Selection of feeders and waterers in growing-finishing facilities represents a major cash outlay that impacts pig performance and facility management for the life of the equipment (often seven to 10 years or longer). In addition to concerns regarding the impact of the equipment selected on pig performance, an increasing number of producers are making equipment decisions on the basis of water use and the resulting implications on manure storage requirements. These experiments compared different feeder and waterer systems to a conventional system consisting of stainless steel dry feeders with nipple drinkers mounted over partial slats.

Methods

General. In each experiment, pigs were housed in similar, mechanically ventilated, partially slatted finishing barns at the University of Nebraska's Northeast Research and Extension Center at Concord. Each barn had six 12 ft x 15 ft pens with 50% of the pen area slatted. There were 24 pigs per pen at the start of each trial. Pen size was not adjusted in the event of pig death or removal for poor performance.

The manure system in each barn was a shallow pit drained periodically into a lagoon (i.e., a pull-plug system). The pens on each side of a center aisle had a common pit and pull-plug system. Feeders and drinkers were assigned to either the north or south side of the aisle so manure production could be estimated from manure depth in the common pit for each feeder or waterer type.

Water disappearance (animal intake and waste) was measured for each drinker or feeder type in each barn by water meters installed in the water delivery line corresponding to the manure pit location. Manure production was estimated by recording the manure depth in each pit prior to removal of the pull-plug.

Carcass lean was measured on individually identified pigs at slaughter using total body electrical conductivity (TOBEC) technology at SiouxPreme Packing Co, Sioux Center, IA.

Experiment 1. Both a winter and a summer trial were conducted to compare the Crystal Springs® wet/dry feeding system to conventional dry feeders with nipple drinkers. The Crystal Springs® feeders provided two feeding spaces for 24 pigs and a single nipple drinker in the feed trough. No other drinking water source was provided in these pens.

Two 3-hole Smidley® stainless steel feeders were provided as the conventional comparison. The feeders were located three to four feet apart so pig access to all feeder holes was not restricted. There were two nipple drinkers provided on the wall opposite the feeders over the slatted portion of the pens.

Corn-soybean meal based diets (meal form) containing 3% added fat were formulated to contain either .9%, .8% or .7% lysine; these diets were fed from 41 to 90 pounds, 90 to 170 pounds and 170 pounds to slaughter weight, respectively. Diets were switched on the week pigs in individual pens achieved the target weights. Overhead sprinklers were used for summer heat relief in all pens. Individually identified pigs were slaughtered the week they weighed 230 pounds or greater.

Experiment 2. One winter trial was conducted to compare pig performance and water use with the Trojan WaterSwing® swinging nipple drinker versus conventionally installed Trojan

nipple drinkers. The WaterSwing® drinker consisted of two nipple drinkers attached to a delivery pipe which was suspended from a chain anchored to the ceiling in the middle of the pen of pigs. The conventional nipple drinkers were installed on the slotted portion of the pen partition over the slatted portion of the pen. The two conventional nipple drinkers were spaced 32 inches apart to limit pig dominance activities when drinking from one of the drinkers. Pigs were weighed every two to three weeks. Both nipple drinker types were adjusted for height, to provide two to four inches of clearance between the shoulder of the pigs (while standing) and the bottom of the drinker.

All diets were corn-soybean meal based (meal form) with no added fat and formulated to meet the University of Nebraska recommendations for pigs of high lean gain potential. Diets were switched on the week pigs in individual pens averaged 80, 130 and 190 pounds. Individually identified pigs were removed for slaughter on the week they weighed 240 pounds or greater.

Results and Discussion

Experiment 1. There was no interaction between feeder type and season. The main effects of feeder type are presented in Table 1. Pigs using the two-hole Crystal Springs® wet/dry feeding system gained weight faster and ate more feed than those using two three-hole Smidley® dry feeders. Because feed disappearance increased more than daily gain, feed:gain was poorer for pigs with access to the wet/dry feeders. There was no effect of feeder type on the number of pigs that died or were removed for poor performance or on carcass lean at slaughter.

