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# EC89-219 1989 Nebraska Swine Report

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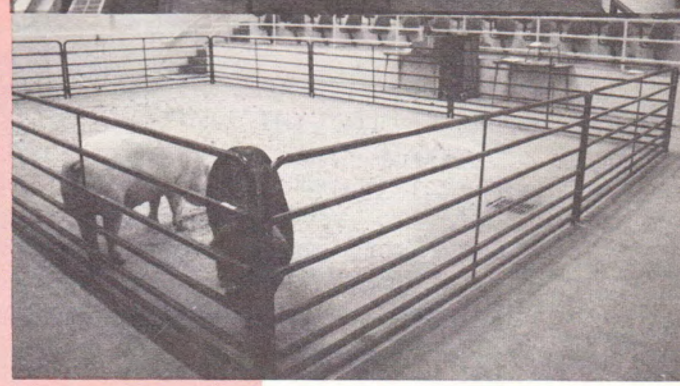
# NEBRASKA SWINE REPORT



- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

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

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*Institute of Agriculture and Natural Resources*

# 1989 NEBRASKA SWINE REPORT

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## Contents



**ON THE COVER:**

*Top:* The west entrance to the new Animal Science Complex at the University of Nebraska-Lincoln. *Center:* Students make use of the Commons Area found just inside the south entrance of the Animal Science Complex. *Bottom:* A practicum lab in the Animal Science Complex teaching area.


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*The 1989 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.*

# Hominy Feed--How Available is the Phosphorus?

**M.A. Giesemann, E.R. Peo, Jr. and A.J. Lewis[1]**

Many nutrients are not fully digested, absorbed and utilized by the pig. Ideally, swine diets should be balanced for available nutrients, not total nutrients. To accomplish this, estimates of available nutrients in feedstuffs and requirements for available nutrients are necessary. Lately, much progress has been made in determining the bioavailability of nutrients for pigs.

The 1988 *Nutrient Requirements of Swine* published by the National Research Council lists available phosphorus requirements for all classes of pigs. Estimates of the availability of phosphorus in some feedstuffs are also given.

Hominy feed is a by-product of the dry corn milling process. Research at the University of Nebraska has shown that hominy feed has considerable potential as an economical feedstuff for growing-finishing pigs (1988 Nebraska Swine Report). As a result of processing, the amount of phosphorus in hominy is nearly twice that of normal corn. The extra phosphorus in hominy could lower feed costs since less supplemental phosphorus would be needed to meet the pigs' requirement. The availability of phosphorus in hominy was unknown. Thus, we conducted research to determine whether the availability of the phosphorus in hominy feed is different from corn.

Pigs were started on test at 57 lb body weight and were fed a 16 percent protein diet to 130 lb, and a 14 percent protein diet to market weight. Composition of the diets is shown in Table 1. Diets were formulated to have a constant amount of phosphorus supplied by either hominy feed or corn. Inorganic phosphorus was added to provide diets with a total of .34, .42 and .50 percent phosphorus. Four pens of 8

DRY CORN MILLING FLOW

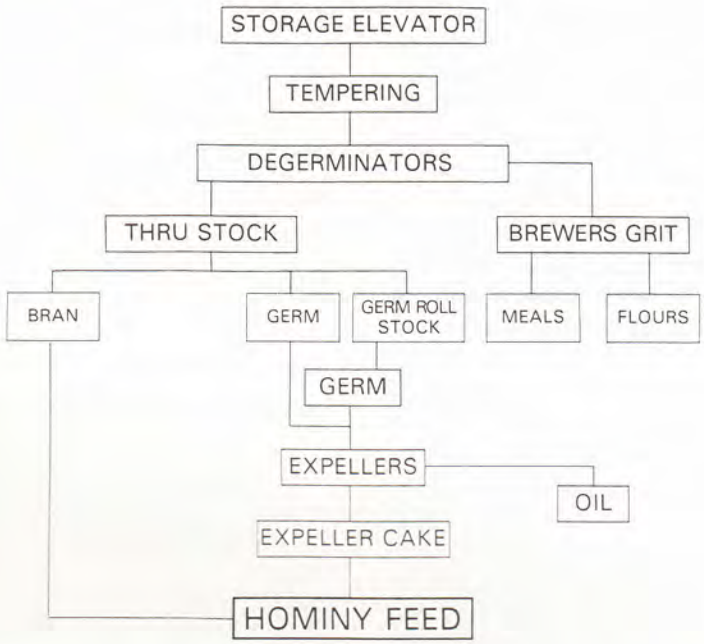



**Table 1. Hominy Feed and Corn for G-F Pigs (Neb. Exp. 86410).**

| Grain: | Corn | | | Hominy Feed | | |
|---|---|---|---|---|---|---|
| Added P: | 0 | .08 | .16 | 0 | .08 | .16 |
| Corn | 72.52 | 72.52 | 72.52 | — | — | — |
| Hominy feed[b] | — | — | — | 58.01 | 58.01 | 58.01 |
| Cornstarch | .62 | .31 | — | 15.13 | 14.82 | 14.51 |
| Soybean meal | 21.00 | 21.00 | 21.00 | 21.00 | 21.00 | 21.00 |
| Tallow | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Monosodium P | — | .31 | .62 | — | .31 | .62 |
| Mins & Vits | 2.86 | 2.86 | 2.86 | 2.86 | 2.86 | 2.86 |

[a]16% protein 57 to 130 lb; 14% protein 130 to 200 lb.

[b]Hominy feed was supplied gratuitously by Lanhoff Grain Co., Danville, IL.

