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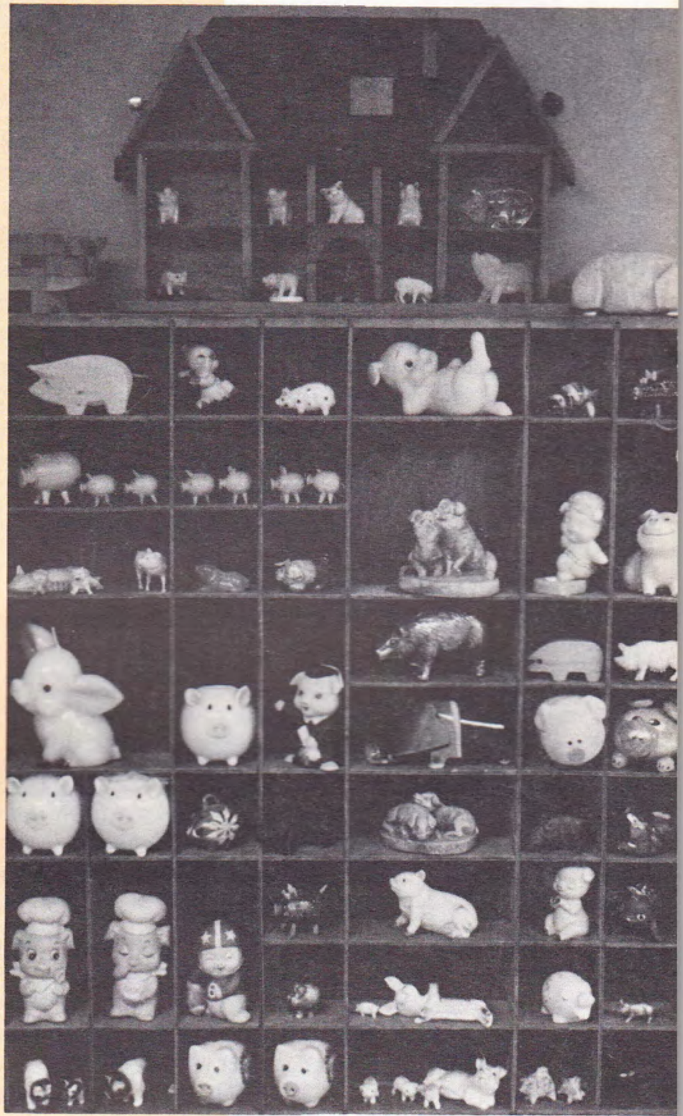

- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

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The 1986 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

Selection for Larger Litters and Earlier Breeding Gilts

Rodger K. Johnson
Dwane R. Zimmerman[1]

Research has shown that the economic health of individual pork producers, and thus the health of the industry, is highly dependent on the reproductive efficiency of the sow herd. There are many components to overall reproductive efficiency, but the most important is number of live pigs per litter at birth. The age at which replacement gilts are added to the gilt pool and the length of time that they remain in the pool are also important. This age and length of time are determined partly by the age at which the gilts are sexually mature, or their age at puberty. Other traits, such as piglet survival and rebreeding interval of the sows, also affect pigs per sow per year. However, it appears that these traits can be improved more easily through improved management than by genetic procedures.

Average litter size weaned has increased during the last ten years in the United States. Many factors, including genetically superior sows, have contributed to this increase. The genetic component is largely the result of introducing breeds with high reproductive ability in crossbreeding systems that make the most efficient use of heterosis. Increased sow productivity has occurred because improved crossbreeding systems have resulted in higher piglet survival and more pigs weaned per litter.

Once commercial producers are using the most productive breeds in efficient crossing systems, further genetic improvements will be realized only through selection for increased litter size at birth by the seedstock industry. Herein is reported the results of on-going research at the University of Nebraska to determine the effectiveness of selection for two components of sow productivity-litter size at birth and age at puberty of gilts.

Population and Selection Background

The University of Nebraska has maintained the Nebraska Gene Pool as a closed herd since 1965. It was formed by crossing 14 breeds. During 9 generations, beginning in 1967, the Gene Pool had two lines, one selected for increased ovulation rate at second estrus (OR) and the other selected randomly (C) to serve as a control to measure changes resulting from selection for ovulation rate.

Selection for ovulation rate was terminated after nine generations. Line OR was randomly selected for one year and then the pigs in each litter were randomly assigned to one of three lines. Line LS was selected for increased number of fully formed piglets at birth, line AP was selected for decreased age at puberty and line RS (relaxed selection) was the high ovulating line maintained with random selection and mating. Line RS is a control line necessary to measure the effects of selection for litter size and age at puberty. The original control line (C) was also maintained with random selection and mating to monitor any changes in line RS when selection for ovulation rate was relaxed.

Figure 1 illustrates the formation and the history of selection of the Gene Pool lines. Each line has been maintained with about 40 litters by 15 sires per generation. Generation interval is one year; thus, selection of all replacements is made from first parity litters. In some generations sows have been used to compare the reproductive performance of the lines at second and third parity. Replacement boars and gilts in line LS are selected from the 15 to 17 largest litters. Selection in line AP is based only on the gilt's age at puberty, which is determined by a standing response to a boar during daily estrous detection beginning at about 130 days of age. Boars in line AP are selected randomly. Results are available for six generations of selection for litter size and five generations of selection for age at puberty.

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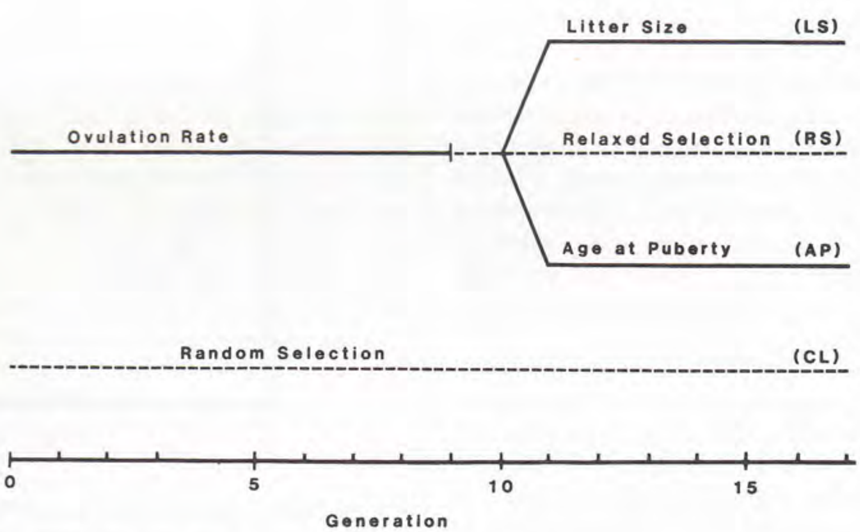

Figure 1. Selection background for gene pool population.

Selection . . .
(Continued from page 3)

Selection for Ovulation Rate

Results of selection for ovulation rate have been previously reported. Selection was effective in increasing ovulation rate. After 9 generations, gilts from line OR ovulated about 3.5 more eggs than gilts from line C. Ovulation rate was quite highly heritable, about 45%. However, higher ovulation rate did not result in much increase in litter size (Figure 2). Even though the average change per generation was not significant, the cumulative response appears to be real. The average advantage of line OR over line C from generations 10 to 16 of relaxed selection was .70 ± .22 piglets. Similar differences between the lines have been found when second and third parity sows were compared.

Selection for ovulation rate increased both ovulation rate and litter size, but only about 20 percent of the increase in ovulation rate was represented by fully formed piglets at birth. Other experiments with these lines have indicated that for embryo survival the genetic makeup of the dam is considerably more important than the genetic makeup of the embryo. Thus, genetic improvement in litter size will be accomplished most efficiently from simultaneous improvement of ovulation rate and uterine effects on embryo survival. The effectiveness of simultaneous selection for these components of litter size is presently being evaluated in a different experiment.

Selection for Litter Size

The response to six generations of selection for litter size in line LS is illustrated in Figure 3. The difference between line LS and line RS increased 0.16 piglets per generation. Thus selection appears to

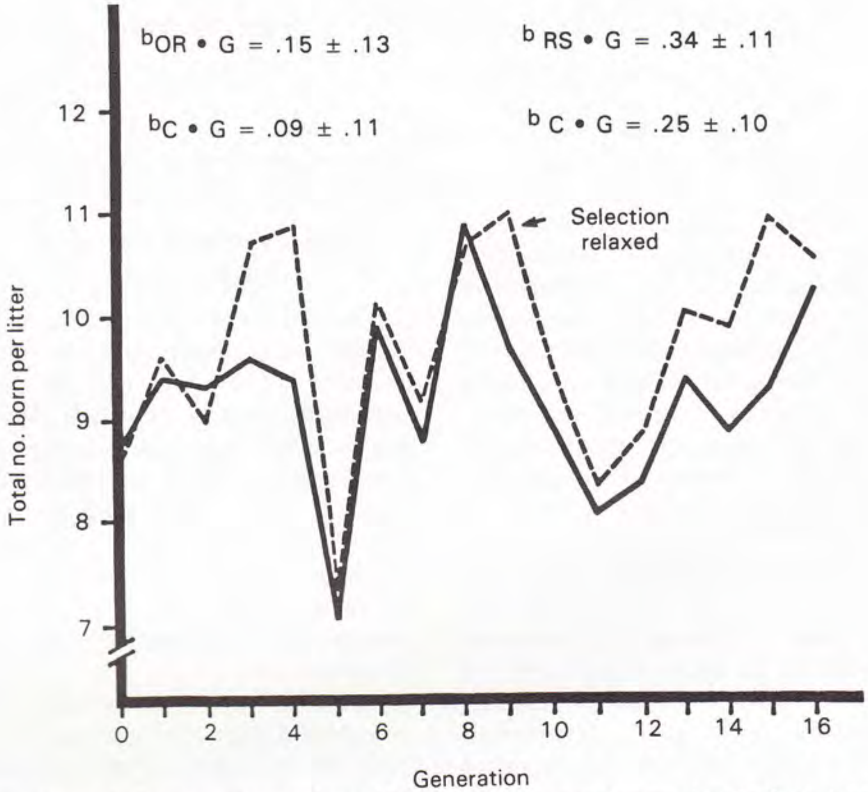

Figure 2. Response (regressions of line means on generation number) in litter size at birth during selection for ovulation rate (lines OR and C from generations 0-9) and during relaxed selection (lines RS and C from generations 10-15).

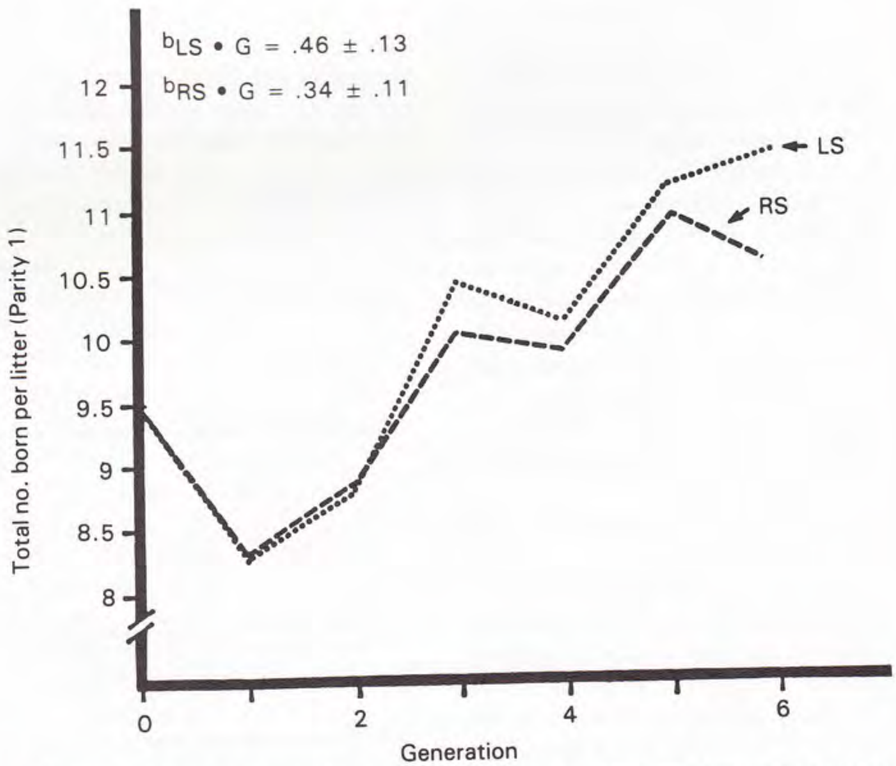

Figure 3. Response (regressions of line means on generation number) in litter size at birth to selection for increased litter size (LS) or to relaxed selection for ovulation rate (RS) in the high ovulation rate line.

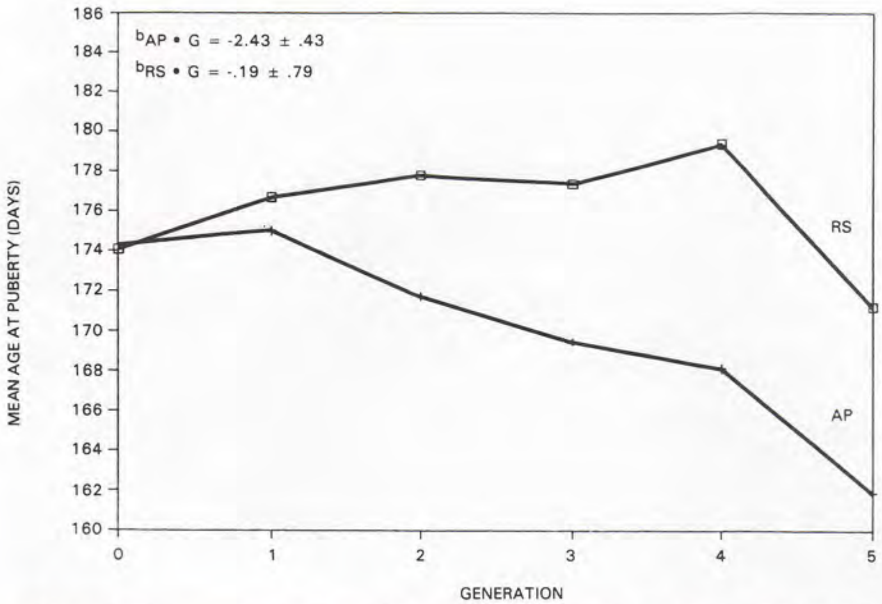

Figure 4. Response (regressions of line means on generation number) to Selection for Decreased Age at Puberty.

have been effective. The estimate of the realized heritability of litter size at birth was .18 ± .06. A change of this size in litter size is valuable, even though it is not as obvious as the change which can be made in more heritable traits like growth rate and fat thickness. At the above rate, genetic changes of one pig per litter are achieveable in about six years if all selection is applied to litter size. In practice, litter size will be only one of several traits in the selection objective and the rate of change will likely be considerably less. Continuous selection pressure applied to litter size in seedstock herds is necessary to produce the small changes each year that will accumulate into significant increases in sow productivity.

Selection for Age at Puberty

Selection for decreased age at puberty in the high ovulating line was effective. Age at puberty decreased at the rate of about 2.2 days per generation of selection (Figure 4). The realized heritability was about 33 percent.

At this point there has been little change in litter size from selection for decreased age at puberty. However, during each generation, all gilts have been mated at the same age. Additional experiments must be conducted to determine the effect on lifetime sow productivity of decreased age at puberty in gilts and to evaluate the effect of mating earlier maturing gilts at younger ages.

Summary

Selection for ovulation rate resulted in a line that was genetically superior for ovulation rate, but litter size did not improve. The high ovulating line had higher embryo and fetal loss so that only about 20 percent of the increase in ovulation rate was represented by piglets at birth. Subsequent selection for increased litter size and decreased age at puberty in this population was effective. The response to six generations of selection for litter size was 0.16 pigs per generation. The response to five generations of selection for decreased age at puberty was −2.2 days per generation.

[1]Rodger K. Johnson is professor, and Dwane R. Zimmerman is professor, both in the Department of Animal Science.

Nursery Drinkers—How Many?

Mike C. Brumm
Dave P. Shelton[1]

One of the changes for newly-weaned pigs is the way liquids are received. The newly-weaned pig must rapidly modify its behavior from drinking warm milk from a private teat on the sow, to sharing a cold, metal apparatus on the pen wall which only dispenses water. The number of drinking spaces available within a pen of weaned pigs may influence their overall performance. This study was conducted to determine if the number of nipple drinkers per pen influenced weaned pig performance.

In this study, 128 three- to four-week-old newly-weaned pigs were housed in a flat deck nursery. Each 4 ft. by 8 ft. pen had a woven wire floor, open mesh sides and two 5-hole feeders. Pigs were divided into heavy and light weight groups, with average starting weights 18.4 and 13.1 pounds, respectively. Sixteen pigs were assigned to each pen (2 ft^2/pig).