Total water use (gallons/pig/day) was reduced 25.6% for the wet/dry feeders compared to the dry feeders and nipple drinkers. There was no effect of season on water use, even though the summer of 1995 was extremely hot.

Manure volume was not statistically analyzed for the winter trial due to a water leak problem in one of the manure pits for part of the trial period, resulting in only one observation of manure volume for the wet/dry feeder. For the summer trial, there was a 28.9% reduction in daily manure volume for pigs with access to the wet/dry feeders. While manure samples were not collected for an estimate of manure dry matter content, it can be theorized the reduction in manure volume was due to a reduction in water wastage.

Experiment 2. There was no effect of nipple drinker type on average daily gain, feed intake, feed conversion efficiency, carcass lean or on the number of pigs that died or were removed from the experiment due to poor performance. Total water use was reduced 11.1% for the WaterSwing® drinker compared to the conventional nipple drinkers. There was a 16.2% reduction in manure volume for the first 103 days of the trial. A water leak in a manure pit prevented collection of manure volume data following the first 103 days of the trial.

Conclusion

Installation and use of either the Crystal Springs® wet/dry feeder or Trojan WaterSwing® drinker resulted in a significant reduction in daily water use and manure volume compared to conventional dry feeders and wall or gate-mounted nipple drinkers. Pigs with access to the wet/dry feeder grew faster as a result of a higher daily feed intake, but they had a poorer feed conversion efficiency. There was no effect of the WaterSwing® on any performance trait measured.

Table 1. Effect of feeder type on pig performance

	Feeder type		
Item	Wet/dry	Dry	P Value
No. pens	12	12	
Pig weight, lb			
Initial	40.9	40.9	
Final	238.1	236.7	
Average daily gain, lb	1.72	1.68	<.05
Average daily feed, lb	5.24	4.96	<.001
Feed:gain	3.05	2.96	<.005
Carcass % lean[a]	46.7	47.0	>.10
Water, gallons/pig/d	1.19	1.60	<.05
Manure production, gallons/pig/d			
Winter[b,c]	.85	1.30	
Summer[d]	1.33	1.87	<.05

[a]Containing 5% fat.
[b]Not statistically analyzed due to a water leak.
[c]One estimate for wet/dry feeders and two for dry feeders.
[d]Two estimates for each feeder type.

Table 2. Effect of drinker type on pig performance

	Drinker type		
Item	Conventional	Swing	P Value
No. pens	6	6	
Pig weight, lb			
Initial	40.3	40.2	
Final	242.3	242.6	
Average daily gain, lb	1.65	1.66	>.10
Average daily feed, lb	5.09	5.08	>.10
Feed:gain	3.09	3.06	>.10
Carcass % lean[a]	52.2	52.3	>.10
Water, gallons/pig/day	1.53	1.36	<.05
Manure volume to d 103, gallons/pig/d	1.17	.98	<.05

[a]Containing 5% fat.

[1]Mike Brumm is a Professor of Animal Science and an Extension Swine Specialist and Jim Dahlquist was a Research Technologist, Animal Science at the Northeast Research and Extension Center, Concord.

Purple Sulfur Bacteria in Anaerobic Treatment Lagoons

Rick Koelsch
Tong Tong Chen
Dennis Schulte[1]

Summary and Implications

Purple or pink colored lagoons, indicating the presence of purple sulfur bacteria, are less likely to be considered an odor nuisance than a more typical non-purple lagoon. The design and management factors that encourage the growth of purple sulfur bacteria are poorly understood. A study of eight purple and non-purple lagoons was initiated during the spring and summer of 1996. The intent of this effort was to identify critical factors that would allow purple lagoons to become a more predictable odor control alternative. A preliminary comparison of design and management factors assumed to be critical suggests more similarities between these two groups of lagoons than differences.