**Table 2. Effect of phosphorus content and source on performance and bone characteristics of growing-finishing swine. (Neb. Exp. 86410).**

| | Grain Source | | | | | |
|---|---|---|---|---|---|---|
| | Corn | | | Hominy Feed | | |
| | Phosphorus Level, % | | | | | |
| | .34 | .42 | .50 | .34 | .42 | .50 |
| Average daily gain, lb[ab] | 1.37 | 1.70 | 1.76 | 1.34 | 1.61 | 1.70 |
| Feed/gain[a] | 3.19 | 2.93 | 2.82 | 3.16 | 2.93 | 2.80 |
| Bone breaking strength, lb[abc] | 141 | 238 | 284 | 137 | 216 | 269 |
| Bone ash, %[ab] | 58 | 61 | 62 | 58 | 61 | 62 |

[a]Linear effect of phosphorus ($P < .01$).

[b]Quadratic effect of phosphorus ($P < .02$).

[c]Effect of grain, ($P < .02$).

pigs each were assigned to each of the six treatments. Leg (metatarsal) bones from 24 pigs per treatment were used to determine bone breaking strength and percentage of bone ash.

Performance and bone characteristics of the pigs are shown in Table 2. Pig performance increased as phosphorus levels in the diet increased. Pigs fed hominy feed gained about the same and had feed conversion ratios similar to the pigs fed corn, but bone breaking strength of pigs fed corn was greater than those of pigs fed hominy feed. This may be due to the corn fed pigs gaining slightly faster and thus being larger. Percentage of bone ash was the same for the two sources of grain.

The responses of bone breaking strength and percent ash to phosphorus intake are presented in Figures 1 and 2, respectively. Only data representing pigs consuming the .34 percent and .42 percent phosphorus diets are presented. Pigs responded similarly regardless of phosphorus source. Therefore we conclude that phosphorus availability of hominy feed is not different from that of corn.

The phosphorus in both corn and hominy feed is only 15 percent available; less than that of soybean meal (25 to 38%) and inorganic sources (85 to 100%). Hominy feed has a higher total phosphorus content than corn, thus less supplemental phosphorus is needed to meet the pigs' total requirement. However, formulating diets with hominy feed on a total phosphorus basis could result in a deficiency of available phosphorus. Thus, a source of inorganic phosphorus should be added to hominy feed-based swine diets. Table 3 gives some suggested swine diets using hominy feed. These diets result in approximately 10 percent savings in the amount of inorganic phosphorus needed.

[1]M.A. Giesemann is graduate student, E. R. Peo, Jr. is professor emeritus, and A. J. Lewis is professor, all in the Department of Animal Science.

**Table 3. Suggested hominy feed diets for swine.**

| Ingredient | % of diet | | |
|---|---|---|---|
| | Growing pig[a] | Finishing pig[b] | Gestating sow[c] |
| Hominy feed | 79.1 | 85.2 | 89.2 |
| Soybean meal, 44% | 17.7 | 11.8 | 6.1 |
| Dicalcium phosphate | .9 | .8 | 2.5 |
| Ground limestone | .9 | .9 | .6 |
| Salt | .3 | .3 | .5 |
| Trace mineral mix[d] | .1 | .1 | .1 |
| Vitamin mix[d] | 1.0 | 1.0 | 1.0 |
| Calculated analysis: | | | |
| Lysine, % | .80 | .65 | .50 |
| Protein, % | 16.2 | 14.2 | 12.2 |
| Calcium, % | .65 | .60 | .90 |
| Phosphorus, % | .70 | .66 | .97 |
| Avail. phosphorus, % | .28 | .24 | .55 |

[a]Provides 16% protein for growing pigs (40-110 lb).

[b]Provides 14% protein for finishing pigs (110 lb to market weight).

[c]Provides 12% protein, feed at 4 lb/head/day.

[d]Percent of diet will depend on carrier.

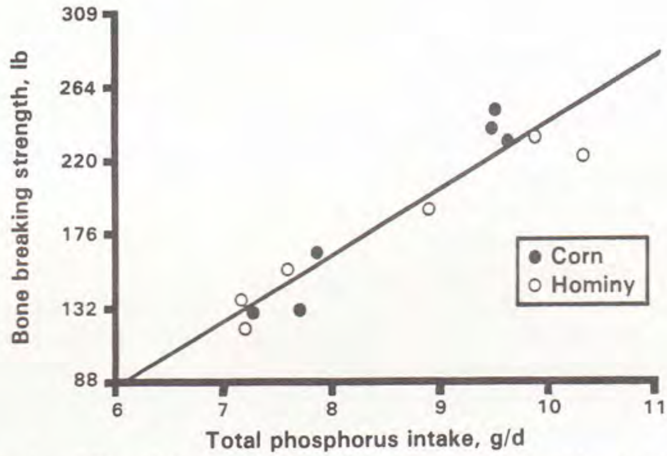



**Figure 1.** **Effect of phosphorus intake and source on bone breaking strength of G-F pigs. Each point represents the average of 8 pigs. (Neb. Exp. 86410).**

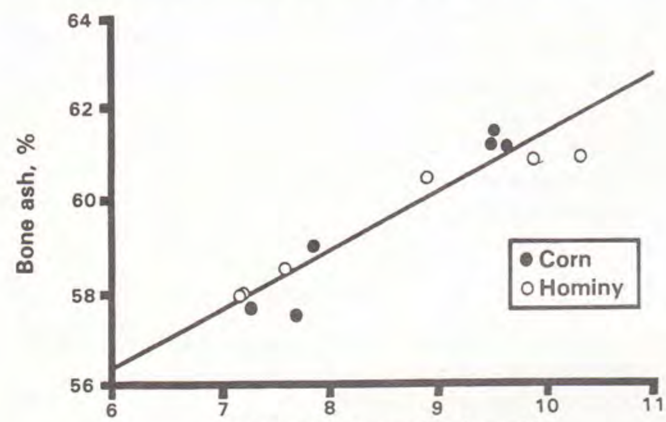



**Figure 2.** **Effect of phosphorus intake and source on bone ash of G-F pigs. Each point represents the average of 8 pigs. (Neb. Exp. 86410).**