Each pen contained one or two nipple drinkers located in the opposite end of the pen from the feeders. If two nipples were in a pen, they were in adjacent corners 4 ft. apart. All nipples were checked at the start of the study and found to be functioning properly.

At the start of the 35-day experiment, the newly-weaned pigs were assigned to the two experimental treatments based on weight and sex. The pigs were full fed a commercial pelleted diet for the duration of the experiment. Pigs were

(Continued on next page)

Nursery Drinkers . . .

(Continued from page 5)

weighed and feed intake determined weekly.

Results

Both light and heavy weight pigs responded similarly to the number of nipple drinkers in a pen. Hence, the data for both weight groups have been combined.

Increasing the number of nipple drinkers per pen from one to two tended to improve average daily gain. (Table 1). After 35 days, pigs in pens with two drinkers were two pounds heavier. Overall daily feed intake or feed conversion was not affected by number of drinkers per pen.

In addition to examining the average weight of pigs on each treatment (Figure 1), variation in pig weight was considered. After three weeks, pig weight tended to be more variable in the pens with only one nipple drinker. (Figure 2). At the end of the trial, the weights of pigs in pens with one drinker were significantly more variable.

Conclusion

Weanling pigs housed in pens with only one nipple drinker weighed about two pounds less at 35 days after weaning and had greater variation in weight than pigs in pens with two nipple drinkers. Similar to the results of a feeder space study reported in the 1985 Nebraska Swine Report, these results suggest that when drinker space is limited, average performance suffers only slightly. However, there is much more variation in weight among the pigs.

These results support the suggestion of two nipple drinkers for a pen of 16 weaned pigs.

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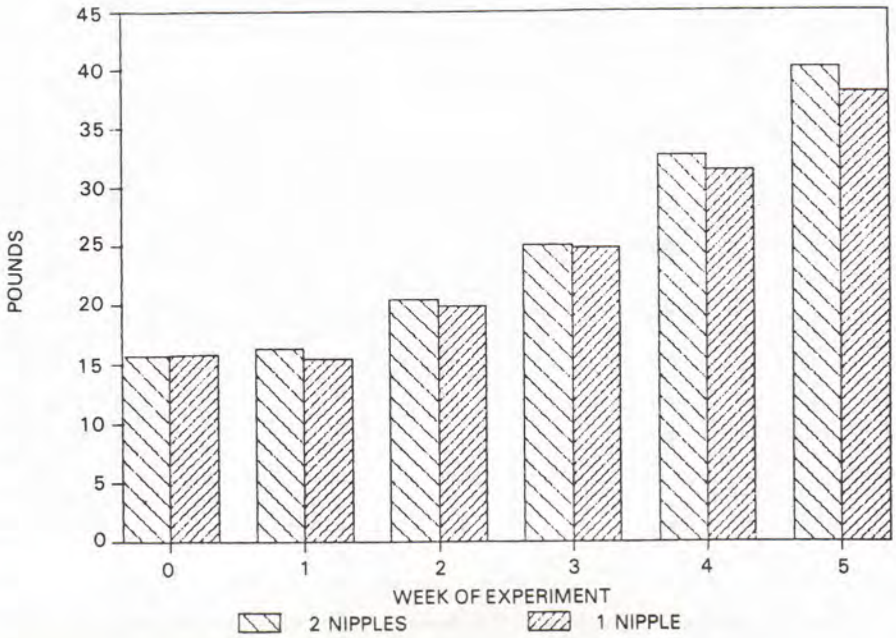
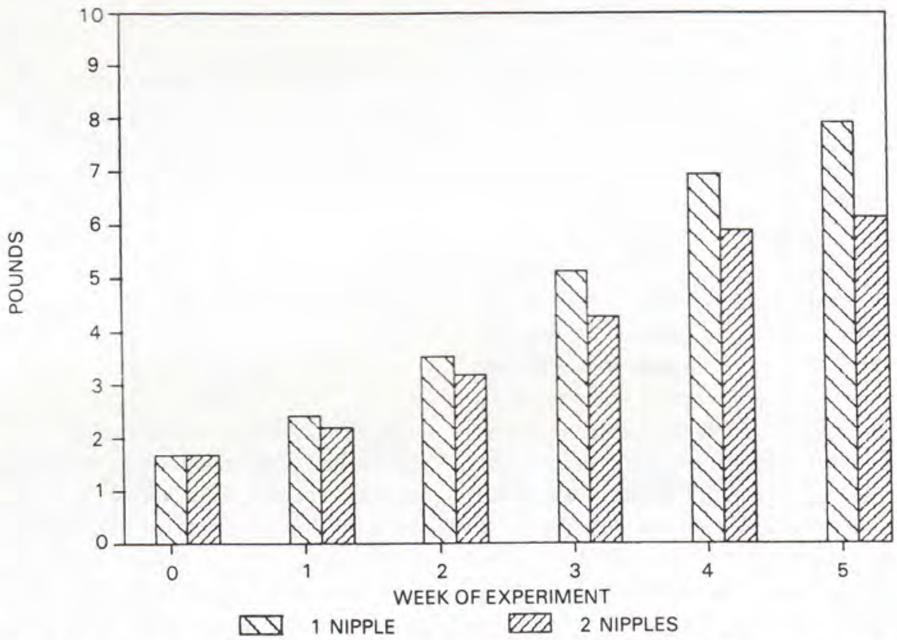
[1]Mike C. Brumm is assistant professor, animal science and Dave P. Shelton is associate professor, agricultural engineering both at the Northeast Extension and Research Center, Concord.





Top: Figure 1. Average weight of pigs on each treatment by week. Bottom: Figure 2. Standard deviation of weekly pig weight by treatment.

Table 1. Effect of Number of Nipple Drinkers on Weaned Pig Performance.

	Nipples/Pen		
Item	1	2	SE[a]
No. of pigs	64	64	
No. of pens	4	4	
Weight (lb); initial	15.8	15.7	
final	38.1	40.1	.7
ADG, lb[b]	.64	.70	.02
ADF, lb	1.00	1.05	.03
F/G	1.56	1.50	.03

[a]Standard Error
[b]Means are different (P<.1)

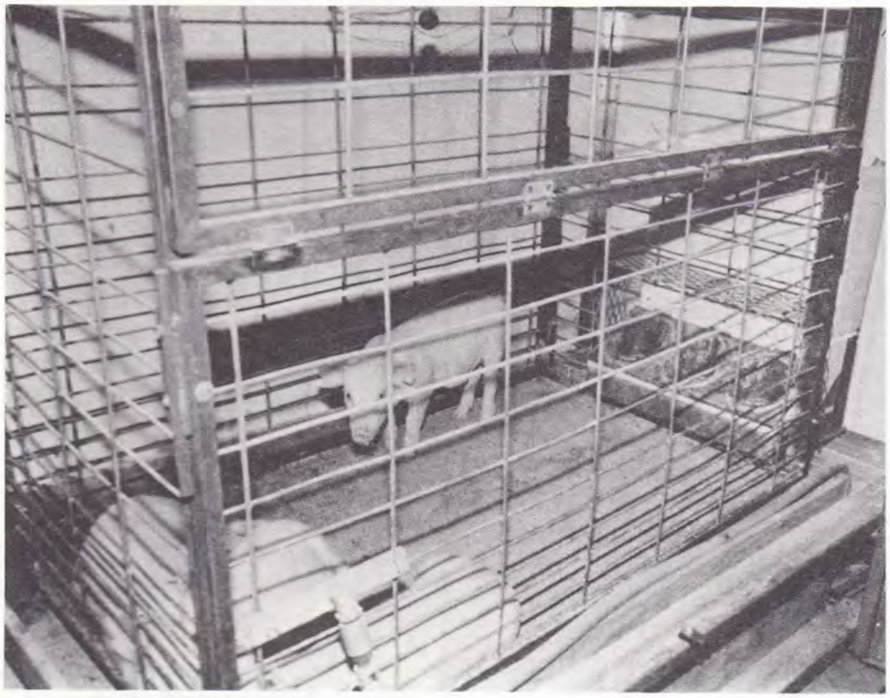


Figure 1. Four pigs were placed in each treatment pen for a two-week period.

How Much Floor Heat For Nursery Pigs?

Keith L. Vacha,
James A. DeShazer
Gerald R. Bodman[1]

Providing an energy efficient thermal environment conducive to good pig performance is important in the design of nurseries. Nursery pigs have been shown to perform favorably in lower than 80°F air temperature environments when the floor of the sleeping area has a heated storage mass. The use of floor heat with storage to offset the reduced air temperature provides for an energy efficient system. How much floor heat is required? The Midwest Plan Service indicated 25-40 watts (85-135 Btu/hr) is needed per sq. ft. of floor surface when no thermal storage is provided. However, experience with field installations indicates that less heat could be used. Animal energy use studies were conducted to determine floor heating requirements at different air temperatures when in-floor thermal storage is provided.

Energetics of the Nursery Pig

Energetics is the study of the energy use. Heat production and feed intake were determined for 4-week-old weaned pigs for several air temperature and floor heat combinations. The average weight of the pigs during the two week study was 18 lbs. Heat production and latent heat loss were measured. Latent heat loss is energy required to evaporate moisture, primarily from the respiratory system. The eight air temperature and floor heat combinations evaluated were 61F8 (61°F air temperature with 8 watts per square foot floor heat input), 61F11, 64F8, 64F11, 75F0, 75F4, 86F0 and 86F4.

Four pigs were placed in each treatment pen (Figure 1) for a 2-week period. The pen floor was heated by an electrical resistance heating mat positioned between an 8" sand thermal storage and the underlying insulation. The four-inch concrete floor was poured over the sand layer. Each pen was enclosed with plastic and ventilated to obtain oxygen, carbon dioxide and moisture concentration data of the air in the pen. The gas concentrations were used to calculate the total and latent heat production of the pigs. The air velocity through the pig zone was approximately 20 fpm. The energy retained by the pigs for growth was determined from the difference between the feed energy intake and the total

(Continued on next page)

Table 1. Average daily total heat production, latent heat loss percentage and energy retained for gain on 5, 7, 11 and 13 days after 4-week weaning in the pen of four pigs.

Variable	Day	61F8	61F11	64F8	64F11	75F0	75F4	86F0	85F4
Total heat production, W									
	5	164	122	110	106	129	126	153	147
	7	179	130	124	138	120	131	169	147
	11	178	173	160	175	208	152	219	228
	13	191	183	181	202	215	157	268	242
Latent heat loss, % of total heat production									
	5	7	12	13	14	12	12	13	13
	7	7	13	13	16	14	16	14	14
	11	11	12	12	12	11	13	13	16
	13	13	13	12	12	12	13	14	17
Energy retained for gain, W									
	5	−56	−6	−12	36	−17	5	−51	−55
	7	−22	28	−2	53	17	−6	−28	−7
	11	62	53	11	31	33	76	−5	0
	13	100	68	62	66	72	68	−17	3

Floor Heat . . .
(Continued from page 7)

heat production.

Heat production (Table 1) changed over days because of the approximate doubling of the daily feed intake from day 5 after weaning to day 13. Latent heat loss, as a percent of total heat production, ranged from 7 percent for day 5 and day 7 of treatment 61F8 to 16 percent and 17 percent for days 11 and 13 of treatment 86F4. This suggests the pigs were cold stressed for the first seven days in the 61F8 environment and heat stressed during the last week of the 86F4 environment.

The cold and heat stress of these environments are further indicated in the energy retained analysis. High negative energy retained values occured at the 61F8 environment and in both the 86°F environments during the first week. The energy retained values at the 86°F environments were also low during the second week of the study. A consistently favorable thermal environment for pig growth was provided at the 64F11 environment.

Results of this study indicate that use of floor heating can maintain the thermal environment for the nursery pig housed in facilities with low air temperatures. Suggested continuous floor heating levels for nursery pigs on a heated floor with 8" insulated heat storage at different air temperature environments are summarized in Table 2.

Field Application of Laboratory Results

Field installations have shown that the suggestions in Table 2 are appropriate for hot water floor heat with thermal floor storage. Hot water floor heat with storage is designed and installed similar to a hot water floor heating system without floor heat storage. However, the heating pipe is placed at mid-depth of an 8" sand storage layer rather than in the concrete floor slab. The hot water pipes should be placed 10 to 12 inches on-center. With 140-150°F water temperature, this provides approximately 10 W/sq. ft. being generated in the floor. Advantages of the system over that of pipes being placed in the concrete floor are:

1. separates work of installing floor heat system and the concrete floor,
2. allows full pressure test of hot water system after installation of pipes and before the concrete floor is placed,
3. reduces maintenance of the heating system caused by cracking of floor from shear and thermal expansion or contraction and
4. dampens the temperature fluctuations of the hot water.

Continuous floor heating may result in the same energy usage as found for higher intermittent floor heating. However continuous floor heating will provide a lower peak load for the system. A thermostat sensor should be placed in the concrete floor to control the floor temperature when the air temperature is higher than 60°F.

[1]Keith L. Vacha is former Graduate Research Assistant, James A. DeShazer is Professor and Gerald R. Bodman is Associate Professor all in Agricultural Engineering, University of Nebraska– Lincoln.

Table 2. Continuous heating levels for nursery pigs on heated floor with 8" insulated thermal storage.

Week after Weaning	Air Temperature, F			
	61	64	75	86
1	*	11 w/sq ft	0-4 w/sq ft	*
2	8 w/sq ft	8-11 w/sq ft	0-4 w/sq ft	*

Effect of Grind Size On Preblended Polish Sausage

James W. Lamkey
Roger W. Mandigo
Chris R. Calkins[1]

Preblending is the technique of adding salt and nitrite to ground meat before processing into sausage.The salt and nitrite may be added as long as 2 weeks before processing. Salt increases the amount of protein that can be extracted and thus increases bind between meat particles. Sausage processors use this technique primarily for the control of composition and inventory. Increasing surface area by decreasing grind size has been shown to be beneficial for protein extraction and water holding capacity. Meat that is trimmed from the carcass before the onset of rigor (hot boned) will have greater protein extraction than cold-boned meat. A combination of these factors may enhance the amount of protein extracted from the meat to aid in binding of the sausage product.

The purpose of this study was to determine if a reduction in particle size before preblending, in combination with hot boning, would improve the textural properties of sausages made with preblended meat.

Procedures

Hams from the right side of carcasses from 16 lactating sows were removed and boned within two hours of exsanguination (hot boned). Left sides were allowed to chill for 48 hours before boning (cold boned). The hams from four sow carcasses were assigned to a group based on the feeding history of the sow. One sow from each of four diets was assigned to each group. The four diets included high and low levels for protein and energy. The meat from the four hams within a group was processed separately from the other groups. Hams were grouped this way to distribute the variation that might arise due to differences in diet effect, including carcass fat content.

Each group of hams was first ground through a kidney-shaped plate and then divided into three subgroups. Samples of the meat were taken at the end of each processing point for pH and water holding capacity tests. Grind size treatments (1/4-, 1/2- or 3/4-inch) were assigned and the meat was then combined with 2 percent salt, 10 percent water and 1/2 the required nitrite. Each batch was mixed for 5 minutes, and then stored in plastic bags for 24 hours in a 32° F cooler.

After the 24 hour preblending period, meat blocks were mixed for an additional three minutes with spices and the remaining portion of the nitrite. All treatments were reground to a final grind size of 1/8 inch and stuffed into 1.34 in collagenous casings. Tests performed on the uncooked mixture included pH and water holding capacity (WHC). Lee Kramer Shear and compression tests on the final product texture were conducted with an Instron Universal Testing Machine.

Results

There were no differences in pH between cold-boned and hot-boned muscle (Table 1). Since the production of lactic acid is typical in muscle after exsaguination, pH values in post-rigor muscle normally approach 5.5. These higher pH values in post-rigor muscle indicate a reduced level of lactic acid production and may be indicative of long term stress. Such stress could have occurred because these were lactating sows and had been fed restricted diets. Water holding capacity is very much influenced by pH. The small magnitude of difference in WHC between hot-boned and cold-boned muscle may be due to the abnormally high pH in the cold-boned muscle.

Boning method, grind size and sample time interactions were evident for WHC (amount of expressed water; Table 1). Water holding capacity increased about 40 percent after preblending. The 1/4-inch grind size expressed the largest amount of moisture for the cold-boned pork and the smallest amount for the hot-boned pork before preblending. After preblending, however, the 3/4 inch expressed the greatest amount of moisture for the cold-boned pork with no differences amoung grind sizes for the hot-boned pork.

There were very slight differences between hot- and cold-boned pork when measuring the final product texture (Table 2). Lee Kramer peak force was lower for hot-boned muscle than cold-boned muscle. Increased extraction of protein from the muscle structure will result in less resistance to shear. Chewiness, a product of the other compression tests, was greater for hot-boned products. Increased

(Continued on next page)

Table 1. Water holding capacity and pH as affected by sampling time, grind size and boning method.