Introduction

A distinct purple to pink coloring is sometimes observed in anaerobic lagoons receiving swine manure. This distinct coloring, attributed to purple sulfur bacteria (PSB), is often observed with a reduction in offensive odors. Under anaerobic conditions, these bacteria use carbon dioxide (carbon source), hydrogen sulfide (electron donor) and ammonia (nitrogen source) for cell growth. The oxidation of sulfides contributes to a lagoon with fewer odorous emissions. In addition, PSB metabolize simple organic compounds reducing the pollution potential of the lagoon wastewater, remove toxic amine compounds, and produce anti-viral substances. Finally, they yield a high protein biomass which, if harvested, could be a potential feed product.

There are several species of PSB including *Chromatium* (purple-red, purple-violet and brown-red), *Thiocapsa* (pink to rose-red) and *Thiopedia*. These bacteria are phototrophic - meaning light is essential to their growth. Sulfides are also essential to their growth, although both high and low concentrations restrict their growth. Most PSB species survive only under anaerobic (no oxygen) conditions. Previous research has also suggested salinity is important to some species.

The goal of this project was to understand the conditions that encourage the growth of PSB. The objectives of our initial effort were to:

1. determine and contrast the design criteria used for both purple and non-purple swine lagoons;
2. determine the management criteria used in these same cases;
3. analyze and report data in case study formats that enable a) producers to improve the management and understand limitations of existing lagoons and b) designers to configure new lagoons that encourage growth of PSB.

Procedures

Eight pork producers with anaerobic treatment lagoons were identified. Five lagoons were selected based upon a previous history of turning purple while the three remaining lagoons were non-purple lagoons. During an initial farm visit, the producer was interviewed relative to:

- livestock numbers and weights (for estimating manure production)
- animal housing, feeding and watering systems,
- cleanup and flush water use,
- lagoon loading and effluent removal frequency and timing,
- lagoon size and other characteristics and
- animal nutrition programs with emphasis on copper, zinc and antibiotics in feed.

Two additional site visits were made in early spring and mid-summer of 1996 to obtain samples from the lagoons. Lagoon wastewater samples were taken by boat from multiple locations at the surface and at various depths. Additional measures were made of lagoon dimension and wastewater depth. Lagoon wastewater samples were analyzed for 18 distinct parameters including bacteriochlorophyll-a (indicator of PSB concentration), sulfide concentration, waste strength and characteristics and nutrient concentrations. The following discussion represents initial results and conclusions.

Results and Discussion

Of the eight lagoons sampled, none exhibited a strong purple coloring during late March or early April. By late July, lagoons, 6, 7 and 8, which had a

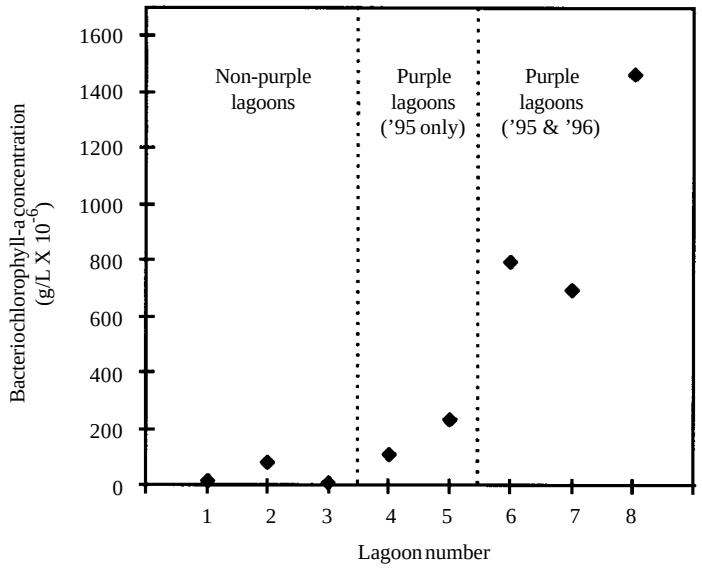
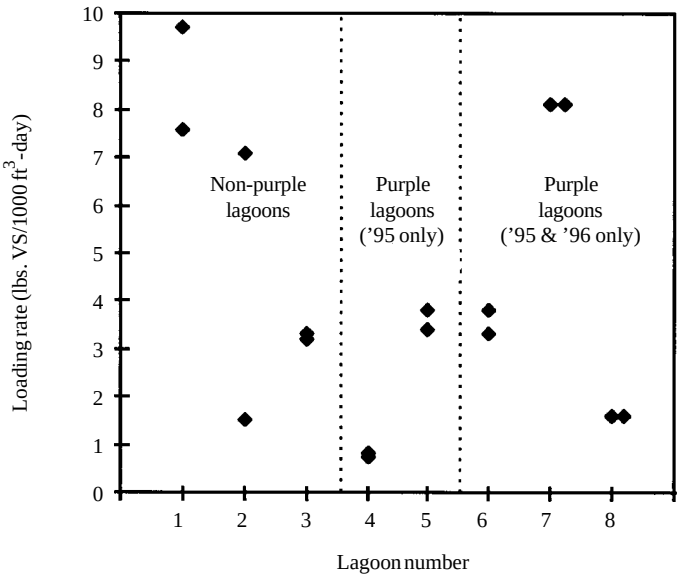