# Nutrient Content of Nebraska Corn

**Duane E. Reese
and Austin J. Lewis**[1]

Sometimes the "missing link" in formulating cost-effective diets for pigs is information about the nutrient content of the ingredients. The nutrient content of grain and some protein sources can vary considerably depending on variety, growing conditions and geographic location. For example, a study in 1969 indicated that the selenium content of corn grown in Nebraska ranged from 0.04 to 0.81 ppm. Such variation may explain some of the wide-ranging nutrient levels that are commonly found in diets mixed on farms. Because corn is the major ingredient in many swine diets in Nebraska, we conducted a study to determine the level of some important nutrients in corn grown in Nebraska during 1987.

A total of 36 normal corn samples were collected from nine counties in Nebraska where University corn hybrid tests were being conducted (Figure 1). Table 1 shows the hybrids tested, production practices and yield for each county. Samples were collected from each of four replicated plots per variety at each location. These samples were pooled by variety at each location for analysis. All corn samples were analyzed for crude protein, lysine, calcium, phosphorus, selenium and vitamin E. Official methods, recognized by the AOAC (Association of Official Analytical Chemists), were used for each of the nutrients. The procedures are summarized in Table 2.

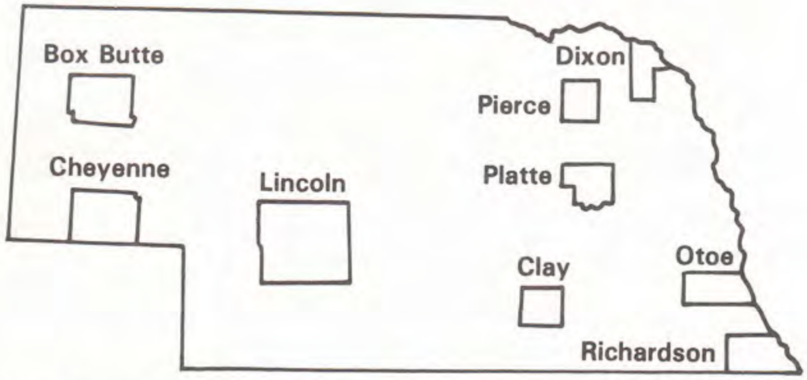



**Figure 1. Counties where corn samples for analysis were obtained.**

**Table 1. Location, Production Practices and Yields of Corn Hybrids Tested[a].**

| County | Hybrids tested[b] | Production practice | Yield, bu/ac Avg | Min | Max |
|---|---|---|---|---|---|
| Box Butte[b] | H1 | Irrigated | 148 | 142 | 153 |
| Cheyenne | H1 | Ecofallow | 78 | 71 | 87 |
| Clay[c] | H2 | Irrigated | 212 | 204 | 223 |
| Dixon | H2 | Dryland | 137 | 133 | 141 |
| Lincoln | H2 | Irrigated | 214 | 198 | 241 |
| Otoe | H2 | Dryland | 145 | 137 | 156 |
| Pierce | H2 | Irrigated | 195 | 188 | 201 |
| Platte | H2 | Dryland | 129 | 123 | 143 |
| Richardson | H2 | Dryland | 194 | 189 | 206 |

[a]Nebraska Corn Hybrid Tests Publication (EC87-105).

[b]H1 hybrids tested were Cargill 5157, Horizon 6103, Lynks Seeds LX4084 and Wilson 1500B.

[c]H2 hybrids tested were AgriPro AP510, Cargill SX352, McCurdy 7372 and Northrup King PX9540.

**Table 2. Analysis Methods.**

| Item | Method |
|---|---|
| Dry matter | Oven drying at 221 ° F |
| Crude protein | Kjeldahl (N x 6.25) |
| Lysine | Ion exchange chromatography after acid hydrolysis |
| Calcium | Atomic absorption spectrophotometry |
| Phosphorus | Colorimetric (molybdovanadate method) |
| Selenium | Fluorometric (diaminonaphthalene method) |
| Vitamin E ($\alpha$-tocopherol) | High performance liquid chromatography |

## Results

Differences in nutrient content among corn hybrids were small and insignificant except for the vitamin E. The vitamin E content of Horizon and Lynks hybrids was about 40 percent less than the average of the other hybrids (2.5 vs 4.1 IU/lb). Furthermore, little variation existed

**Table 3. Crude Protein and Lysine Content of Corn[a].**

| County | Crude protein (%) | | | Lysine (%) | | |
|---|---|---|---|---|---|---|
| | Avg | Min | Max | Avg | Min | Max |
| Box Butte | 8.4 | 8.1 | 8.6 | 0.25 | 0.23 | 0.26 |
| Cheyenne | 9.2 | 8.7 | 10.0 | 0.26 | 0.23 | 0.27 |
| Clay | 7.9 | 7.8 | 8.1 | 0.26 | 0.25 | 0.28 |
| Dixon | 8.8 | 8.4 | 9.1 | 0.28 | 0.27 | 0.28 |
| Lincoln | 8.2 | 7.9 | 8.5 | 0.25 | 0.24 | 0.28 |
| Otoe | 8.7 | 8.5 | 8.9 | 0.28 | 0.25 | 0.32 |
| Pierce | 8.1 | 7.8 | 8.3 | 0.23 | 0.22 | 0.24 |
| Platte | 9.5 | 9.3 | 9.7 | 0.26 | 0.25 | 0.28 |
| Richardson | 8.8 | 8.7 | 9.1 | 0.26 | 0.25 | 0.27 |

[a]88% dry-matter basis.