Sampling point	WHC Grindsize 1/4	WHC Grindsize 1/2	WHC Grindsize 3/4	pH Grindsize 1/4	pH Grindsize 1/2	pH Grindsize 3/4
Cold boned						
Before preblending	61.72[a]	59.55[b]	59.31[b]	6.34[a]	6.24[b]	6.26[b]
After preblending	37.19[b]	36.51[b]	39.66[a]	6.25[a]	6.24[a]	6.23[a]
Hot boned						
Before preblending	60.66[b]	64.08[a]	64.12[a]	6.33[a]	6.28[b]	6.32[a]
After preblending	34.22[a]	34.84[a]	34.12[a]	6.33[a]	6.31[a]	6.33[a]

[a,b]Means in the same row with different superscripts are significantly different (P<.05).

Table 2. Lee Kramer shear values for Polish sausage from hot or cold boned pork.

Boning method	Lee Kramer peak Force (kg/g)	Compression tests: Hardness	Cohesiveness	Elasticity	Chewiness
Cold boned	1.01[a]	22.08	4.88	0.77	82.16[b]
Hot boned	0.93[b]	22.71	4.92	0.77	86.32[a]

[a,b]Means within the same column with different superscripts are significantly different (P<.05).

Table 3. Lee Kramer shear and compression values for polish sausage by grind size.

Grind size	Lee Kramer peak force (kg/g)	Compression tests: Hardness	Cohesiveness	Elasticity	Chewiness
1/4	1.00[a]	22.62	4.92	0.77	85.73[a]
1/2	0.98[a]	22.56	4.79	0.77	83.02[b]
3/4	0.94[b]	22.01	4.98	0.77	83.98[b]

[a,b]Means within the same column with different superscripts are significantly different (P<.05).

Grind Size . . .
(Continued from page 9)

protein extraction and interaction probably enhanced bind and created a greater resistance to deformation (enhanced chewiness).

The larger grind size, on the other hand, also resulted in less force required for shearing (Table 3), but a lower chewiness value. The force exerted on the 3/4-inch particle when reduced to 1/8 inch during the final grind may cause muscle tissue rupture without enhancing protein extraction. This would explain the decrease in shear values and chewiness.

Greater force was required to shear sausage made from cold-boned pork than hot-boned pork. Grind size produced small differences in the precooked emulsion, but no differences occurred the final product. Differences between grind size in the raw meat mixture were negated when subjected to a final grind of the same size. Based on these data, it is suggested to grind meat intended for preblending no larger than 1/2 inch to minimize particle destruction during regrinding. Preblended meat should be obtained from hot-boned muscle to enhance WHC.

[1]James W. Lamkey is a graduate student, Roger W. Mandigo is professor, Chris R. Calkins is associate professor, all in the Department of Animal Science.

Preblending Time and Texture Of Coarse Ground Sausage

Larry W. Hand,
Roger W. Mandigo,
Chris R. Calkins[1]

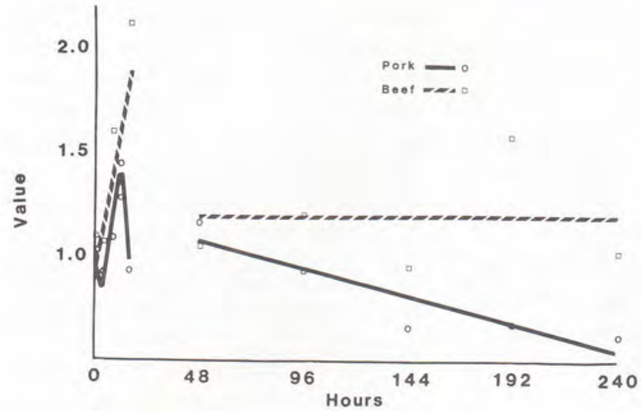
Preblending of sausage raw materials is widely used in the meat industry. Preblending generally involves mixing the ground meat with salt and some of the nitrite and water and storing it in a cooler for up to two weeks. This allows control of inventory, cost, proximate composition and microbial load. Improved functional properties and maximum protein extraction result when salt has had time to infuse the muscle tissue. Little research has addressed the impact of preblending time on textural properties of the finished product. This research was conducted to characterize the effects of short and long preblending times on the textural properties of coarse ground sausages.

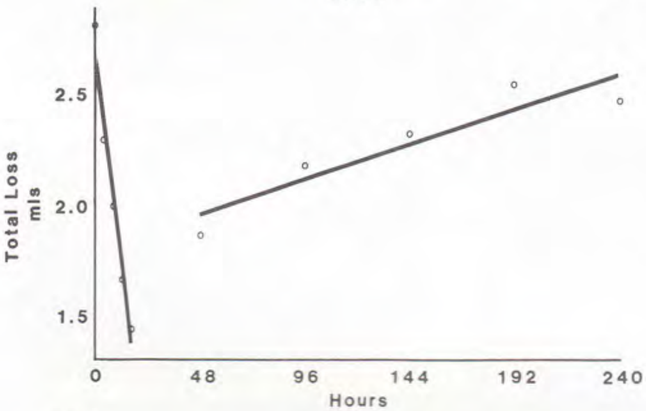
Materials and Methods

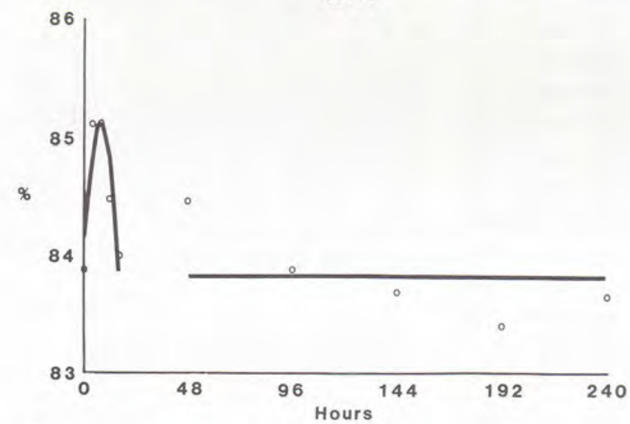
Pork and beef trim were mixed separately for 5 minutes with 2 percent salt, 78 ppm nitrite and 10 percent water, held at 32-36°F for specified time periods and subsequently manufactured into polish sausages. Two replications including time treatments of 0, 4, 8, 12, 16, 48, 96, 144, 192 and 240 hrs. were conducted. Raw material characteristics (pH, water holding capacity, temperature) were determined at each treatment hour. Sausage manufacture consisted of mixing the preblends for 5 minutes with spices, regrinding, stuffing into 1.34 in. collagen casings and linking (5-6 in/link). To remove variation within replication, all preblending treatments were scheduled to allow for simultaneous thermal processing in the smokehouse. The polish sausages were thermally processed using a conventional cooking schedule to an internal temperature of 152° F and cold water showered for 15 minutes. Raw sausage batter was analyzed using the Instron extrusion test and an emulsion stability test. Finished sausage processing yields were determined. Sausage textural differences were analyzed by Instron evaluation (Lee-Kramer shear, compression). Regression analyses were performed on data within short and long term preblending time intervals.

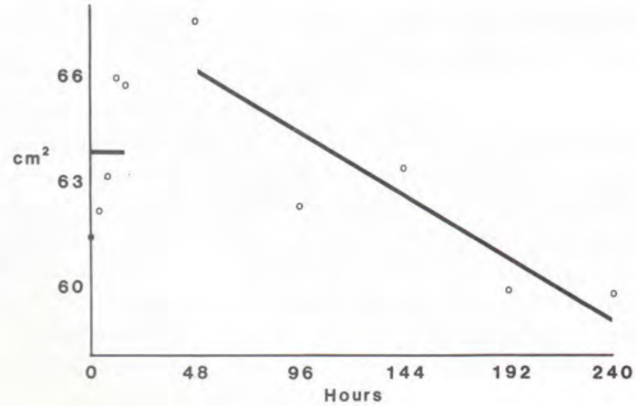
Results and Discussion

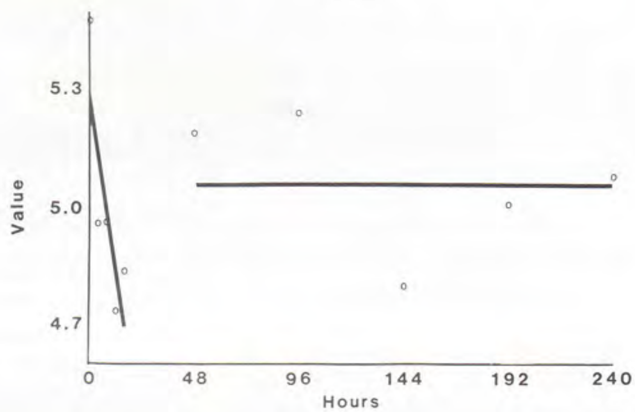
As preblending time increased, the pH of the raw materials increased linearly from 5.80 to 5.90 for beef and from 5.82 to 5.91 for pork. Water holding capacity (Fig. 1) of the pork raw materials reached a peak at 12 hrs. and decreased after 12 hrs. to levels lower than the initial levels. Water-holding capacity of the beef raw materials increased from 0-16 hrs, but decreased to levels similar to initial levels by 48 hrs., with no differences from 48-240 hrs. Thus the improvement in water-holding capacity due to preblending occurs rapidly during preblending and is lost with extended preblending times.











Top left: Figure 1. Water holding capacity values of pork and beef raw materials. Figure 2. Product stability (total losses) as influenced by preblending time. Figure 3. Sausage processing yields as influenced by preblending time. Top right: Figure 4. Raw batter extrusion (area under the curve) as influenced by preblending time. Figure 5. Finished product cohesiveness as influenced by preblending time.

The product stability tests (Fig. 2) indicated total losses decreased from 0-16 hrs. and then increased from 48 to 240 hrs. Processing yields (Fig. 3) increased during the short preblending time to a maximum at 8 hrs., but decreased to yields lower than product that had not been preblended (0 hr.). There were no differences among the long preblending times (48-240) in processing yields. The product stability results indicate that extended preblending times may be detrimental to product integrity with benefits of preblending being evident only in the short time period.

Extrusion of the raw batter (Fig. 4) showed no significant differences in product bind (as measured by the area under the curve) within the short term preblending period. A decrease in product bind occuring during the long term preblending period. Product bind was decreased in the extended preblending times to levels lower than the 0 hour treatment. Instron compression tests showed linear increases in cohesiveness, the ability to maintain integrity, between 0-16 hrs. and no difference from 48-240 hrs. (Fig. 5). These values indicate

(Continued on next page)

Preblending Time . . .

(Continued from page 11)

that products manufactured after long preblending times were less cohesive than those from the short preblending times (4-16 hrs.). This reemphasizes that the textural benefits from preblending appear in the short periods (0-16 hrs.) and are not apparent or are decreased in the long periods (48-240 hrs.).

Conclusions

The textural properties of coarse-ground sausage increased through 16 hrs. of preblending. Preblending from 48-240 hrs. showed little improvement in textural properties and in some cases was detrimental. Thus, the textural advantages of preblending coarse-ground sausage occur only during short preblending times. While production planning, inventory and cost control benefits may be observed from longer preblending, there are textural advantages with shorter preblending.

[1]Larry W. Hand is a graduate student; Roger W. Mandigo is professor, and Chris R. Calkins is assistant professor, Department of Animal Science.

Retail Lighting Conditions and Fresh Pork Color

Chris R. Calkins,
Steven J. Goll
Roger W. Mandigo[1]

Consumers use meat color to evaluate flavor, juiciness, tenderness and freshness of fresh retail pork. Type of light in the retail case can alter the perceived color and, thus, plays a major role in pork sales. Much work has been conducted to compare retail lighting conditions and beef color, however, few studies have examined fresh pork color. An informal survey of 12 retail supermarkets revealed a wide variety of retail lighting conditions for pork. Since light alters consumer perception of color and perhaps rate of oxidative rancidity, our objectives were to assess the impact of light type and length of light exposure on color and rancidity of fresh pork.

Table 1. Color desirability of fresh pork chops displayed under different light types.

Light type[a]	Color desirability[b]
CF	5.26[c]
CW	5.49[d]
CWSC	5.08[e]
WW	5.04[e]

[a]CF = 75W cool flood, incandescent; CW = 40W delux cool white, fluorescent; CWSC = 40W cool white, flourescent, surlyn coated for shatter resistance; WW = 40W warm white flourescent.
[b]Eight-point rating scale (8 = extremely desirable; 1 = extremely undesirable).
[c,d,e]Means in the same column bearing different superscripts are significantly different ($p<.05$).

Experimental Procedure

This research was conducted in two phases. Phase I consisted of 50 or more consumers rating color desirability (8 = extremely desirable; 1 = extremely undesirable) of 32 fresh chops for each of two replications displayed under 200 ft. candles of light from four light types: 75W cool flood incandescent (CF); 40W deluxe cool white fluorescent (CW); 40W cool white fluorescent, surlyn coated for shatter resistance (CWSC); 40W warm white fluorescent (WW). Phase II consisted of objective measurements of color (every other day) and rancidity (initial and final) of chops displayed five days for either 12 or 24 hrs. per day under one of the four light types. Reflectance was measured to determine percentage distribution of meat pigments between myoglobin (purple), oxymyoglobin (pinkish-red) and metmyoglobin (grayish-brown). Hunter L, a, and b values were also obtained to determine lightness, redness and yellowness of color. Oxidative rancidity was determined 0 and 5 days after initiation of the display period. All display and storage occurred at 36-38° F.

Light Types Different

Table 1 reveals that consumers found light type CW to be most desirable, followed by light type CF. Chops displayed under CWSC or WW lights were rated least desirable. This suggests that shatterproof lights (CWSC) are not desirable for fresh pork retail display and that CW or CF lights generate the most desirable perceived color. For pork, WW lights should be avoided. This latter point is contrary to recommendations often made for beef.

Figure 1 indicates that chops displayed under CF lights become grayish-brown more quickly than all other light types. This is likely because the high intensity of light generated heat and elevated the temperature of the chops, a con-

Table 2. Oxidative rancidity in chops stored 0 or 5 days under different light types.

	Final TBA Values for Light Types[b]			
Initial TBA[a] Values	Cool Floods	Cool White Surlyn Coated	Deluxe Cool White	Warm White
0.22[c]	0.32[d]	0.34[d]	0.34[d]	0.34[d]

[a]TBA values = mg malonaldehyde/1000g sample.
[b]Final thiobarbituric acid (TBA) test was on day 5.
[c,d]Means in the same row with different superscripts are significantly different ($p<.05$).

dition well known to decrease color desirability.

The different response over storage time for CF lights was also noted in Hunter L (lightness/darkness) values (Figure 2). The lower L values indicate that the color darkened during storage. No differences were observed on the initial day of display, thus explaining how desirability ratings could have been rated high under light type CF (Table 1).

Light Exposures Not Different

Throughout the study, few differences were noted between the 12- and 24-hour light exposure periods. This is in contrast to data reported for other meats. However, it is probably best to minimize exposure of pork to light, especially during overnight storage when sales are closed.

Lights Do Not Alter Rancidity

Table 2 presents the results of rancidity measurements in pork displayed under the various light types. These data were collected to determine if light type affected the rate of oxidation. No differences were observed among light sources.

Conclusions

These data suggest that of the light types used in this study, the most desirable pork color can be obtained using 40W deluxe cool white fluorescent lighting. Acceptable color was also perceived when 75W cool floods were used, although the light intensity should be reduced to avoid excess heat build-up. Light source did not affect rancidity. Although no differences were found between the 12 hour and 24 hour per day light exposure treatments, it is suggested that the exposure of pork to display light be minimized.

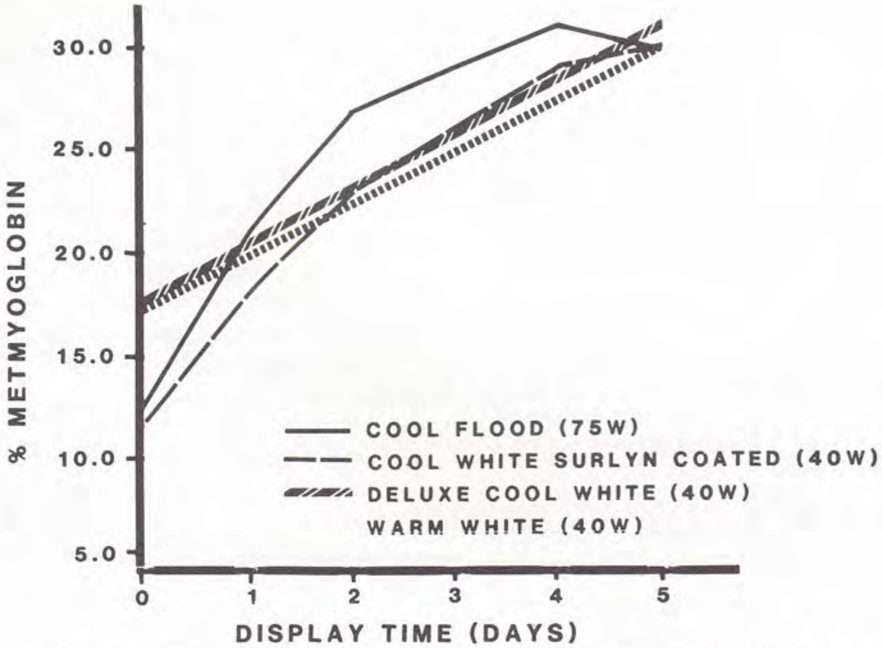


Figure 1. Percentage of meat pigment as metmyoglobin as influenced by light type over display time.