Figure 1. Bacteriochorophyll-a concentration in lagoons (average of summer 1996 lagoon surface and one foot samples).



*Two distinct points for each lagoon represent loading rate as measured at time of spring and summer visits.

Figure 2. Volatile solids (VS) loading rate vs lagoon type*.

history of turning purple, were again bright purple in color. Lagoons 4 and 5, which had a history of purple coloring, did not exhibit this purple color and appeared more of a brown or gray color. Two of the three non-purple lagoons, 1 and 3, were very dark brown to black in color. The third lagoon (2) was green as a result of an algae bloom. All lagoons were highly anaerobic at the surface and at all depths sampled with the exception of lagoon 2, where an algae bloom caused elevated levels of oxygen in the wastewater. Anaerobic conditions are generally considered important for PSB growth.

To distinguish a purple lagoon from a non-purple lagoon, the concentration of bacteriochlorophyll-a was used in addition to visual observation. Non-purple anaerobic lagoons exhibited very low bacteriochlorophyll-a levels while purple lagoons exhibited greater concentrations (Figure 1). The lagoon with an algae bloom (2) and the two lagoons that failed to turn purple in 1996 (4 and 5) had moderate levels of bacteriochlorophyll-a. While there was a reduced level of PSB present in lagoons 4 and 5 compared to lagoons 6, 7 and 8, it appears these lagoons have the potential to be purple again in the future.

Sulfide concentration is considered important to the survival of PSB. For all lagoons, sulfide concentrations were in a similar range (1 to 6 mg of sulfide per liter) with slightly lower levels observed for purple lagoons than for non-purple lagoons. However, the observed ranges for sulfide in all lagoons were not at levels considered a limitation for PSB growth.

Producers are often encouraged to increase lagoon size in an effort to reduce odor nuisance potential and encourage growth of PSB. While oversizing lagoons remains critical to reducing odor nuisance, it may be less essential to survival of PSB. Volatile solids loading rate is a typical measure of lagoon size. All three purple lagoons had a volatile solids loading rate considered high by most design standards (Figure 2). Purple lagoon 7 had one of the highest loading rates observed for all lagoons. The lowest loading rate observed was for lagoon 4 which had a history of turning purple but which failed to do so in 1996. It would appear that loading rate may be less critical than previously anticipated for allowing PSB to prosper.

Management factors may play a role in encouraging purple lagoons. Since these bacteria require sunlight, dilution of the manure with barn flush and clean-up water was thought to influence the potential for sunlight penetration and PSB growth. The purple lagoons typically showed higher water

(Continued on next page)

dilution levels. However, measures of sunlight penetration of each lagoon with a standard Sechi disk[2] revealed penetration of 1 to 2 inches for all lagoons with little apparent differences between non-purple and purple lagoons. These results suggest PSB growth would occur very near the surface of the lagoon. However, PSB were distributed fairly evenly to all depths of the lagoons likely due to mixing caused by anaerobic activity and other factors.