**Table 4. Phosphorus, Selenium and Vitamin E Content of Corn[a].**

| County | Phosphorus (%) | | | Selenium (ppm) | | | Vitamin E (IU/lb)[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Avg | Min | Max | Avg | Min | Max | Avg | Min | Max |
| Box Butte | 0.27 | 0.25 | 0.28 | 0.13 | 0.12 | 0.14 | 2.8 | 1.9 | 3.5 |
| Cheyenne | 0.32 | 0.31 | 0.34 | 0.13 | 0.12 | 0.14 | 3.5 | 2.7 | 4.4 |
| Clay | 0.27 | 0.26 | 0.28 | 0.12 | 0.12 | 0.12 | 4.2 | 3.9 | 4.4 |
| Dixon | 0.29 | 0.28 | 0.30 | 0.11 | 0.10 | 0.12 | 3.6 | 3.4 | 4.0 |
| Lincoln | 0.25 | 0.24 | 0.26 | 0.12 | 0.12 | 0.13 | 3.7 | 3.5 | 3.9 |
| Otoe | 0.30 | 0.29 | 0.31 | 0.11 | 0.10 | 0.11 | 4.5 | 3.9 | 5.8 |
| Pierce | 0.26 | 0.25 | 0.27 | 0.13 | 0.12 | 0.16 | 3.4 | 3.0 | 4.0 |
| Platte | 0.29 | 0.29 | 0.30 | 0.12 | 0.11 | 0.13 | 4.4 | 4.2 | 4.5 |
| Richardson | 0.29 | 0.29 | 0.30 | 0.12 | 0.12 | 0.12 | 4.7 | 4.2 | 5.0 |

[a]88% dry-matter basis.

[b]alpha-tocopherol form only.

in the calcium content of corn as each corn sample contained approximately .01 percent calcium.

Larger differences were observed among locations for crude protein, lysine, phosphorus, selenium and vitamin E (Tables 3 and 4). The variation in crude protein and phosphorus content was related to corn yield. As corn yield increased, the percentage of crude protein and phosphorus tended to decrease. In contrast, there was little relationship between lysine, selenium and vitamin E content of corn and yield. The overall average, minimum and maximum values for the nutrients are shown in Table 5.

Figure 2 shows the relationship between the lysine and crude protein content of all corn samples in the study. As expected, the correlation between lysine and protein content was low, indicating that the lysine level of corn can vary widely at any given level of protein.

**Table 5. Overall Average, Minimum and Maximum Values for Nutrients in Corn[a].**

| Nutrient | Average | Minimum | Maximum |
|---|---|---|---|
| Crude protein, % | 8.6 | 7.8 | 10.0 |
| Lysine, % | 0.26 | 0.22 | 0.32 |
| Calcium, % | 0.01 | 0.01 | 0.01 |
| Phosphorus, % | 0.28 | 0.24 | 0.34 |
| Selenium, ppm | 0.12 | 0.10 | 0.16 |
| Vitamin E, IU/lb[b] | 3.9 | 1.9 | 5.8 |

[a]88% dry-matter basis.

[b]alpha-tocopherol form only.

## Discussion

These results indicate that the nutrient content of corn grown in Nebraska during 1987 was variable, especially for crude protein, lysine, phosphorus and vitamin E. While the average values for the nutrients are similar to those shown in the University of Nebraska publication *Swine Diet Suggestions* (EC88-210), the wide ranges observed could result in nutrient deficiencies in some instances.

Chemically analyzing a representative sample of corn that will be used in swine diets would remove much of the guesswork in routine diet formulation. However, chemi-

cal analyses are costly and generally unnecessary for most nutrients in corn except crude protein. Diets made with corn having a lower than expected protein level could result in disappointing pig performance especially if the quality of supplemental protein is over-estimated and feed mixing problems occur.

In lieu of a routine chemical analysis for selenium and vitamin E content of corn, we recommend that all swine diets contain added quantities of these nutrients as a safety factor. Also diets should be formulated and mixed to contain amounts of crude protein, lysine, calcium and phosphorus that are sufficient to account for variations in nutrient content and ingredient quality. More details are shown in Swine Diet Suggestions available at local Extension offices.

The corn in our study contained less selenium than that analyzed in a 1969 study of Nebraska corn (0.12 vs 0.35 ppm). Furthermore, we observed much less variation in selenium values due to location than reported previously (0.10 to 0.16 vs 0.04 to 0.81 ppm). Thus, our latest information indicates that corn grown in Nebraska contains less selenium than we thought previously. Therefore, it is important that all swine diets contain supplemental selenium, which can be added up to the legal limit of 0.3 ppm or 0.27 g/ton.

The weak relationship between crude protein and lysine content of corn has some important implications for pork producers. When protein content in corn increases, as a result of drought or increased nitrogen fertilization, protein quality (as measured by lysine content) does not improve at the same rate. For example, one corn sample in our study contained 10 percent crude protein but only 0.26 percent lysine - the same quantity that was present in other samples containing as little as 7.8 percent crude protein (Figure 2). Thus, a good rule of thumb when using corn that contains more than 9.5 percent protein is to ignore the extra protein and use the 9.5 percent value (or 0.26 percent lysine) in formulating diets. On the other hand it is best to be conservative and proportionally discount the lysine content of corn having a crude protein level below 8.6 percent, to reduce the chances of lysine deficiency. For example, a lysine value of 0.24 percent should be considered when formulating with corn containing 8.0 percent crude protein [(8.0 ÷ 8.6) x 0.26].