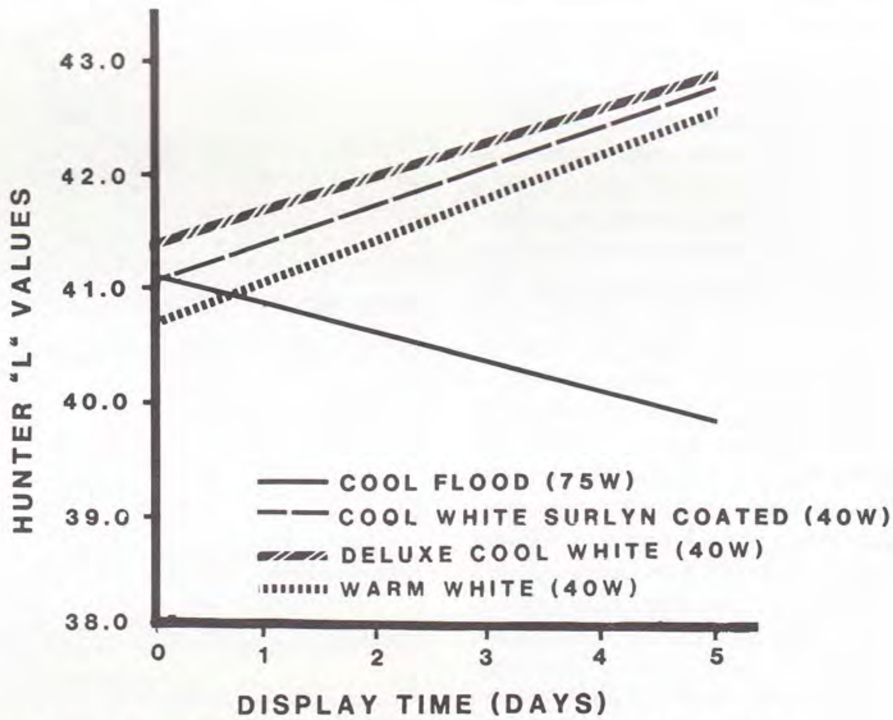


Figure 2. Hunter "L" values as influenced by light type over display time.

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[1]Chris R. Calkins is assistant professor, Steven J. Goll is a former graduate student, Roger W. Mandigo is Professor, all in Animal Science.

Vitamin D—A Beneficial But Sometimes Problem Vitamin

E.R. Peo, Jr.,
Roy Carlson
Austin J. Lewis[1]

Vitamin D, the so-called "sunshine vitamin" is needed by all animals for normal development and maintenance of the skeleton and muscle function. The body manufactures a substance, 7-dehydrocholesterol, which is changed in the skin to vitamin D by ultraviolet light (UV) rays from the sun. In modern pork production systems, pigs are housed inside and thus, their exposure to UV light is minimal. Consequently there is little synthesis of vitamin D by the pig itself. At one time, housing pigs inside would have created a potential for a severe vitamin D deficiency or rickets. After the discovery of vitamin D in the 1920's, modern technology soon made plant (D_2) and animal (D_3) sources of the vitamin available for dietary supplementation.

Surprisingly, only a small amount of vitamin D is necessary to carry out its role in the body. The National Research Council (NRC) in its 1979 publication "Nutrient Requirements of Swine" states that the vitamin D requirements vary from 57 to 100 international units (IU) per pound of diet depending upon the class of swine being considered with young pigs and breeding stock

Table 1. Effect of Vitamin D_2 and Sunshine on Gains, Feed Conversion and Bone Traits of G-F Pigs[a].

	Treatments[b]			
Item	None	Vitamin D_2 (90 IU/lb)	Access to Sunshine	Vitamin D_2 + sunshine
ADG, lb	1.79	1.80	1.77	1.56
F/G	3.21	3.35	3.34	3.28
Bone ash, %	64.3	65.4	65.9	64.1
Bone breaking strength (kg/cm2)	473	501	724	893

[a]Adapted from Wahlstrom and Stolte, 1958. J. Anim. Sci. 17:699.
[b]Data from pigs from 33-200 lb.

Table 2. Effect of Vitamin D_2 on Gains, Feed Conversion and % Bone ash of Young Pigs[a].

	Dietary vitamin D_2 (IU/lb)[b]					
	0	50	100	200	400	UV[c]
Exp. 1						
ADG, lb	.59	—	.75	.64	.68	—
F/G	2.18	—	2.12	1.97	2.06	—
Bone ash, %	49.3	—	47.8	48.7	48.4	—
Exp. 2						
ADG, lb	.62	.51	.62	.48	.55	—
F/G	2.00	2.35	2.14	2.41	2.12	—
Bone ash, %	48.0	48.4	48.9	49.6	49.7	—
Exp. 1						
ADG, lb	.35	—	.40	—	.40	.37
F/G	2.37	—	2.44	—	2.22	2.29
Bone ash, %	50.4	—	52.7	—	52.5	51.3

[a]Adapted from Combs et al., 1966 J. Anim. Sci. 25:48 and 827.
[b]Data from pigs 2-6 or 8 weeks of age.
[c]No vitamin D in diet; pigs exposed to UV light for 10 min, 3 times/week.

having the higher requirement; finishing hogs having the lower. The Nebraska Agricultural Experiment Station (see report EC 84-210, "Swine Diet Suggestions") recommends 250 IU vitamin D/lb diet for all classes of swine, which is about 2.5 times that of the NRC. It should be pointed out that Nebraska recommendations are allowances and carry a margin of safety to be sure there are adequate levels of vitamin D in the diet under all stress conditions encountered in the field.

Vitamin D, whether synthesized in the body or added to the diet, is further changed by the liver and kidney to the active form 1,25 dihydroxyvitamin D_3. In this form, vitamin D will stimulate intestinal calcium absorption and/or take calcium from the bones to meet other body needs such as calcium for muscle function.

The importance of vitamin D in swine nutrition can be seen from the research data presented in Tables 1, 2 and 3. Quite often, average daily gain and feed efficiency will not be affected appreciably by a lack of vitamin D, but percentage of bone ash (an indicator of bone mineralization) and bone strength are often reduced markedly. The research by Wahlstrom and Stolte (Table 1) showed a 2 percent increase in percent of bone ash and a 6 percent increase in bone strength when pigs were fed diets with 90 IU of vitamin D_2/lb of diet and a 53 percent increase in bone strength when pigs were exposed to sunshine. Combs and co-workers (1966) fed several levels of vitamin D_2 and in two of three experiments reported a greater percent of ash from bones of pigs fed vitamin D compared to those fed none (Table 2) with a variable effect of D_2 on gains and feed conversion. Jurgens et al. (1968) observed a 9 percent and 7 percent increase in gains and feed conversion, respectively, in older pigs fed vitamin D_3 (animal source) compared to pigs fed no vitamin D even though the pigs fed no vitamin D had continuous exposure to sunshine. Bone strength was also increased (10%) with supplementary D_3.

Table 3. Effects of Vitamin D_3 on Gains, Feed Conversion and Bone Traits of G-F Pigs[a].

Item	Treatments[b] None	Vitamin D_3 (500 IU/lb)
ADG, lbs.	1.89	2.05
F/G	3.57	3.33
Bone breaking strength (kg/cm2)	218	240

[a]Adapted from Jurgens et al., 1968. Neb. Swine Nutrition Exp. 68401.
[b]Data based on 24 pigs/treatment; 143 lbs. to market weight.

In the previously mentioned studies, there was no evidence that vitamin D was harmful. However, few reports occasionally indicate that high levels of vitamin D may be toxic to swine. In most of these instances, the addition of high levels of vitamin D to swine diets (up to 100 times the NRC requirements) has been the result of mixing errors. These errors include adding premixes designed for other species to swine diets. Use of one vitamin premix for several species is hazardous at best.

Since little information was available as to what level of vitamin D is toxic for swine, we conducted two experiments to investigate the problem.

In the first study, 35 lb. pigs were fed an 18 percent protein starter diet to which vitamin D_3 was added at levels of 250, 100,000 and 200,000 IU/lb. The high levels were similar to those fed in a field case in which vitamin D toxicity had been suspected. As can be seen from the results shown in Table 4, pig performance was severely depressed with 100,000 IU of vitamin D. Pigs could not tolerate 200,000 IU; five of eight died during the first seven days on test. The remaining three were switched to the basal diet containing 250 IU and survived.

The second experiment, again with young pigs (14 lb. initial wt.), was conducted with levels of vitamin D_3 from 250 to 80,000 IU/lb.

(Continued on next page)

Table 4. Effect of High Levels of Vitamin D_3 on Gains and Feed Conversion of Young Pigs.

Item	Vitamin D_3 (IU/lb. diet)[a,b] 250	100,000	200,000
Avg daily gain, lb.	.99	.19	c
Avg daily feed intake, lb.	2.48	1.79	c
Feed/Gain	2.57	7.70	c

[a]Adapted from Moser et al., 1980. Neb. Exp. 80416; 18% protein starter-type diet containing 10% oats.
[b]Data based on 2 pens/treatment, 4 pigs/pen. Initial wt. 35 lb, final wt. 48 lb; 21-day trial.
[c]Five of 8 pigs on this treatment died during the first 7 days on test; remaining 3 pigs switched to diet with only 250 IU vitamin D_3/lb.

Table 5. Effect of High Levels of Vitamin D_3 on Gains, Feed Conversion and Serum Metabolites of Young Pigs.

Item	Vitamin D_3 (IU/lb diet)[a,b] 250	5,000	10,000	20,000	40,000	80,000
Avg daily gain, lb[c]	.90	.90	.88	.79	.84	.70
Avg daily feed intake, lb[g]	1.43	1.41	1.34	1.30	1.36	1.21
Feed/gain[d]	1.60	1.58	1.58	1.66	1.63	1.73
Final serum						
Ca, mg/dl[e]	12.1	12.6	12.2	12.4	12.4	14.8
P, mg/dl[f]	9.5	9.7	9.4	9.5	9.5	7.8
Alkaline phosphatase, (IU/lb)[g]	117	103	118	104	95	103

[a]Adapted from Peo et al. 1983. Neb. Exp. 83407; 18% protein starter-type diet.
[b]Data based on 2 pens/treatment; 4 pigs/pen. Initial wt. 14 lb; final wt. 37 lb; 28-day test.
[c]Linear effect sig. (P<.08).
[d]Linear effect sig. (P<.09).
[e]Linear, quad and cubic effect of vitamin D levels sig. (P<.02).
[f]Linear and quad effect of vitamin D levels sig. (P<.10).
[g]None of the differences sig. (P>.10).

Vitamin D . . .
(Continued from page 15)

As can be seen from the data (Table 5), pig performance started to be reduced with 10,000 IU of D and was severely reduced with 80,000 IU. The reduced average daily gain, feed intake, feed conversion and blood serum phosphorus and the elevated serum calcium level all support the finding that vitamin D is toxic to swine when fed at levels of 80,000 IU or greater. Similar results have been reported by the Cornell workers, Chineme et al. (1976). It appears that young pigs can tolerate dietary additions of 5,000 IU of vitamin D_3/lb (10,000,000 IU/ton) for at least 28 days without any adverse effect on gains, feed conversion or blood calcium and phosphorus. However, feeding levels of this magnitude are unwarranted, ill-advised and not recommended. We now know that feeding high levels of vitamin D will result in poor gains and feed conversion and can lead to calcification (hardening) of the soft tissues of the body such as blood vessels, heart, kidney and muscles. Alkaline phosphatase, an enzyme associated with mineralization of bone apparently was not affected by the vitamin D_3 levels fed in this experiment.

Vitamin D is readily available for diet formulation from protein supplements, base mixes or vitamin premixes. It is concentrated in these products because they will be diluted with grain to make a complete diet. Ordinarily, these three products will not be overfortified with vitamin D. Thus, the only real problem will be if a mixing error occurs when the supplement or premixes are made or if they are used at levels over and above that for which they are intended.

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[1]E.R. Peo, Jr. and Austin J. Lewis are professors of Animal Science; Roy Carlson is research technologist in Animal Science.

Restructured Pork Roasts—Effects of Formulations And Cooking Systems

Fayrene Hamouz,
Roger Mandigo
Chris Calkins[1],[2]

Smoked pork products and fresh loin roasts and chops are the traditional pork items offered on the food service menu. Inconsistencies in slice integrity of fresh ham and pork shoulder roasts decrease yield and increase cost per serving, thus limiting their use by the food service industry. A restructured pork roast would satisfy the need for an intermediate, consistent-quality product and enhance pork use. The objective of this study was to investigate formulations and roasting environments of restructured pork roasts.

Experimental Design

Trimmed, fresh hams which were blade tenderized and ground through a kidney plate and flaked pork trim (2.3 mm head) were used to manufacture nine 25 lb. batches of restructured roasts. Each batch was randomly assigned one of nine salt and phosphate formulations. Salt levels of 0.0, 0.5 and 1.0 percent were each paired with phosphate levels of 0.0, 0.25 and 0.5 percent. Each treatment was vacuum mixed for 12 minutes, stuffed into casings, formed into 5 lb. roasts and frozen at −35°F. Raw samples were evaluated for emulsion stability and water holding capacity.

Roasts were tempered 5 days at 35°F prior to cooking. They were cooked in a 225°F oven to an internal temperature of 170°F in a moist or dry environment. Yield and deformation measurements and Hunter Lab color measurements were obtained. The bind strength or adhesion was evaluated on an Instron Universal Testing Machine by pulling apart representative sections of roast slices.

Results

Improved raw product stability and water holding capacity were observed when either salt or phosphate levels were increased, indicating enhancement of protein extraction in their presence. Increased levels of either salt or phosphate in the formulations improved cooked yields (Table 1). Significant differences in slice count were observed as salt level increased and phosphate was included in the formulation (Table 1).

Synergistic Effect

Salt and phosphate reacted synergistically to increase slice weight yield, (Table 2) which results in ad-

ditional product being served to the consumer as improved cooked yields are achieved. Increases in salt levels and phosphate levels generally enhanced adhesion of cooked roasts (Table 3). In the presence of salt and the high phosphate level, roasts cooked in the moist environment were more easily sheared than those cooked in a dry environment, indicating that they were more tender.

Slices cut from all roast formulations showed good slice integrity and could have been served to the consumer. However, the advantage realized by inclusion of increased salt or phosphate levels would benefit the food service operation by lowering cooked cost per serving. Table 4 shows the impact of increased yield or slice count on cost per 3 oz. serving (cooked weight). The effect of salt alone is seen in the 0.00 phosphate column where the cost per serving was reduced from 44.1 to 42.4 and 38.5 cents respectively, for the addition of 0.50 and 1.00 percent salt. The effect of phosphate alone can be illustrated by looking at the 0.00 percent salt row. The addition of 0.25 and 0.50 percent phosphate reduced the cost per serving from 44.1 cents for the control to 41.1 and 40.6 cents. Significant improvements in cost were found for any level of added non-meat ingredients. The synergistic effect is most easily understood if one compares the high level of both ingredients to the high level of either in the absence of the other. The high salt, high phosphate combination had a cost of 31.5 cents per serving. Salt alone or phosphate alone at the high levels had cost of 38.5 and 40.6 cents per serving.

Table 1. Effect of increased levels of salt and phosphate on cooked yield and slice count of restructured pork roasts

Salt (%)	Yield (%)	Slice Count
0.0	70.78	17.2
0.5	78.51	20.2
1.0	85.75	22.3
Phosphate %	**Yield**	**Slice Count**
0.00	70.77	18.0
0.25	80.20	20.6
0.50	84.25	21.0

Cooked yield = cooked roast weight/raw roast weight × 100

Table 2. Effect of salt-phosphate levels on slice weight yield[1].

	Phosphate Levels (%)		
Salt Level (%)	0.00	0.25	0.50
0.00	63.71	68.49	69.33
0.50	66.41	74.31	82.53
1.00	73.10	87.34	89.38

[1]Slice Weight Yield = Total Weight Sliced Meat/Raw Roast Weight × 100

Table 3. Effect of cooking environment on bind values at varying salt and phosphate levels.

DRY ENVIRONMENT

	Phosphate Level (%)		
Salt Level (%)	0.00	0.25	0.50
0.0	89.68	101.13	163.15
0.0	120.29	196.32	274.16
1.0	172.25	254.49	304.07

MOIST ENVIRONMENT

	Phosphate Level (%)		
Salt Level (%)	0.00	0.25	0.50
0.0	108.34	113.53	166.88
0.5	144.59	214.60	236.20
1.0	175.32	282.07	207.11

Table 4. Calculated cost (cents) per serving of restructured pork roasts at varying salt and/or phosphate formulations.