Finally, anti-bacterial products in the manure were considered a potential factor affecting PSB survival. Copper, zinc and antibiotics from animal feed may impede the growth of PSB. The addition of copper and zinc to the lagoon (assuming the animal did not retain these elements) varied by a factor of 10 when compared on a per unit of lagoon volume basis. However, above average levels of copper and zinc addition were observed in both purple and non-purple lagoons. Lagoon 5, which had a history of turning purple, failed to do so during the summer of 1996 following an increase in zinc addition (30 times greater than previous use) to the animal feed as zinc oxide for a four month period. Additional research into the role of antimicrobial products relative to PSB growth is necessary before definite conclusions can be made.

Conclusion

This preliminary review of the data from eight lagoons has revealed more similarities than differences between purple and non-purple lagoons. Factors such as sulfide concentration, anaerobic conditions, volatile solids loading rate and copper and zinc loading rate do not vary substantially between purple and non-purple lagoons. These preliminary observations will receive additional scrutiny as all data collected from this research effort are examined further.

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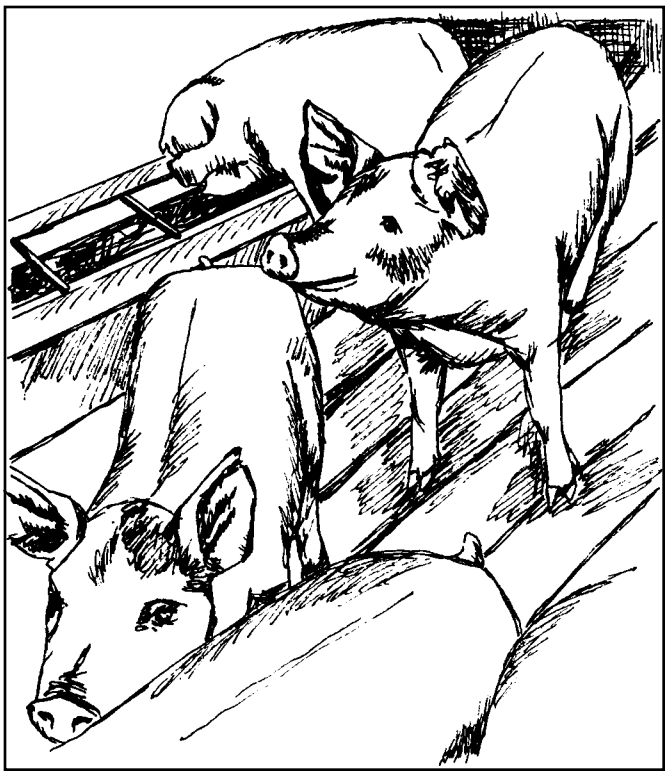
[1]Rick Koelsch is an Assistant Professor, Tong Tong Chen is a graduate student and Dennis Schulte is a Professor in Biological Systems Engineering, University of Nebraska, Lincoln.

[2]Black and white disk commonly used to measure clarity of lakes.



Environmental Assurance Program

Jill Lorenz-Goodrich
Rick Koelsch[1]

Summary and Implications

The popular press has brought environmental challenges in the pork industry to the forefront, making the pork industry a key political issue in several states. In Nebraska, the Nebraska Department of Environmental Quality and the Nebraska Pork Producers Association have been cooperators in providing educational opportunities to producers on how they can meeting the state's regulations and ensuring production in an environmentally safe manner. The National Pork Producers Council is a partner is this effort through the development of a national curriculum called the Environmental Assurance Program. This educational program stresses the fundamentals of protecting natural resources as well as on-farm management practices and tips to help producers manage their operations in harmony with the land. The Nebraska Pork Producers Association, in cooperation with local pork producer associations and extension offices, will make this program available through workshops emphasizing local cooperation and enhancing a sense of teamwork between producers, local government and environmental agencies.