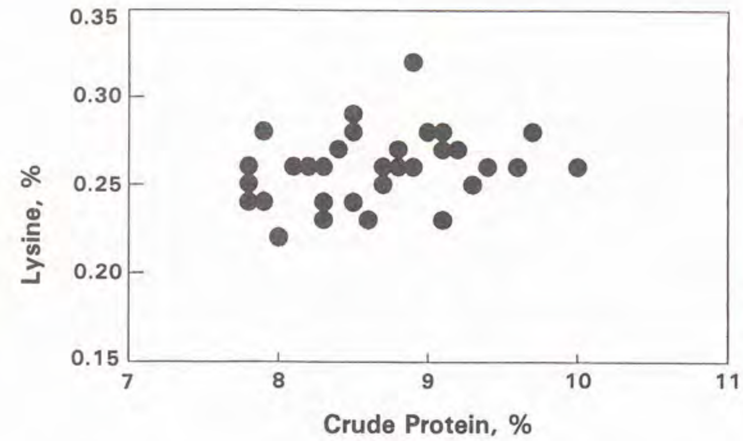
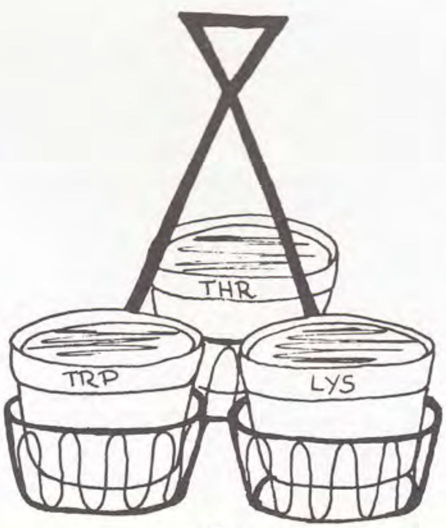



**Figure 2. Relationship of lysine and crude protein content of corn.**

[1]Duane E. Reese is assistant professor and Austin S. Lewis is professor, Department of Animal Science. Acknowledgment is made to August Dreier, Russell Moomaw, Roger Elmore, Paul Nordquist and Lenis Nelson who assisted in collecting corn samples, and to Richard Ewan (Iowa State University) for vitamin E analysis.

# Replacing Soybean Meal with Crystalline Amino Acids

**Austin J. Lewis[1]**




When the price of soybean meal is high, as it was during 1988, pork producers examine several alternatives to reduce diet cost. One alternative is to reduce the protein content of the diet. This will reduce pig performance, but may be a sound economic decision nonetheless. Optimum protein levels for growing pigs were discussed in the 1988 Nebraska Swine Report. Another alternative is to replace the soybean meal with a different protein source or with crystalline amino acids. An experiment to investigate the use of crystalline amino acids in the diets of finishing pigs was described in

the 1979 Nebraska Swine Report. That research has now been extended.

Crossbred pigs, weighing 132 lb initially, were used to determine the response of finishing pigs to the amino acids lysine, tryptophan and threonine. Equal numbers of barrows and gilts were assigned to each diet. There were six pens with ten pigs per pen fed each diet. The amino acids were added to a basal diet consisting of ground corn with supplemental minerals and vitamins (negative control). A 14 percent corn-soybean meal diet served as a standard (positive control). The composition of the four diets is shown in Table 1. Pigs were removed from the experiment when they weighed approximately 240 lb and carcass measurements were made at a commercial packing plant.

**Table 1. Diet composition (%).**

| Ingredient | Diet | | | |
|---|---|---|---|---|
| | Corn-SBM Positive Control | Corn Negative Control | Corn + Plus Lys & Trp | Corn + Plus Lys, Trp & Thr |
| Corn | 80.20 | 96.48 | 95.993 | 95.893 |
| Soybean meal (44%) | 16.28 | —— | —— | —— |
| Minerals | 2.52 | 2.52 | 2.52 | 2.52 |
| Vitamins | 1.00 | 1.00 | 1.00 | 1.00 |
| L-lysine.HCl | —— | —— | 0.45 | 0.45 |
| DL-tryptophan | —— | —— | 0.037 | 0.037 |
| L-threonine | —— | —— | —— | 0.10 |
| *Composition* | | | | |
| Protein-calculated | 14.0 | 8.2 | 8.7 | 8.7 |
| Protein-analyzed | 12.9 | 7.0 | 7.3 | 7.4 |
| Lysine-calculated | 0.67 | 0.24 | 0.59 | 0.59 |
| Lysine-analyzed | 0.60 | 0.21 | 0.54 | 0.54 |
| Tryptophan-calculated | 0.18 | 0.09 | 0.12 | 0.12 |
| Threonine-calculated | 0.57 | 0.35 | 0.35 | 0.45 |
| Threonine-analyzed | 0.47 | 0.25 | 0.24 | 0.33 |

**Table 2. Results.**

| Item | Diet | | | |
|---|---|---|---|---|
| | Corn-SBM Positive Control | Corn Negative Control | Corn + Plus Lys & Trp | Corn + Plus Lys, Trp & Thr |
| Number of pigs | 59 | 58 | 57 | 58 |
| Initial wt., lb | 132.5 | 132.1 | 132.3 | 131.6 |
| Final wt., lb | 246.9 | 213.2 | 238.8 | 237.2 |
| Avg. feed intake, lb/d | 6.60 | 4.73 | 5.91 | 5.55 |
| Avg. wt. gain, lb/d | 1.75 | 0.70 | 1.19 | 1.30 |
| Feed/gain | 3.77 | 6.79 | 4.98 | 4.28 |
| Dressing percent | 75.5 | 74.0 | 74.7 | 74.9 |
| Adj. backfat, in | 1.22 | 1.38 | 1.34 | 1.29 |
| Estimated lean percent | 54.9 | 53.0 | 53.4 | 54.1 |