	Phosphate Levels (%)		
Salt Level (%)	0.00	0.25	0.50
0.00	44.1	41.1	40.6
0.50	42.4	37.8	34.1
1.00	38.5	32.2	31.5

[1]Based on 5 lb. restructured roast costing $1.50/lb. and a 3-oz. serving. Only meat costs considered.

Moist vs. Dry Oven

While previous work with whole muscle roasts has shown improved yields when roasts were cooked in a moist environment, this result was not observed with the restructured roasts. Roasts cooked in the dry environment did take significantly longer to cook.

Summary

Acceptable restructured pork roasts can be manufactured by the addition of salt and phosphate. However, their synergistic effects on slice yield and adhesion suggest that both salt and phosphate should be included in the restructured pork roast formulations. Decreased cooking time results in a moist environment and would facilitate production scheduling in the food service operation.

Additional research is required to determine the salt and phosphate levels which would optimize product quality and yield. Palatability assessment of the restructured pork roasts is being planned.

[1]Fayrene Hamouz is Graduate Student, Roger Mandigo is Professor and Chris Calkins is Assistant Professor all in Animal Science.

[2]Support of the National Pork Producers Council, Des Moines, IA is recognized in helping to conduct this work.

Feed Distribution with An Auger System

Lee I. Chiba, E.R. Peo, Jr., Austin J. Lewis, Joy L. Kovar[1]

Many swine confinement buildings are equipped with a mechanical feed distribution system. Augers used to distribute feed often extend 150 feet or more. Since feed ingredients differ in density and particle size, there is potential for considerable mechanical separation as feed is moved along the building. Pigs at one end of the building may receive feed different in composition from the feed received by pigs at the other end. Consequently, ingredient separation may account for some of differences in pig performance often observed within the same building.

To control dust and to reduce nutrient separation, ingredients such as white mineral oil, molasses, vegetable oils and animal fats are often added to swine diets. Animal fats are rather expensive and are not widely used. However, the use of animal fat has many advantages (see "Hog-house dust reduced with fat in diet", 1985 Nebraska Swine Report). Dietary fat tends to bond minute particles together, and therefore may aid in reducing separation of feed ingredients when using a mechanical feed distribution system.

Experiments

Three experiments were conducted using two modified-open-front buildings and 1,500 pigs to determine the effect of dietary fat on separation of feed ingredients when using a mechanical feed distribution system. The compositions of the experimental diets are presented in Table 1. In each experiment, 250 pigs (25 pens of 10 pigs/pen) in one building were fed a diet without tallow and 250 pigs in another building were fed a diet with tallow. Both diets were distributed to a feeder in each pen by a "Flex-auger" system[2]. Feed samples were taken directly from drops three times during each experiment at the 25 feeders along the length of the building. The distance from the bulk storage bin to the last feeder was approximately 140 feet. Feed samples were analyzed for crude protein, calcium,

Table 1. Composition of Experimental Diets.

Experiment:	1		2		3	
Added tallow, %:	0	2.5	0	5.0	0	7.5
Ingredients, %						
Corn	77.07	74.32	77.95	71.70	77.63	68.28
Soybean meal	19.48	19.71	18.85	20.05	18.91	20.74
Tallow		2.50		5.00		7.50
Vitamins and minerals	3.45	3.47	3.20	3.25	3.46	3.48
	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analyses						
Crude protein, %	15.20	15.07	15.00	15.00	15.00	15.00
Calcium, %	.70	.70	.65	.65	.70	.70
Phosphorus, %	.55	.55	.50	.50	.55	.55
Copper, ppm	9.69	9.68	9.50	9.72	9.51	9.85

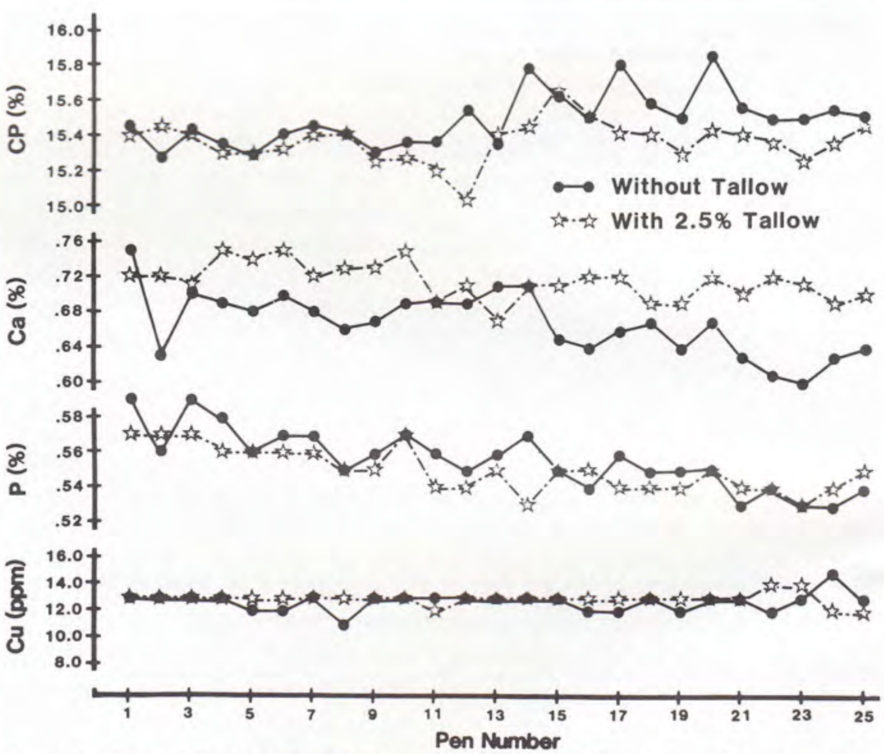

Figure 1. Effect of dietary tallow (2.5%) on crude protein (CP), calcium (Ca), phosphorus (P) and copper (Cu) content of diets along the length of the automated "Flex-auger" feed distribution system (Experiment 1). The bulk bins were located outside of pen 1.

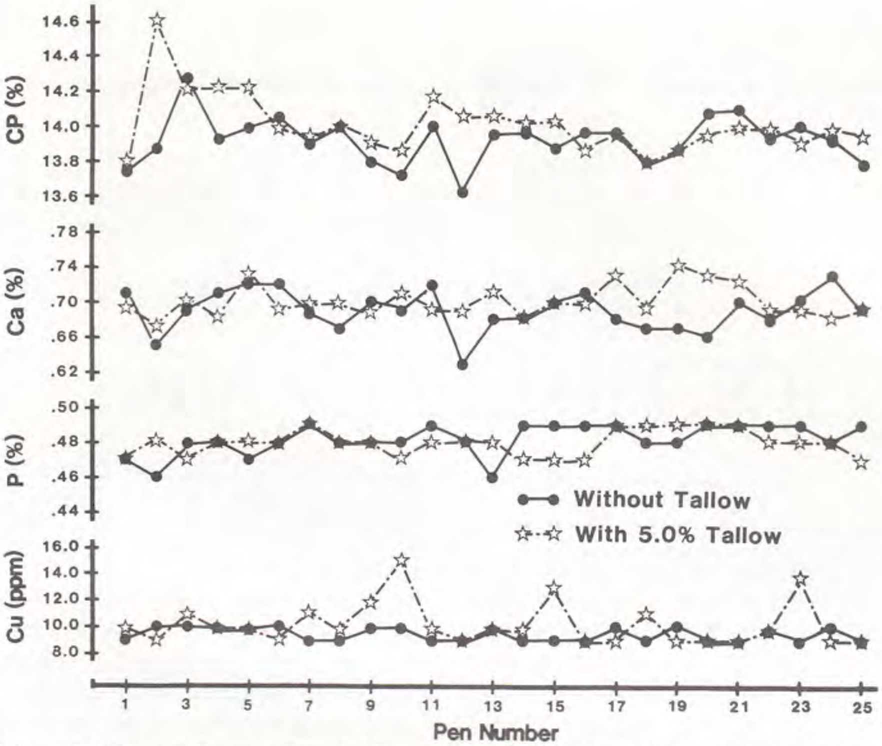

Figure 2. Effect of dietary tallow (5.0%) on crude protein (CP), calcium (Ca), phosphorus (P) and copper (Cu) content of diets along the length of the automated "Flex-auger" feed distribution system (Experiment 2). The bulk bins were located outside of pen 1.

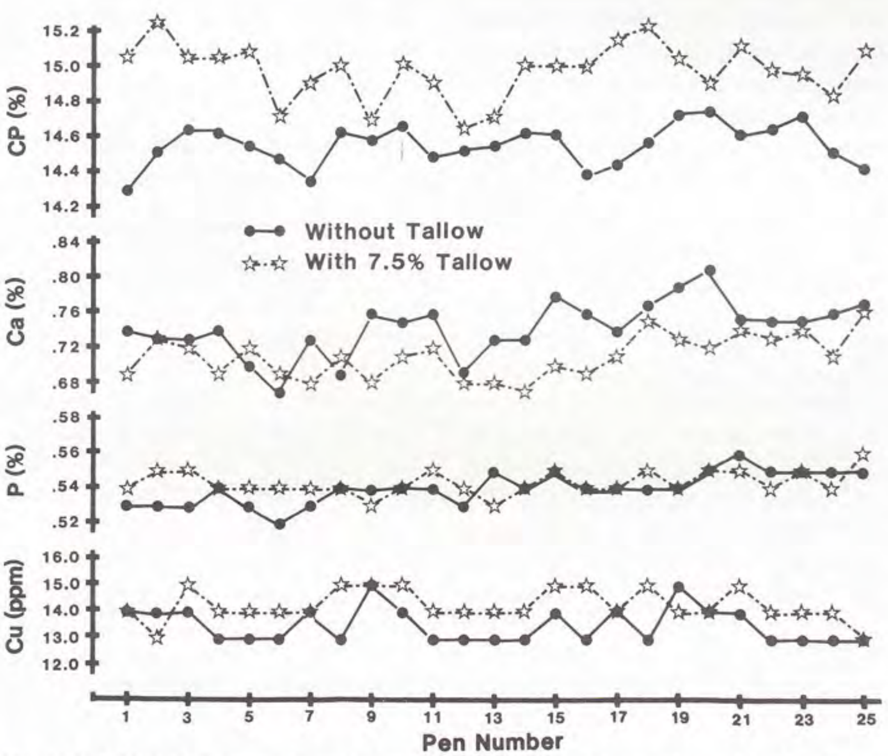

Figure 3. Effect of dietary tallow (7.5%) on crude protein (CP), calcium (Ca), phosphorus (P) and copper (Cu) content of diets along the length of the automated "Flex-auger" feed distribution system (Experiment 3). The bulk bins were located outside of pen 1.

phosphorus and copper. Protein was analyzed to provide information about possible separation of major ingredients (corn and soybean meal), and calcium, phosphorus and copper were analyzed to determine whether there was separation of mineral supplements and the trace mineral premix.

Results and Discussion

The results are summarized in Figures 1, 2 and 3. Each value (as fed basis) represents the average of three sets of feed samples taken during each experiment. In the first experiment, protein content of both diets was similar, and although there was some variation along the distribution system there was no consistent trend. The concentrations of both calcium and phosphorus decreased slightly toward the end of the distribution system for both diets. This was somewhat more evident for calcium content in the diet without tallow than in the diet with tallow. Copper content of both diets was essentially the same and was consistent throughout both buildings. All differences between pens were small and probably unimportant from a practical standpoint.

In experiment 2, although diets were formulated to contain 15 percent protein, the average analyzed value was approximately 14 percent for both diets. Protein content was generally consistent from pen to pen. The difference between the highest and lowest value was .8 percent. Calcium and phosphorus contents of both diets were similar along the feed distribution system. Feed samples from three pens contained a relatively high copper content. These pens were all in the building that received the diet with tallow. The high copper values were caused by abnormally high values during the second sampling period (23, 22 and 23 ppm Cu for pens 10, 15 and 23, respectively). The

(Continued on next page)

Feed Distribution . . .
(Continued from page 19)

copper content of the feed in those three pens in the first and third sampling periods were similar to other pens.

In the third experiment, the average crude protein content of the diet without tallow was lower than the diet containing 7.5 percent tallow (14.6 vs 15.0%). This may be explained partially by the difference in the dry matter content of the diets (88 and 90% for the diets without tallow and with tallow, respectively) which may also account for the slightly lower copper content of the diet without tallow. Crude protein content was relatively consistent throughout the feed distribution system for each diet. The concentrations of calcium in both diets and phosphorus in the diet without tallow increased slightly toward the end of the feed distribution system. These trends were the opposite of experiment 1. Thus, it seems unlikely that any significant ingredient separation occurred throughout the distribution system. There were no consistent changes in copper concentration along the length of the building.

Conclusion

Although there were some minor variations in nutrient content, in general, the diet compositions were very similar throughout the buildings. It appears that there was very little ingredient separation along the automated feed distribution system used in this study. Furthermore, the addition of tallow to the diet had neither positive nor negative effects on ingredient separation.

[1]Lee I. Chiba is Graduate Assistant; E.R. Peo, Jr. is Professor, Austin J. Lewis is Professor, and Joy L. Kovar is Laboratory Technician.

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Energy and Protein Needs Of First-Litter Sows

Joel H. Brendemuhl
Austin J. Lewis[1]

Approximately one-third of the sow herd are first-litter sows. Their reproductive efficiency has a major influence on the overall performance of the herd. Unfortunately, the reproductive efficiency of first-litter sows is often relatively poor. There is frequently a delay in return to estrus or heat after their litters are weaned.

A number of factors are responsible for the delay in return to estrus. Research reported in the 1984 Nebraska Swine Report indicated that the energy intake by sows during lactation is a factor that influences the length of the weaning to estrus interval. In those studies, sows were fed the equivalent of 6, 7, 8.5, 10 or 12 lbs. of a corn-soybean meal diet per day during a 28-day lactation. Sow weight and backfat losses were less when energy intake was higher. Individual pig weights and litter weights were heavier from sows fed 8.5, 10 or 12 lbs. of feed per day than from sows fed either 6 or 7 lbs. of feed per day. The severe energy restriction of 6 lbs. of feed per day during lactation resulted in only 60 percent of the sows returning to estrus by seven days after weaning, ninety seven percent of the sows returned to estrus by seven days postweaning when they were fed 12 lbs. of feed per day during lactation.

Evaluation

Another factor that may influence the return to estrus after

Table 1. Effect of Dietary Protein and Energy Intake of Sows During Lactation on Sow and Litter Performance.

Item	Diet: / Protein, lb/day: / Energy, kcal of ME/day:	LE-LP / 0.84 / 8,000	HE-LP / 0.84 / 16,000	LE-HP / 1.67 / 8,000	HE-HP / 1.67 / 16,000
Number of sows		62	50	61	48
Lactation wt. change, lb					
0-14 day		−24.5	−18.3	−20.3	−4.0
14-28 day		−33.7	−23.9	−24.3	−4.2
0-28 day		−58.2	−42.1	−44.6	−8.2
Lactation backfat change, in.					
0-14 day		−.19	−.11	−.20	−.11
14-28 day		−.15	−.06	−.17	−.08
0-28 day		−.33	−.17	−.38	−.19
Pig wt., lb					
Avg 14 day		8.3	8.5	8.5	8.5
Avg 28 day		13.4	13.8	14.5	15.2
Litter wt., lb					
Avg 14 day		76.7	78.7	78.5	76.5
Avg 28 day		121.1	126.9	130.0	132.5
Litter size					
14 day		9.3	9.3	9.1	8.9
28 day		9.1	9.2	8.9	8.8

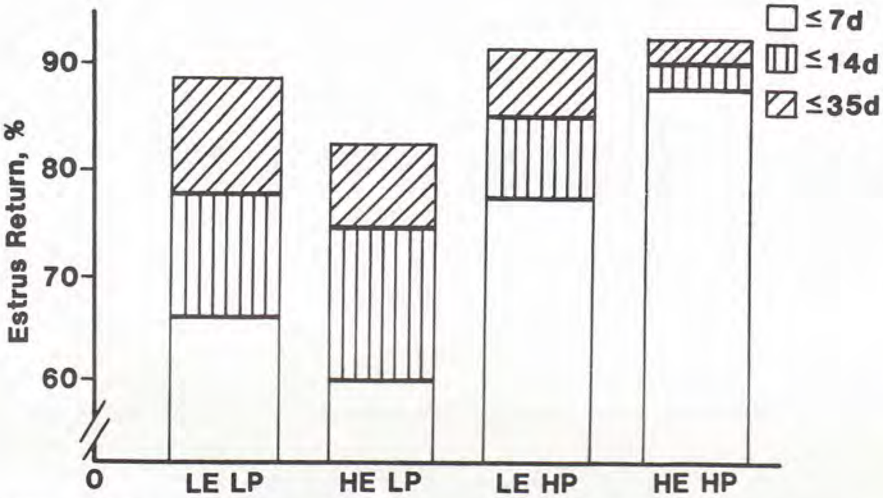

Figure 1. Effect of dietary protein and energy intake of sows during lactation on the cumulative percentage of sows in estrus by days 7, 14 and 35 postweaning. LE, low energy (8,000 kcal per day); HE, high energy (16,000 kcal per day); LP, low protein (0.84 lb per day); HP, high protein (1.67 lb per day).

weaning of first-litter sows is the protein intake during lactation. Low intakes of protein during lactation may prolong the weaning to first estrus interval even when energy intake is adequate. To further evaluate the effects of protein and energy intake on sow and litter performance, 221 first-litter sows were assigned to four diets. The dietary treatments during lactation consisted of combinations of two levels of protein consumption and two levels of energy consumption. On a daily basis, low protein (LP) provided 0.84 pounds of protein, high protein (HP) provided 1.67 pounds of protein, low energy (LE) provided 8,000 kilocalories (kcal) of metobolizable energy (ME) and high energy (HE) provided 16,000 kcal of ME. These levels of protein and energy were combined to make the following four diets; LE-LP, HE-LP LE-HP and HE-HP which were fed during a 28-day lactation. Sows were assigned to treatment in groups of four as they farrowed. Litter size was standardized within group. Creep feed was not available to the litter. After weaning, sows were fed 4 lbs. of feed per day, and were heat checked with a mature boar once daily.