What is Environmental Assurance?

The goal of the Environmental Assurance Program is to provide producers with the environmental knowledge they need to operate profitably. Since every producer has unique needs, the program is flexible and allows producers to adapt the information having the greatest impact on their operation.

Written by and for pork producers, the Environmental Assurance Program is a voluntary program with two primary components. The first is a workshop led by local experts and the second is an on-farm environmental assessment the producer does individually. Here are the benefits producers receive:

Confidence -- When producers evaluate their own environmental management techniques and learn new ones, they gain confidence in their abilities.

Profits -- Efficient nutrient management can reduce the need for commercial fertilizer and add to the operation's bottom line.

Reduce Problems -- Taking action, rather than reaction, will help avoid problems that might result in nuisance suits or other legal actions.

Enhance Relationships -- Establishing and maintaining good relationships with neighbors and showing that an operation is environmentally friendly is important to the long-term success of the pork industry.

Program Components

Knowing Where You Stand. At the beginning of the program, producers take a survey of their operation to establish their current situation. This component is designed to help producers understand how their operation currently ranks on the environmental stewardship scale.

Understanding Fundamentals. Water, air, nutrient and facility management comprise the key topics of the program workshops. These sessions explain the fundamentals of environmentally sensitive management techniques and implementation of cost-effective practices for profitable pork production.

Learning About Regulations. Industry regulations are complex. This session provides ideas on how to avoid problems, rather than react to them.

Evaluating Yourself. The most important part of the workshop comes when producers thoroughly review their own operations after they leave the workshop. The on-farm, self-assessment in the curriculum is designed to guide the producer in improving the operation's efficiency and profits. It will also help producers to identify practices to improve their stewardship of the environment.

Knowledge is Power

Knowledge is power for today's pork producer. Learning how to protect the environment pays off in both short and long-term dividends. Short-term dividends, like improved profits, reduced problems and enhanced relationships, can go straight to an operation's bottom line. Equally important, the long-term growth of the entire pork industry will be directly affected by the sensitivity, knowledge and action each producer directs toward protecting the environment. For more information about the Environmental Assurance Program, contact the Nebraska Pork Producers Association, Inc., at (402) 472-2563 or Dr. Rick Koelsch at the University of Nebraska at (402) 472-4051.

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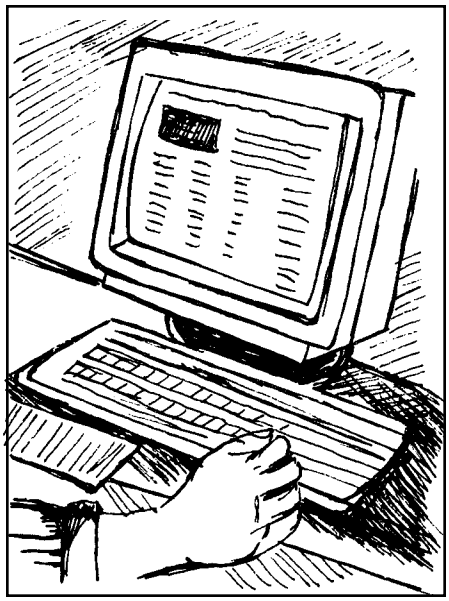
[1]Jill Lorenz-Goodrich is Director of Information and Producer Programs, Nebraska Pork Producers Association, Inc., and Rick Koelsch is an Assistant Professor in Biological Systems Engineering, University of Nebraska, Lincoln.

Explanation of Statistics Used in This Report

Pigs treated alike vary in performance due to their different genetic makeup and to environmental effects 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 research 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: the treatment effects are "real" and caused different performance for pigs on each treatment. However, if the researcher obtained this result in each of 100 experiments, five differences would be declared to be "real" when they were really due to chance. Sometimes the probability value calculated from a statistical analysis is P < .01. In this example, 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 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 the 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 pounds/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 pounds/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 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.