Pigs fed the corn-soybean meal diet consumed more feed, and gained faster with better feed utilization (feed/gain) than pigs fed the three other diets (Table 2). As expected, the poorest performance was by the pigs fed corn alone. The addition of lysine and tryptophan increased weight gain by 70 percent (0.70 to 1.19 lb/d) and decreased feed/gain from 6.79 to 4.98. When threonine was added also there was a further increase in weight gain and improvement in feed/gain. Although the addition of the three amino acids together resulted in a considerable increase in performance, it was still not equal to that of pigs fed the corn-soybean meal diet. Carcass traits were also improved by the addition of amino acids. However, the best carcasses (lowest backfat and highest lean percentage) were from pigs fed the corn-soybean meal diet.

The protein content of the corn used in the diets fed in this experiment was lower than expected (7.1% instead of 8.5%). Consequently the protein and amino acid levels of all diets were less than expected (Table 1), and this may have affected the results.

This research confirms our previous findings that lysine and tryptophan are the first two limiting amino acids in corn for finishing pigs. The experiment identifies that threonine is third limiting. All three of these amino acids are now available commercially in feed-grade forms for inclusion in swine diets. The results of this experiment indicate that they have considerable potential for replacing soybean meal, but that more research is needed before all the soybean can be replaced without any reduction in performance.

[1]Austin J. Lewis is professor, swine nutrition, Department of Animal Science.

# Thyroxine: The Key to Return to Estrus?

Mark A. Giesemann
E. R. Peo, Jr.
A. J. Lewis and
J. D. Hancock[1]

Thin sows often do not return to heat (estrus). Why? This question has troubled pork producers and researchers for years. Sows that do not cycle are an economic liability to the producer in several ways. They require feed during unproductive days, cause problems in production scheduling and make it necessary to maintain a larger gilt pool. Establishing why and how thin sows shut down their reproductive system may allow us to avoid such problems.

Past research at the University of Nebraska has suggested that the hormone thyroxine may be involved in the return to estrus. Thyroxine ($T_4$) is produced in the thyroid gland and is distributed to the body via the bloodstream. It regulates the metabolic rate of virtually all tissues. This article reports upon research conducted to determine if levels of $T_4$ following weaning affect the speed with which first litter sows return to estrus.

One hundred fifty nine (159) first litter (primiparous) sows were fed either 8 (LE) or 14 (HE) Mcal of metabolizable energy per day during a 28-day lactation. This is equivalent to the energy in approximately 5.5 or 10 pounds of a grain-soy diet, respectively. All sows received adequate amounts of amino acids, vitamins and minerals. Following weaning, all sows were fed the same level of energy (5.6 Mcal ME, or 4 lb/day). From 2 days before weaning until 14 days postweaning all sows were fed either 0 (C) or 675 mg of thyroprotein (TP) per day, a substance that provides $T_4$ to the bloodstream when digested. Thyroprotein was withdrawn from the feed gradually thereafter. Sows were weighed and ultrasonically scanned-for backfat depth on the day of farrowing and day of weaning. Sows were heat checked daily from day 1 postweaning until day 35 or 2 consecutive days of standing estrus, whichever came first. Twenty sows from each treatment group (LEC, LETP, HEC, HETP) were bled on days 0, 1, 2, 3, 5 and 7 postweaning.

The effects of lactation energy intake on sow and litter performance are given in Table 1. As expected, sows consuming the LE diet lost more weight and backfat during lactation than sows consuming the HE diet. Piglets nursing sows consuming the HE diet grew faster than piglets of sows consuming the LE diet. Lactation energy level did not affect litter size weaned.

Feeding thyroprotein greatly increased blood $T_4$ levels (Figure 1.). Surprisingly, $T_4$ levels markedly increased following weaning regardless of treatment. Sows consuming thyroprotein were clearly hyperthyroid during the postweaning period.

Restricting lactation energy intake reduced the percentages of sows returning to estrus by day 7, 14, and 35 postweaning (Figure 2.). The hyperthyroid condition of sows consuming thyroprotein, however,

**Table 1. Effect of sow lactation energy intake on sow and litter performance.[a]**

| | Energy Intake | |
|---|---|---|
| | Low | High |
| Sow lactation weight change, lb[b] | -58.4 | -32.8 |
| Sow lactation backfat change, in[b] | - .31 | - .17 |
| Litter size weaned, 28 days[c] | 9.3 | 9.2 |
| 28-day litter weight gain, lb[c] | 110.5 | 117.3 |

[a]Energy intakes were 8 and 14 Mcal ME/day for Low and High energy intake, respectively.

[b]No. of sows were 47 and 43 for Low and High energy, respectively.

[c]No. of sows were 81 and 78 for Low and High energy, respectively.