Sow weight loss was greatest for sows fed the LE-LP diet and least for sows fed the HE-HP diet during the first 14 days, the second 14 days and for the entire 28-day lactation (Table 1). A protein by energy interaction was also observed in which sow weight loss was reduced more when energy level was increased in the diet containing HP than in the diet containing LP. Sow backfat loss was greater for sows fed LE diets than for sows fed HE diets. Sows fed HP diets lost more backfat than sows fed LP diets (Table 1).

Average 28-day pig weights were heavier from sows fed diets containing HP than LP and for sows fed diets containing HE than LE (Table 1). Level of energy in the diet did not influence litter weight or litter size at weaning. However, litter weight at weaning was heavier from sows fed HP than for sows fed diets containing LP. Litter size was slightly smaller for sows fed HP than for sows fed diets containing LP at both day 14 and day 28 of lactation.

The data on pig performance suggest that sows consuming inadequate levels of either protein or energy (or both) are not able to compensate fully for these dietary inadequacies by using body reserves to maintain milk production. Thus, pig and litter weights from sows fed inadequate levels of protein or energy are reduced.

Level of protein intake also influenced the number of sows returning to estrus by 7, 14 and 35 days after weaning. Sows fed the diets containing LP, regardless of energy level, took longer to return to estrus than sows fed diets containing HP (Figure 1). These results demonstrate that both protein and energy intake are important in shortening the interval from weaning to first estrus.

Suggestions

From results of this research, we suggest a protein intake at least 1.7 lb. per day during lactation for first-litter sows. Based on previous work, an energy consumption of at least 12,000 kcal of ME per sow per day is also suggested to assure adequate litter performance and to reduce sow weight and backfat loss. In practice, this means that to maximize litter performance and ensure a rapid return to estrus after weaning, sows should be full-fed a diet with at least 14 percent protein during lactation. This diet should have a lysine content of at least 0.60 percent.

Other research has shown that, even when first-litter sows are full-fed during lactation, energy consumption may be inadequate. Adding fat to the diet will help to increase energy intake particularly with high farrowing house temperatures. However, the fat may dilute the diet so that inadequate amounts of the other nutrients may be consumed. If fat is added to the sow's diet during lactation, the levels of other nutrients (amino acids, vitamins and minerals) should also be increased to ensure that a properly balanced diet containing adequate daily amounts of protein is consumed by the sow.

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[1]Joel H. Brendemuhl is a graduate student; Austin J. Lewis is Professor, Animal Science.

Threonine Requirement Of Young Pigs

Austin J. Lewis
E. R. Peo, Jr.[1]

Threonine is one of the three most important amino acids in swine nutrition. It is the third limiting (most deficient) amino acid (after lysine and tryptophan) in corn, and the second limiting amino acid (after lysine) in milo. Although threonine is important, there have been few experiments to determine threonine requirements of swine, largely because the cost of crystalline threonine has been very high. During the last two years the price of threonine has fallen substantially, and this has aroused interest in the practical supplementation of swine diets with crystalline threonine. The reduced price of threonine has also permitted more thorough determinations of the threonine requirements of various classes of swine.

What We Did

Crossbred pigs weaned between three and four weeks of age, with an initial weight of 14 lbs., were used to determine the threonine requirement of young pigs during the first four weeks after weaning. There were 192 pigs kept in groups of four in an environmentally- regulated room. The pigs were fed one of six diets containing either 0.53, 0.57, 0.62, 0.68, 0.75, or 0.83 percent threonine. The current National Research Council (NRC)

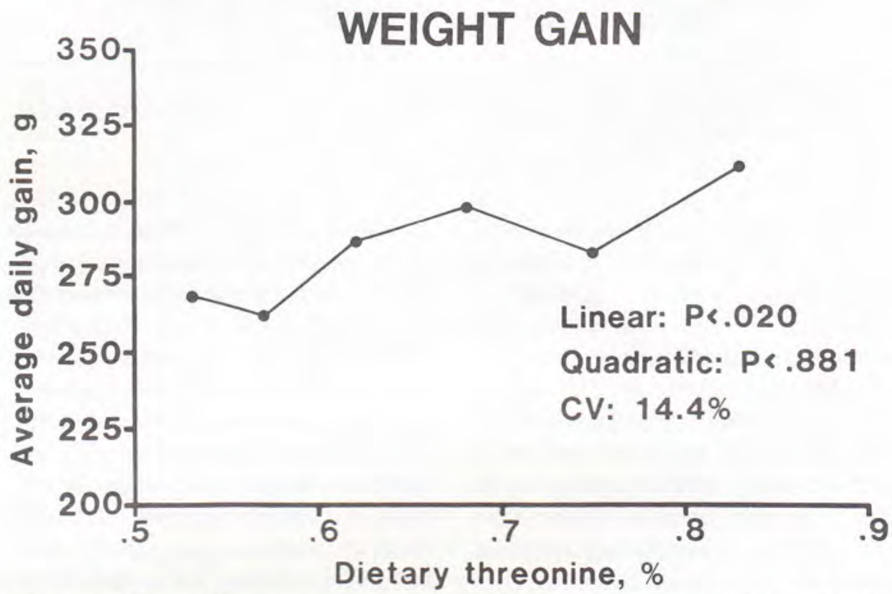

Figure 1. Effect of dietary threonine content on weight gains of young pigs. Each point represents the average weight gain of 32 pigs. The average initial weight was 14 lbs.

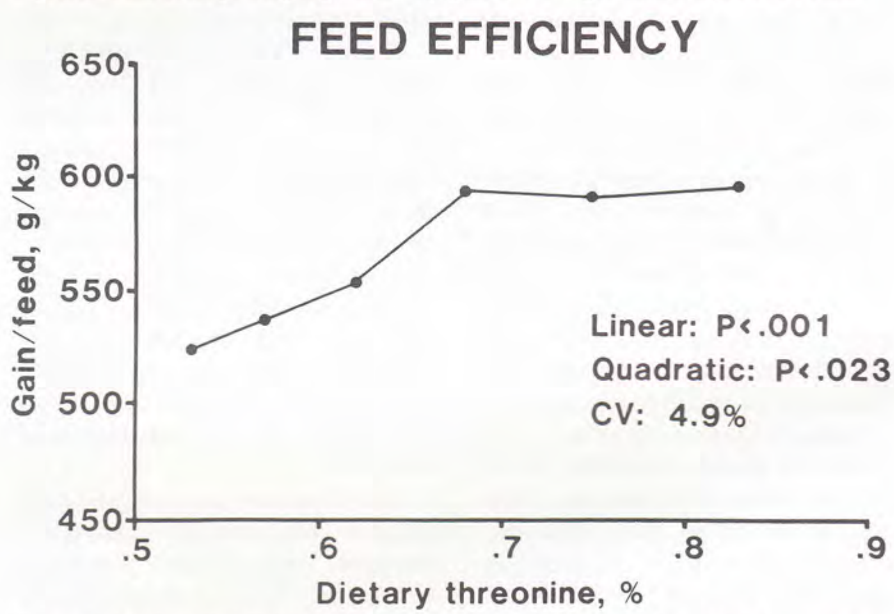

Figure 2. Effect of dietary threonine content on feed efficiency (gain/feed) of young pigs. Each point represents the average feed efficiency of 32 pigs.

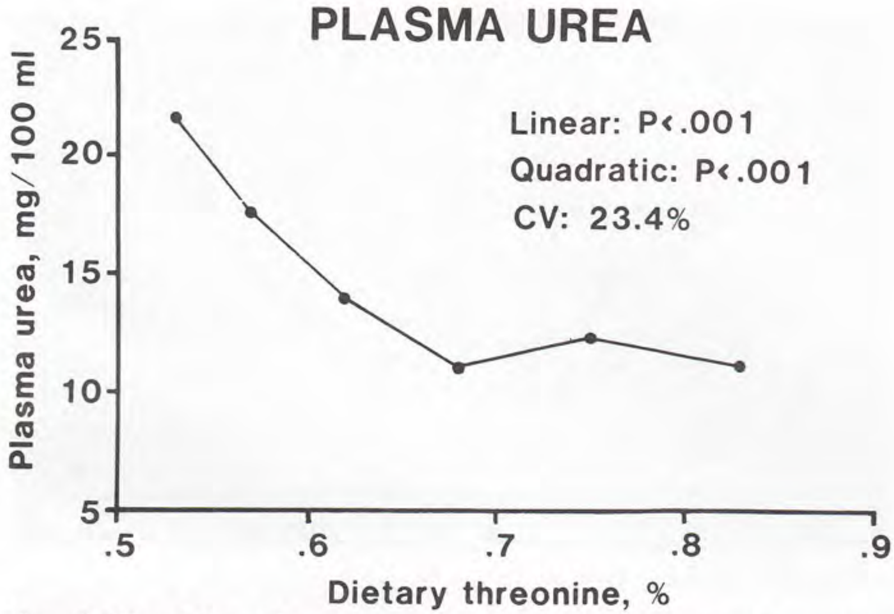

Figure 3. Effect of dietary threonine content on plasma urea concentrations of young pigs at approximately 8 weeks of age. Each point represents the average plasma urea concentration of 32 pigs.

estimate of the threonine requirement is 0.56 percent. Nebraska's recommended allowance for this amino acid is 0.65 percent. The diets were calculated to be adequate in all nutrients except threonine, and contained 15.9 percent protein, 1.28 percent lysine, 0.18 percent tryptophan, 0.90 percent calcium and 0.75 percent phosphorus. Pigs were allowed ad libitum access to feed and water. Pig weights and feed intakes were recorded weekly. Blood samples were taken from the pigs at the end of the experiment and analyzed for urea, which is an index of how well amino acids are used by the pig.

Results

The weight gains and feed efficiencies (expressed as gain/feed) of the pigs fed various levels of threonine are shown in Figures 1 and 2.

Adding threonine to the diet did not have a large effect on pig weight gain, but the two lowest levels (0.53 and 0.57 percent threonine) resulted in poorer weight gains than the other treatments. Weight gain appeared to be maximized at 0.68 percent threonine, with no consistent effect above that level.

The effect of additional threonine on feed efficiency was clear. Feed efficiency was progressively improved as dietary threonine was increased from 0.53 to 0.68 percent, and there was no further improvement at higher levels.

The changes in the concentration of urea in the blood plasma of the pigs in response to the various levels of threonine are illustrated in Figure 3. Urea is produced when amino acids are broken down, and it is ultimately excreted from the body in urine. In an ideal situation, when all amino acid requirements are met and there are few excesses, the production and excretion of urea is very low. The concentration of urea in blood plasma increases when the production of urea by the liver increases. Therefore plasma urea concentration is a useful indicator of urea production, and consequently of the adequacy of the amino acid intake of the pig. As shown in Figure 3, plasma urea declined progressively as dietary threonine was increased from 0.53 to 0.68 percent, suggesting that the optimum dietary threonine concentration was 0.68 percent.

Significance of the Research

The results of this experiment demonstrate that the threonine requirement of the young pig from four to eight weeks old is approximately 0.70 percent. This requirement is 25 percent higher than the current NRC (1979) recommendation of 0.56 percent.

Accurate estimates of threonine requirements are not of major practical importance when swine diets are formulated solely from natural protein sources such as corn and soybean meal, because if the lysine requirement is met, the threonine requirement will normally be met also. On the other hand, when crystalline lysine (and tryptophan) are added to swine diets, and the protein content is reduced, accurate estimates of threonine requirements are crucial. As shown in this experiment, if the threonine requirement is not met weight gain and particularly feed efficiency will be reduced.

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[1]Austin J. Lewis and E. R. Peo, Jr. are Professors, Animal Science.

Eradicating Pseudorabies From A Swine Herd With the Use of Killed Vaccine

Alex Hogg
William G. Kvasnicka
Clayton L. Kelling[1,2]

Top: Figure 1. Typical 3-day-old pig acutely infected with pseudorabies displaying the classical signs of meningioencephalitis. Center: Figure 2. High mortality in pigs that are less than 3 weeks of age when acutely infected with pseudorabies virus. Bottom: Figure 3. Occasionally mortality can be fairly high in pigs that weigh 100 to 200 lbs., in contrast to the usually low mortality in 40 lb. or larger pigs.

Psuedorabies is caused by a herpesvirus that affects swine as well as nearly all other mammals with the exception of man. Major clinical signs in swine are due to nervous system infection (meningioencephalitis) in young pigs and abortions of pregnant females. Signs of meningioencephalitis are pigs that are down and paddling, shaking, rolling the eyeballs and throwing the head back. (Figs. 1-3). In addition, growing pigs in some herds infected with pseudorabies virus develop signs of respiratory disease including coughing and signs of pneumonia.

Other than problems in baby pigs and pregnant females, swine are fairly resistant to pseudorabies. This resistance is age related in that many infected pigs over 5 or 6 weeks of age either never exhibit clinical signs, or when they do, will recover without treatment. Recovery, however, does not mean the end of the problem. Pseudorabies virus, like other herpesvirus, has the characteristic of latency. That is, the virus has the ability to lie

Table 1. Data on Two Herds in Which Pseudorabies was Eradicated.

CHARACTERISTICS	HERD "A"	HERD "B"
1. Type of Herd	Research Farrow/Finish	Commercial Farrow/Finish
2. Original Outbreak	Dec. 1980	1979
3. Number of Sows	700	130
4. Vaccine History	MLV, Jan. 1981	MLV, 1979-1982
5. Killed Vaccine	Gilts, sows, boars every 6 months starting July 1981	Gilts, sows, boars every 6 months starting April 1982
6. Stopped All Vaccines	Jan. 1983	Aug. 1983
7. Culling of Sows	Sows culled after 1 or 2 litters	Culled highest titred sows first-replaced with negative gilts
8. First Completely Negative Test	Sept. 1983	Aug. 1984
9. Time Required to Get Negative Test	26 months	28 months
10. Present Status of Herd	Controlled Killed Vaccine 10% unvaccinated sentinels	PRV Qualified Herd

dormant in the pig's body and later, usually after stress, be shed and infect other pigs.

On the other hand, pseudorabies virus infection in all other species of animals, including cattle, sheep, dogs, cats and wildlife, is virtually 100 percent fatal.

Surveys of blood samples taken from sows at slaughter indicate that about 10 percent of Nebraska's swine herds are infected with pseudorabies virus. This translates to about 1,500 herds.

The motivation to eradicate pseudorabies virus from an infected herd of swine is to:

1. Eliminate losses from this virus, including latent infections and outbreaks.

2. Eliminate the cost of use of pseudorabies vaccination.

3. Remove quarantine and other restrictions that state and federal animal health officials place on pseudorabies infected herds.

4. Remove the threat of a highly fatal disease to other species of animals on the farm.

This paper will report on the successful eradication of pseudorabies from two Nebraska swine farms by use of killed pseudorabies vaccine, followed by rigid culling of seriologically positive animals.

Virulent field strains of pseudorabies virus were present on both farms as determined by a history of severe clinical signs including high mortality rate in baby pigs and abortion in pregnant sows, many sows with high serum titers to pseudorabies virus, and isolation of pseudorabies virus from pig tissues.

Killed vaccine was used because positive antibody titers persist for as long as one year after use of modified live virus (MLV) vaccine. Positive titers from the killed vaccine that was used are nearly always absent within six months after the last killed vaccine is given. The short-lived titers from killed vaccine make it possible to obtain a negative blood test from most vaccinated animals six months after the use of the vaccine.

Table 1 outlines details of the two herds and the time span required to eliminate all the animals from the herd that had positive serology titers by the serum virus neutralization test.