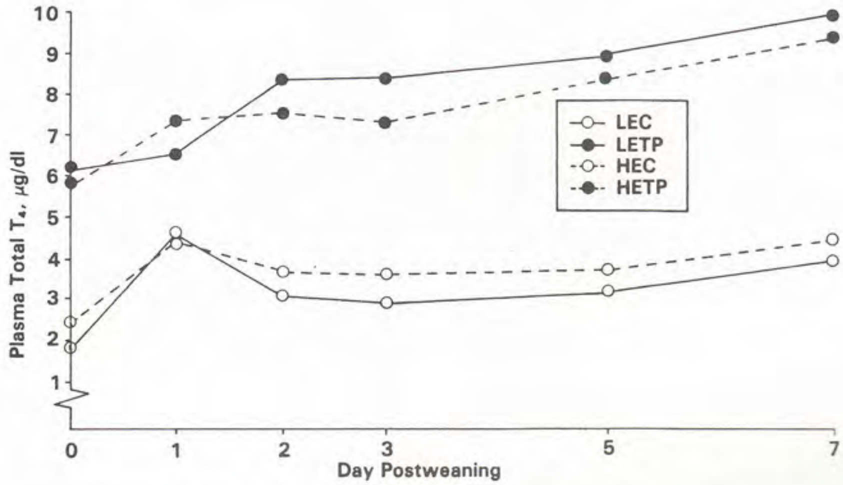



Figure 1. Effect of sow lactation energy intake and 675 mg thyroprotein per day on postweaning plasma levels of total thyroxine ($T_4$) of primiparous sows. Data represent 20 sows per treatment. LE = low energy; HE = high energy; C = control; TP = thyroprotein.

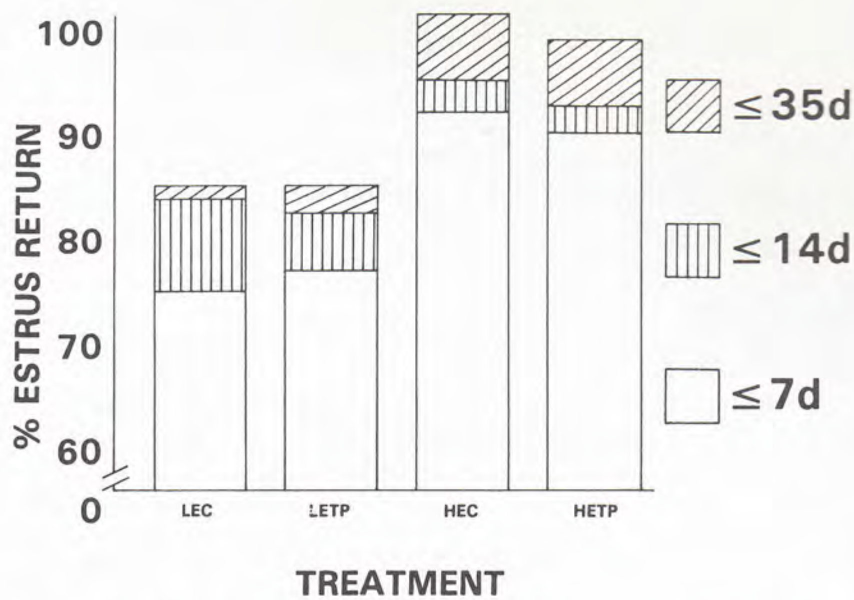



Figure 2. Effect of sow lactation energy intake and 675 mg thyroprotein per day on percentages of primiparous sows returning to estrus by 7, 14 and 35 days postweaning. No. of sows were 41, 40, 39 and 39 for LEC, LETP, HEC and HETP respectively. LE = low energy; HE = high energy; C = control; TP = thyroprotein.

did not affect the pattern of return to estrus.

These results support the findings that reduced lactation energy intake prolongs the return to estrus. It is clear that high circulating levels of $T_4$ neither impairs nor aids the energy restricted sow in returning to estrus. Thyroxine, therefore, does not appear to be an important factor in understanding why thin sows discontinue reproducing. This avenue need not be further explored as we work to solve problems with return to estrus which can be so critical to economic swine production.

[1]Mark A. Giesmann is graduate student, E.R. Peo, Jr. is professor emeritus, A.J. Lewis is professor and J.D. Hancock is former graduate student in the Department of Animal Science.

# Influence of Added Energy Source on Nursery Pig Performance


**Murray Danielson**[1]

There are many approaches to combating stress in the nursery. Aside from the various management, environmental and disease forms of stress, nutritional factors may either be sources of stress or helpful in promoting desirable pig performance. The level and source of protein and fiber, level of vitamins, lysine content, presence of milk products and grain source are a few of the factors that may affect the level of performance in the nursery pig. This study was designed to compare the effect of two dietary fat sources on nursery pig performance.

## Procedure

Two dietary treatments were used in this study. The treatments differed only in that 3 percent corn oil was added to one diet and 3 percent lard was added to the other. The complete meal diet formulations are shown in Table 1.

Eighty crossbred pigs weaned at three to four weeks of age were used in the 28-day study. They were sorted into a light group (40 pigs) and a heavy group (40 pigs). Each of these groups were divided into four pens of four pigs and four pens of six pigs, with sex equalized within each pen. The treatments were assigned equally among pen size for the two weight groups. The pigs were started on test immediately following weaning.

The pigs were housed in an environmentally regulated nursery equipped with decks that allowed free access to feed and water. Pig weight gain and pen feed conversion data were collected at 7-day intervals throughout the study.

## Results

As shown in Table 2, the light

**Table 1. Composition of nursery diets.**

| | Diet | |
|---|---|---|
| Ingredient | Corn oil | Lard |
| Yellow corn | 40 | 40 |
| Soybean meal 44% | 29.5 | 29.5 |
| Dried whey | 20 | 20 |
| Alfalfa hay | 2.5 | 2.5 |
| Corn oil | 3 | —— |
| Lard | —— | 3 |
| Iodized salt | .3 | .3 |
| Calcium carbonate | .2 | .2 |
| Dicalcium phosphate | 1.9 | 1.9 |
| Trace minerals[a] | .1 | .1 |
| Copper sulfate | .1 | .1 |
| Selenium | .05 | .05 |
| Vitamin antibiotic mix[b] | 2.35 | 2.35 |
| | 100.00 | 100.00 |
| Calculated Analysis, % | | |
| Protein | 18.96 | 18.96 |
| Calcium | .84 | .84 |
| Phosphorus | .81 | .81 |
| Lysine | 1.04 | 1.04 |

[a]Calcium Carbonate Company, Swine, 20% zinc.