The following comments are pertinent to this study:

1. There was no evidence of virulent field pseudorabies virus circulating in either of these two herds after use of the killed vaccine. This conclusion was reached because none of the replacement gilts, which were produced on each respective farm, were ever positive to pre-selection blood tests for pseudorabies.

2. Several thousand blood tests were conducted during the pseudorabies eradication procedures in these two herds. This was done to establish the rate of decline of serum titers that were judged to be due to killed vaccine. However, it is not anticipated that a large volume of testing would be necessary to try this method of eradicating pseudorabies in other herds.

Present Recommendations for Eradicating Pseudorabies Without Depopulation

1. Stop the use of modified live virus vaccines and start using killed vaccine.

2. Vaccinate every six months on a calendar basis only, (Example: April 1 - October 1), not on the reproductive cycle of the sows.

3. Vaccinate the entire breeding herd, including replacement gilts, every 6 months.

4. Keep good records. When all of the original herd, including animals that were naturally infected or those that had MLV vaccine, have been culled, test 30 or 40 sows and boars at random to establish the status of the herd. In smaller herds, test the entire breeding herd. Wait six months after administering the last killed vaccination to do this monitoring test.

5. Make a decision, based on the monitoring test, to either, (a) continue killed vaccine for another year, or (b) stop vaccination and test the entire breeding herd.

6. Cull any animals with titers until a completely negative herd can be established.

7. Accelerate the turn-over of the herd by going to as close to a gilt program as economically feasible. Rapid culling will eliminate animals that are latent carriers of pseudorabies virus and potential sources of new infections within the herd.

Considerations for selecting herds suitable for this method of pseudorabies eradication:

1. Select herds that have no evidence of clinical signs of pseudor-

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Pseudorabies . . .
(Continued from page 25)

abies or other indication that the virus is circulating in the herd.

2. Infected herds that used killed vaccine for 2 or 3 years or longer are good candidates for the monitoring blood test as stated in #4 of the recommendations above.

3. Remember that although these two herds had 100 percent success in eradicating pseudorabies, this procedure is still experimental and should be used with caution. Caution certainly would include consulting with a practicing veterinarian who is knowledgeable about pseudorabies and the management of the herd in question.

4. After abandoning the use of vaccine, be alert for any signs that pseudorabies virus has not been completely eradicated as evidenced by recurrence of clinical signs of the disease. If clinical signs of failure occur, the use of MLV pseudorabies vaccine should be considered in consultation with the practicing veterinarian to keep losses at a minimum.

Summary

Successful eradication of pseudorabies virus from two Nebraska swine farms within 26 and 28 months respectively is described. This was accomplished by using killed vaccine to protect the breeding herd while previously infected animals or those that had been injected with modified live virus vaccine were being culled.

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[1]Alex Hogg is Professor of Veterinary Science, William G. Kvasnicka is former Associate Professor of Veterinary Science, Clayton L. Kelling is Associate Professor of Veterinary Science, University of Nebraska–Lincoln.

[2]Partial support of this project by Norden Laboratories, Lincoln, Nebraska is gratefully acknowledged.

Maximizing Feed Intake By Lactating Sows

Duane E. Reese[1]

Pork producers are searching for ways to enhance sow reproductive efficiency, ultimately to improve overall production efficiency and profitability. Through the use of maternal breeds and specialized crossbreeding systems, producers have increased the number of pigs weaned per sow. Unfortunately, this improvement has not been problem free. Too often highly productive sows experience delayed estrus after weaning of their first litter and reduced size of their second litter.

Many problems that producers encounter with lactating sows stem from low feed intake during lactation. University of Nebraska research indicates that sows should consume at least 10 to 11 lbs. of feed a day during lactation. Reduced feed intake causes excessive loss of body weight, which may impair subsequent reproductive performance.

What can producers do to maximize sow feed consumption during lactation?

Optimize farrowing house temperature. Sows respond immediately to heat stress by reducing feed intake. In one experiment, when the temperature in the farrowing house was lowered from 80° to 70°F, feed consumption increased by 1.3 lbs. per day. This reduced sow weight loss by 37 percent during lactation.

Producers get caught in a squeeze trying to maintain 90°F temperatures for baby pigs to prevent chilling and not heat-stressing the sow. Many times the needs of the baby pigs are considered most critical, so farrowing house temperature is kept high, to the detriment of the sow. The use of hovers and creep boxes in farrowing crates generally allows producers to lower farrowing house temperatures for the benefit of the sow without compromising baby pig comfort. This way both baby pigs and sows have separate temperature zones for optimum performance. Hovers and creep boxes can be built various ways at little expense. Farrowing house temperatures should not be above 65°F when using hovered creeps.

Consider drip cooling. Recent University research indicates that drip cooling is an inexpensive and effective means of relieving heat stress in lactating sows when room temperature exceeds 80°F. Drip cooling involves periodically wetting the sow's skin over her shoulders. When the water evaporates from the skin, the sow is cooled. In one experiment, sows with drip coolers consumed 2.1 lbs. more feed per day during lactation than those that were not drip cooled. Weight losses were consequently decreased by 78 percent. Farrowing house temperature ranged from 81° to 94°F in this study.

Generally, drip rates range from .5 to .8 of a gallon of water per hour. Commercial drip cooler systems are available, but some producers have devised their own system at substantial savings. Experience with drip coolers indicates that they can be successfully

used with partially-slotted floors in farrowing crates if water drip rate is properly controlled.

Producers can identify heat stress in lactating sows by counting respiration rate. If the respiration rate of several sows exceeds about 35 breaths per minute it is likely the sows are heat stressed and thus would benefit from drip cooling.

Avoid overfeeding sows during gestation. The quantity of feed consumed by sows during lactation is influenced by their feed intake during gestation. University studies have indicated that overfeeding sows during gestation causes reduced appetites during lactation and hence, increased weight loss (Figure 1).

It appears that for sows to consume feed readily during lactation they should be fed rather modestly during gestation (3.5 to 6 lbs. of a corn-soybean meal diet daily depending on sow condition, weather and housing situation) and heavily during lactation (full-fed). One objective in sow management is to minimize fluctuations in body weight during the reproductive cycle. Sows experiencing small changes in body weight during their reproductive cycle are more apt to maintain a high level of production for an extended time period.

Check water adequacy. Feed consumption by sows depends upon the quantity of water consumed. Water flow rates through nipple waterers in farrowing crates of 1/2 gallon per minute will assure unlimited access of water for sows. Mounting the nipple waterers so they are within easy access of sows is also important for adequate water consumption. A good practice in preparing a farrowing room for an incoming group of sows is to check the waterers to be sure they are functioning properly.

Conclusion

Many problems associated with high producing sows can be reduced by proper management. Maximizing feed intake by lactating sows is an important management objective. The following points are important considerations when trying to remedy feed intake problems by lactating sows.

1. Optimize farrowing house temperature, such that chilling of baby pigs is minimized but sows are not heat-stressed. Generally room temperatures should not exceed 65°F when using hovers or creep boxes.

2. When farrowing house temperature exceeds 80°F consider drip cooling as a means of relieving heat stress in sows.

3. Limit sow energy intake sufficiently during gestation to restrict gains and avoid fat sows at farrowing.

4. Be sure sows have ready access to water in farrowing crates.

[1]Duane E. Reese is an Extension Swine Specialist, Animal Science.

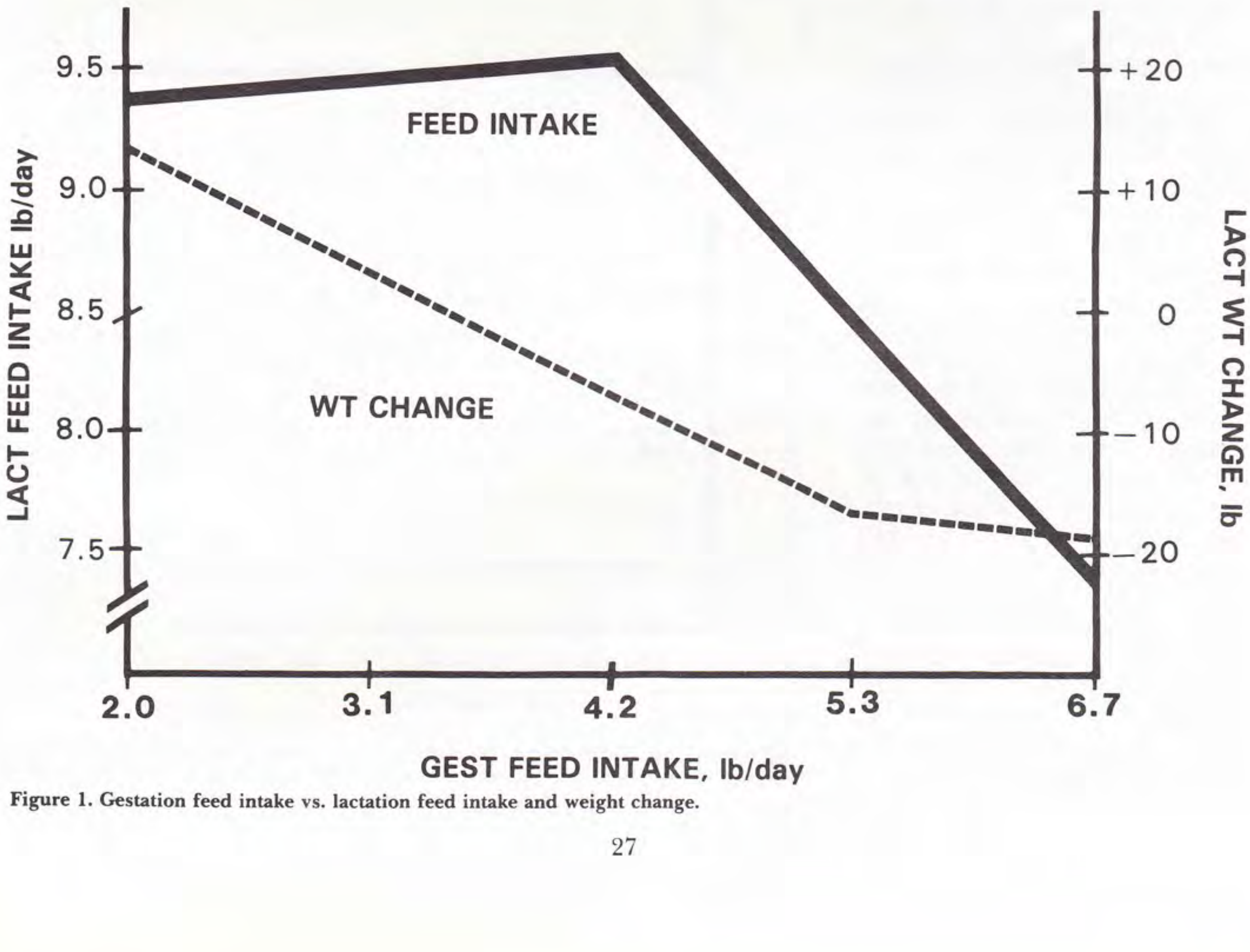

Figure 1. Gestation feed intake vs. lactation feed intake and weight change.

Market Hog Weight—Feed, Fat, Value

William T. Ahlschwede[1]

New grade and yield buying systems which grade hog carcasses according to the measured fat thickness offer incentives to reduce fat thickness. Of the methods for reducing fat thickness, one of the easiest is to sell at lighter weights. It is well established that finishing pigs get fatter as they get heavier. However, many factors are considered when market weight decisions are made. This paper will evaluate the effect of market weight on price, feed efficiency and opportunities for profit.

We reported in the 1977 Nebraska Swine Report that average probe backfat thickness increased proportionally with weight. That is, a pig with an average probe fat thickness of 1.1 in at 220 lbs. would be expected to have 1.2 in. of fat at 240 lb. Or a market hog with 1.2 in. of fat at 200 lbs. would be expected to have 1.44 in. of fat at 240 lbs. Results from a recent study with slaughter weights ranging from 200 to 300 pounds show that this relationship holds for single carcass fat measurements as well. Based on this relationship, Figure 1 shows the expected last rib fat thickness expected on hogs as they grow from 200 to 260 lbs. Pig B is an average hog, with 1.15 in. of fat at 220 lbs. In this example, pig A has .95 and pig C 1.35 in. fat at 220 lbs. Each of the pigs gets fatter as he gets heavier. The fatter hog gets fatter at a faster rate.

Three packers whose trade areas include Nebraska have announced new grade and yield buying programs in recent months. Hormel, Morril and Wilson all have new programs, each different from the other, but all offering incentives similar to that suggested by NPPC's Pork Value System. In general, these new programs offer about $1.00 per market hog for reducing fat thickness by 0.1 in. Figure 2 imposes Hormel's grading system on the three hogs in Figure 1. Hog A would be a No. 1 if marketed at 230 lbs. or less and a No. 2 from 231 to 277 lbs. Pig B would be a No. 2 if marketed under 230 lbs., and a No. 3 from 231 lbs. to 267 lbs. Pig C would be a No. 3 if marketed at 228 lbs. or less, a No. 4 from 229 to 260 lbs. and a No. 5 above 260 lbs. All three of the pigs

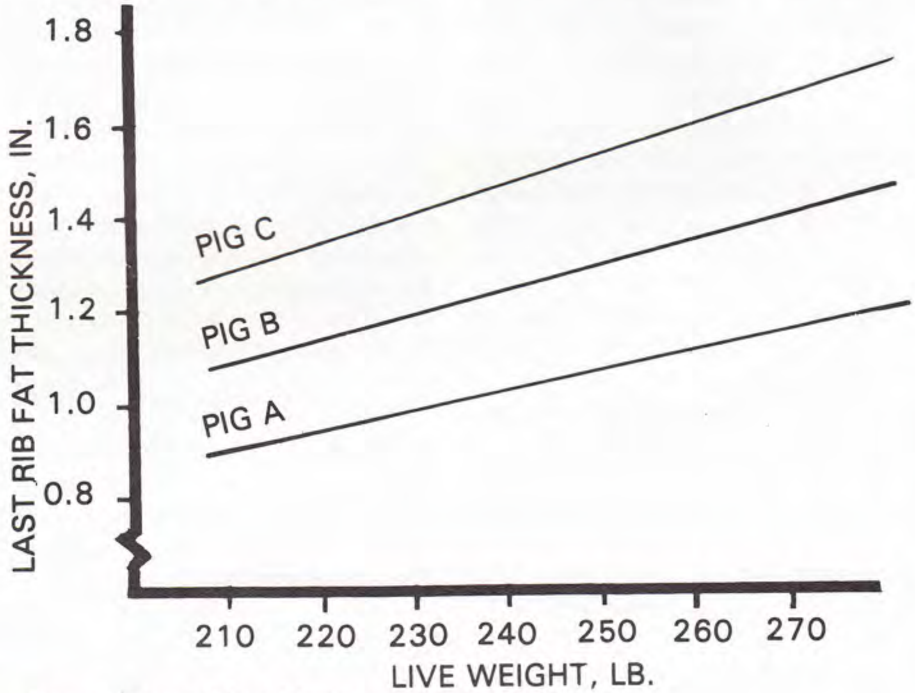

Figure 1. Expected fat thickness as pigs grow heavier.

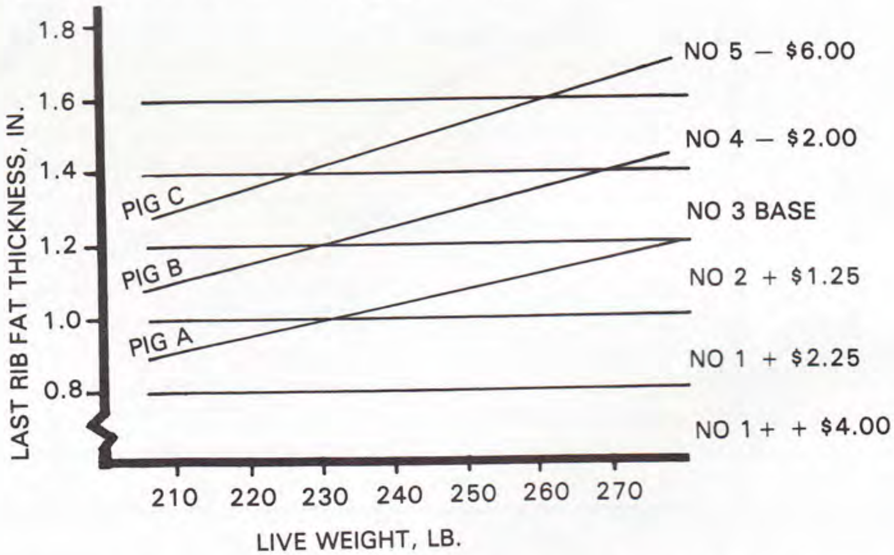

Figure 2. Expected grade and carcass weight premiums of market hogs as they grow heavier (Geo. A. Hormel & Co.; weight discounts for hogs under 210 lbs. and over 240 lbs.).

change grade as they get larger. All have a reduced sale price per pound as they get heavier.

As a more complete example of the effect of weight on the grade and value of hogs, Table 1 shows the average prices of large truckloads of hogs at 220, 240 and 260 lbs. Last rib backfat thickness, the determiner of grade, was taken to average 1.15. in at 220 lbs. Figure 3 shows the expected distribution of fat thicknesses at these weights. Base price and standard yield were established to sell the 220 lb. load of hogs for $40 per hundred weight using Hormel's system and the distribution of fat thickness shown in Figure 3. The 240 lb. hogs were then priced using the same base price and standard yield. A $0.75 per hundred weight carcass discount was assigned to the 260 lb. hogs.

The procedure was repeated with a $50 per hundred market price. At 240 and 260 lbs., more of the hogs fell in the fatter grades than at 220 lbs. and the average price per pound was less for the load. The effect of a lower price per pound on heavier hogs is often larger than it appears. The reduced price per pound for a 240 lb. hog is applied to all 240 pounds, not just the last 20 pounds of gain.

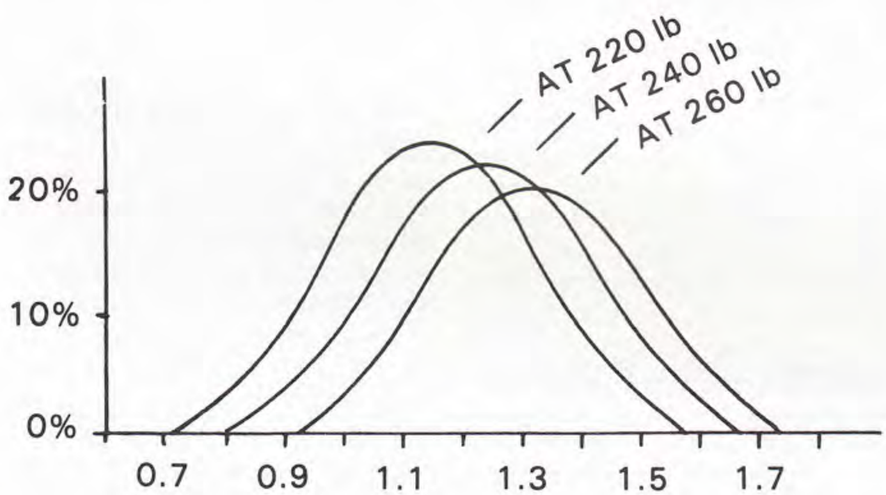

Figure 3. Distribution of last rib fat thickness for growers of pigs at these weights.

Table 1. Effect of Weight on Grade and Yield Value

Market Price Cwt	Grade & Yield Value at 220 lb	at 240 lb	at 260 lb	Added Value From 220 lb To 240 lb Per Hog	lb	From 240 lb To 260 lb Per Hog	lb
$40	88.00	94.77	99.7	6.77	.339	4.93	.247
$50	110.00	118.77	125.7	8.77	.439	6.93	.347
Avg Fat	1.15	1.25	1.36				

Table 2. Expected Lean Content of Hogs of Increasing Market Weight.

Live Weight	Carcass Weight	Pounds Lean	Percent Lean	Lean % of Added Wt
200	146	81.36	55.73	
210	153	84.99	55.44	49.64
220	161	88.53	55.12	48.56
230	168	92.00	54.79	47.48
240	175	95.38	54.44	46.40
250	183	98.69	54.08	45.32
260	190	101.92	53.70	44.23
270	197	105.07	53.31	43.15

The per unit column shows the value added per pound for the added weight. At 240 pounds, the reduced value of the added weight is due to the added fat and its effect upon grade. At 260 pounds, both poorer grade and a weight discount come into play. This example is based on only one grade and yield system. Others are different in how they assign grades, the size of grade premiums, and in weight discounts. Differences in yields will also affect final outcome.

The pork producing industry may be concerned with the broader implications of the composition change which comes with added weight. Table 2 shows the expected lean composition of the added carcass weight. These expected values are based upon the results of a cooperative study sponsored by the National Pork Producers Council. The values represent an average of several types of market hogs. The trend would be expected to be similar for pigs less fat than average, as well as for hogs more fat than average. As the hog gets heavier, its carcass composition becomes less desirable. Each added pound contains even more fat. In a period when consumers seem to be asking for leaner meat products, the pork industry may choose to place even more value upon leanness than the new grade and yield programs offer.

Changes in market weight would be expected to affect production costs. Feed costs and non-feed costs are involved. Table 3 shows expected feed costs for pigs at various market weights. The table values for feed efficiency represent a composite of experiments which reported performance of growing-finishing pigs over multiple weight ranges. The prediction equation was scaled to give an average of 3.6 lbs. feed per lb. gain from 40 to 220 pounds. This corresponds with the feed efficiency experienced with the feeder pigs from the Ne-

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braska Pork Industry Exposition at Columbus. The feed efficiency value in the second column of Table 3 indicates the expected feed requirements for pigs growing from 40 lbs. to the weight indicated in the first column. Next 20 refers to the amount of feed required per pound of gain for the next 20 pounds of gain. Feed costs to reach the current weight and for the next 20 pounds of gain are shown for three feed prices. At any feed price, feed costs for the next 20 pounds of gain are substantially higher than the feed costs required to reach the current weight.

Non-feed costs during the growing-finishing period add another $.07 - $.10 per pound of gain.

Tables 4 and 5 represent an attempt to integrate these costs and price factors. The total cost figure includes a charge for a 40 lb. feeder pig, an added 2 percent to cover death loss of feeder pigs, feed costs and non-feed costs. The non-feed costs were calculated at $7.00 per pig plus $0.045 per pound gain. This represents per pig costs for marketing, trucking and medication and per pound of gain costs for labor, facilities and interest. Feed costs are as shown in Table 3. The sale prices for hogs at 220, 240 and 260 pounds are from Table 2. Table 4 was calculated with a $35 price for a 40 lb. feeder pig and a $40 market hog price. Table 5 set feeder pig price at $40 and market hog price at $50. Within the range of prices considered here, there were only small differences in profit or loss per pound as market weight increased. However, net returns per pound decreased when the pigs were heavy enough to be discounted. Heavier market weights spread the fixed non-feed and feeder pig purchase costs over more pounds. This is balanced by increased feed costs and reduced market price as the pigs get larger.

As a strategy for improving price per pound of market hogs sold grade and yield, selling at lighter weights is effective. The pigs are lighter and grade better because they have less fat. Marketing at lighter weights also saves feed. The last pounds of gain cost the most feed. However, when the fixed costs of feeder pig price and non-feed finishing costs are considered, they tend to offset the value of feed savings and improved grade. As the fixed costs are spread over more pounds, the fixed cost per pound decreased. Hence, within the preferred weight range of the buyer, reducing market weight to improve grade would not be expected to improve profit. The value of the improved product, beyond that recognized by the new grade and yield systems, may make the lighter weights desirable.

Of the variables considered, fatter hogs make lighter weights desirable; poorer feed efficiency makes lighter weight desirable; higher feed costs make lighter weights desirable; and higher market prices for feeders and butchers favor heavier weights.

Table 3. Feed Effeciency of Finishing Hogs as They Increase in Weight.

Feed Efficiency Since 40 Pound			Feed Cost Per Pound of Gain: to Wt	Next 20 lb	to Wt	Next 20 lb	to Wt	Next 20 lb
WT	*F/G*	*NEXT20*	*120*	*120*	*140*	*140*	*160*	*160$/TON FEED*
200	3.50	4.36	.210	.262	.245	.305	.280	.349
210	3.55	4.44	.213	.266	.249	.310	.284	.355
220	3.60	4.51	.216	.271	.252	.316	.288	.361
230	3.65	4.59	.219	.275	.255	.321	.292	.367
240	3.69	4.66	.221	.280	.258	.327	.295	.373
250	3.74	4.74	.224	.284	.261	.332	.299	.379
260	3.78	4.82	.227	.289	.265	.337	.302	.385

Table 4. Production Costs and Sales Price of Hogs Marketed at Different Weights.

$Feed/ T	120 Cost		140 Cost		160 Cost		$40 Sale Price	
Weight	Pig	lb	Pig	lb	Pig	lb	Pig	lb
200	82.45	.412	87.87	.439	93.29	.466		
210	85.40	.407	91.24	.434	97.09	.462		
220	88.40	.402	94.67	.430	100.94	.459	88.00	.400
230	91.45	.398	98.15	.427	104.85	.456		
240	94.54	.394	101.68	.424	108.82	.453	94.77	.395
250	97.68	.391	105.26	.421	112.85	.451		
260	100.86	.388	108.90	.419	116.94	.450	99.70	.383
270	104.08	.385	112.59	.417	121.09	.448		

Feeder pig cost, $35; non-feed cost, $7, plus $.045 per pound gain.

Table 5. Production Costs and Sales Price of Hogs Marketed at Different Weights.

$Feed/ T	120 Cost		140 Cost		160 Cost		$50 Sale Price	
Weight	Pig	lb	Pig	lb	Pig	lb	Pig	lb
200	87.55	.438	92.97	.465	98.39	.492		
210	90.50	.431	96.34	.459	102.19	.487		
220	93.50	.425	99.77	.454	106.04	.482	110.00	.500
230	96.55	.420	103.25	.449	109.95	.478		
240	99.64	.415	106.78	.445	113.92	.475	118.77	.495
250	102.78	.411	110.36	.441	117.95	.472		
260	105.96	.408	114.00	.438	122.04	.469	125.70	.484
270	109.18	.404	117.69	.436	126.19	.467		

Feeder pig cost, $40; non-feed cost, $7, plus $.945 per pound gain.

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Induced Farrowing: Can We? Should We?

J. D. Kopf
Dwane R. Zimmerman[1]

Gouping farrowing within a preplanned period is an available management tool for pork producers and may be beneficial for a number of reasons. Grouping birth dates of litters should facilitate producer attendance during farrowing, fostering between litters, scheduling of farrowing to avoid weekends or other weekly conflicts, farrowing in the cooler part of the day, and better management of facilities, especially with the all-in all-out system of management. But regardless of the potential benefits, each pork producer must evaluate the feasibility of successful application of induced farrowing.

Prostaglandins Approved for Farrowing Induction

The term prostaglandin refers to a family of naturally-occurring hormones within the body. The specific compound prostaglandin $F_2\alpha$ ($PGF_2\alpha$) causes regression of the corpora lutea and stimulates uterine contractions just ahead of natural parturition. Corpora lutea are glands on the ovaries that produce progesterone and maintain pregnancy. Injection of $PGF_2\alpha$ and a number of its synthetic analogues are capable of inducing the parturition process prematurely. Currently, only the naturally occurring $PGF_2\alpha$ (available under the trade name Lutalyze, The UpJohn Company) is approved for use for induction of parturition in swine.

Farrowing Response

A number of studies have evaluated optimum dosage of $PGF_2\alpha$ and time of injection. $PGF_2\alpha$ is approved for use as a single 10 mg. injection. Parturition may be induced up to three days prior to predicted farrowing date without jeopardizing litter performance. The percentage of females treated with $PGF_2\alpha$ which farrow within 48 hours after injection normally is above 80 percent. Most studies have attained a 90 percent or greater response. The average interval from $PGF_2\alpha$ administration until birth of the first pig varied between studies but typically averaged around 30 hours.

Though the majority of sows farrow close to the average interval the range in time from when the first and last sow farrow may be as large as 48 hours. Researchers at the University of Missouri observed that 57 percent of the sows farrowed within a 10 hr. period on the day following administration of $PGF_2\alpha$. Sows were injected one to three days before the expected date of parturition. Thirty one percent of the sows farrowed before and 12 percent of sows farrowed after the 7 a.m. to 5 p.m. working day. Thus, programming parturition of all sows into a typical working day is not usually attainable. The duration of parturition does not appear to be changed by induction of parturition with $PGF_2\alpha$.

Pig Performance

Pig performance does not seem to be affected by $PGF_2\alpha$-induced farrowing when induction occurs no earlier than three days before to the end of herd's average gestation period. Birth weights of induced pigs may be slightly lower, depending on day of gestation the sows are treated. The percentage of pigs born alive after $PGF_2\alpha$ treatment normally ranges between 90 and 95 percent, and is not different from control values. The survival of the pigs to weaning is also comparable to the survival rates of naturally-farrowed litters. Weaning weights of induced litters did not differ from controls in most studies.

Synchrony of Parturition Improved by Addition of Oxytocin

Oxytocin, a hormone which enhances uterine contractions and causes milk let down, is sometimes administered during natural parturition to assist in movement of pigs through the birth canal when the parturition process is prolonged. Recently, oxytocin has been evaluated for improving the synchrony of induced parturition when administered the day following $PGF_2\alpha$ administration.

Oxytocin injection 15 and 28 hours after injection of $PGF_2\alpha$ or analogue has been reported to improve parturition synchrony. Studies conducted at several locations observed farrowing responses of 90 percent or greater within one to two hours after oxytocin administration. Studies at UNL have produced similar but less synchronous parturition responses. Sows administered oxytocin 15 or 20 hrs. after prostaglandin analogue (clo-

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prostenol) administration averaged 2.7 hrs. to farrowing their first pig. All 22 sows farrowed over a 7 hr. period.

The favorable results from this study prompted further work at UNL with the prostaglandin-oxytocin treatment to determine whether farrowing could be effectively programmed during working hours on two days of the week (Monday and Thursday). Twenty-two second litter sows were injected with cloprostenol on days 111, 112 or 113 of gestation (114.5 day average gestation) followed by an oxytocin injection 20 hours later. The injections were timed to obtain group farrowing during the day of the 8:30 a.m. injection of oxytocin. Cloprostenol was administered at noon on the previous day. A control group was injected with saline at equivalent times.

All treated sows began farrowing by 42 hours after the cloprostenol injection. Seventy-two percent farrowed within the 8:30 a.m. to 4:30 p.m. period of the day following cloprostenol injection. Sixty-seven percent of the farrowings occurred within four hours of the oxytocin injection. Nineteen percent farrowed during the night or early morning hours before the oxytocin injection and 9 percent did not farrow until evening. Fifty-two percent of the control sows farrowed during the workday hours, but farrowing was distributed over most days of the week. For treated sows that farrowed during the working day, the interval from oxytocin administration until birth of the first pig averaged 69 minutes.

Average duration of the farrowing process following prostaglandin-oxytocin treatment was comparable to control values in most studies but the farrowing process deviated from normal in some sows. Certain sows in the UNL study were observed to farrow one or two pigs within two hours after oxytocin administration and then delay a few hours before farrowing the remainder of their litter. These sows were often restless and failed to show normal maternal behavior until farrowing was resumed. The first-born pigs were at greater risk from trampling or overlay by the sow and it was felt that attendance was important and necessary to prevent added pig loss. Though most of these sows resumed farrowing on their own, some sows were given an additional injection of oxytocin to assist the sow to resume farrowing.

Birth weight, number and percent born alive and percent alive at 21 days were comparable to naturally-farrowed litters (Table 1). Pig weaning weight at 21 days was reduced in treated litters but this was attributed to larger litter size at birth (1.1 more pigs) in treated sows, a chance occurrence. The majority of studies have reported no effect on weaning weights from prostaglandin-oxytocin treatment.

Is Induced Parturition for Me?

One should not consider applying farrowing induction procedures unless accurate breeding dates are available for individual sows. In addition, gestation records on the herd are needed to calculate the average gestation length of the herd. Farrowing should not be induced more than three days before the average day of natural parturition. Litters farrowed earlier than this may have reduced survival.

Synchronized farrowing can be achieved at a reasonable cost of $1.50 to $2.00 per sow. It makes attendance possible at most farrowings. However, most studies have failed to demonstrate that farrowing induction saves more pigs. Therefore, the decision on whether or not to use farrowing induction as a management tool must be based on considerations involving labor and pig management. Controlled farrowing, though not a precise technique at present, allows programming the birth of most litters on certain days of the week and can concentrate farrowing during a preferred part of the day. This facilitates attendance at most farrowings and provides an opportunity to give more immediate attention to parturition problems when they occur.

Grouping of farrowing may also allow for more synchronized movement of sows and pigs through the unit. This may produce better utilization of farrowing and nursery facilities and provide more complete breaks between groups. This is especially important in "all in-all out" systems of management. Fostering of pigs may also be aided through the more uniform age of pigs achieved with synchronized farrowing. Induced farrowing may be a viable management alternative to Mother Nature if accurate breeding records are available and pig, facilities and labor management are improved sufficiently to pay for the cost.

Table 1. Performance of induced vs naturally farrowed pigs.

Treatment[a]	No. sows	Birth wt (lb)	% born alive	Weaning[b] Wt, lb	Weaning[b] Alive, %
Prostaglandin-oxytocin	22	3.21	93	13.02	92
Control	21	3.26	93	13.53	91

[a]Administered 175 g cloprostenol ($PGF_{2\alpha}$ analogue) at 12:30 p.m. on days 111, 112 or 113 and 20 I.U. oxytocin at 8:30 a.m. the day following cloprostenol. Controls received saline at comparable times.
[b]Pigs weaned at 21 days of age.

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