[b]Vitamin mix provided each lb of diet the following: vitamin A, 2010 IU; vitamin D, 252 IU; riboflavin, 0.7 ,g; calcium pantothenate, 4.5 mg; niacin, 11 mg; choline, 100 mg; vitamin $B_{12}$, 16.7 mcg; vitamin E, 5 IU; lysine, 298 mg; and tylan 20, 1135 mg.

**Table 2. Effect of added energy source on weight group.**

| Weight group | Light | | Heavy | |
|---|---|---|---|---|
| Diet Item | Corn oil | Lard | Corn oil | Lard |
| No. of pigs | 20 | 20 | 20 | 20 |
| Initial wt, lb | 12.9 | 12.9 | 15.8 | 16.0 |
| Final wt, lb | 33.7 | 33.5 | 40.2 | 37.8 |
| ADG, lb | .74 | .73 | .87 | .78 |
| ADFI, lb | 1.25 | 1.26 | 1.47 | 1.35 |
| F/G | 1.69 | 1.73 | 1.69 | 1.73 |

group of pigs had comparable average daily gain (ADG), average daily feed intake (ADFI) and feed required per pound of gain (F/G) on both diets. However, the heavier pigs receiving corn oil gained 0.09 lb faster per day than those which received lard. Likewise, the ADFI was increased for the heavy pigs fed corn oil. F/G was not affected by energy source.

### Summary

To relieve stress problems with early weaned pigs, it is necessary to provide a diet that encourages feed intake. In this study, the heavier pigs recieving the diet with added corn oil consumed more feed and grew faster than the heavier pigs recieving the diet containing lard. There was no difference in performance of the lighter pigs recieving the two diets.

[1]Murray Danielson is professor, swine nutrition, West Central Research and Extension Center, North Platte.

**Table 3. Effect of added energy source, overall.**

| Item | Diet | |
|---|---|---|
| | Corn oil | Lard |
| No. of pigs | 40 | 40 |
| Initial wt, lb | 14.3 | 14.5 |
| Final wt, lb | 36.9 | 35.6 |
| ADG, lb | .81 | .76 |
| ADFI, lb | 1.36 | 1.31 |
| F/G | 1.69 | 1.73 |

# Mycoplasmal Pneumonia Prevented in Pigs with Oxytetracycline

**Marvin B. Rhodes, Merwin L. Frey, Alan R. Doster, and Homer E. Connell[1]**

Mycoplasmal pneumonia is a chronic disease of pigs. It affects a high percentage of Nebraska herds and causes losses to producers amounting to millions of dollars annually. The disease is caused by *Mycoplasma hyopneumoniae,* an organism which is smaller than most bacteria, but larger than viruses. It is readily passed from the sow to the newborn. One of the objectives of the SPF program was to break this chain of infection by taking pigs by hysterectomy or caesarean section to prevent contact between the sow and the pig. This procedure has been successful except that it has proven difficult to totally prevent exposure of pigs in some SPF herds to *M. hyopneumoniae* and subsequent infection. A successful vaccine has yet to be developed which would control or prevent this disease, but efforts are underway in several laboratories to develop such a product. It has been reported that several antibiotics (including the use of tiamulin and trimethoprin) will control or prevent mycoplasmal pneumonia.

The current study was conducted to determine if the injection of a long acting oxytetracycline (Liquamycin LA-200*) would prevent mycoplasmal pneumonia. Naturally-farrowed pigs were used in this study. They were allowed to suckle and thus receive colostrum. The pigs were obtained from the Veterinary Science Department SPF herd which is free of mycoplasmal Pneumonia. Four-day-old pigs were moved to isolation rooms and fed a commercial milk replacer diet which was later supplemented with an 18 percent protein diet free from antibiotics. The pigs were divided into 3 groups, Control Group #1 untreated and noninoculated, Group #2 pigs were inoculated intranasally on day 2 of this study with lung extract of pigs previously inoculated with *M. hyopneumoniae,* and Group #3 pigs inoculated with *M. Hyopneumoniae* on day 2 and injected with 100 milligrams (mg) of oxytetracycline on day 1 and 200 mg on day 8, 15, and 22. The control pigs (Group #1) were housed in a separate isolation room while the pigs in Group #2 and #3 were comingled throughout the experiment. All pigs were necropsied on day 29, which was 4 weeks after the pigs in Group #2 and #3 were inoculated with *M. hyopneumoniae.*

Clinically, the control pigs Group #1 and the pigs in Group # 3 showed no signs of respiratory disease during the 28 day experimental period. In contrast, some of the pigs inoculated with *M. hyopneumoniae* and not treated (Group #2), started coughing at approximately 2 weeks after inoculation. Many developed a rough hair coat. The lungs (Table 1) of the uninoculated pigs (Groups #1) and the inoculated-treated pigs (Group #3) were completely free of lesions of pneumonia while 8 of 10 pigs in Group #2 had visual lesions of pneumonia that involved from 10 percent to 62 percent (average = 19%) of the total area of the lung. In addition, 9 of 10 pigs had lung lesions detectable by microscopic examination. This compares to 2 of 7 pigs from Group #1 and one of 11 pigs from Group #3 which had mild microscopic lung lesions. The fluorescent antibody test detected mycoplasma in the lung sections from pigs in each group (Table 1). These results were partially substantiated by the detection of mycoplasmal bodies on the ends of cilia (hair-like projections) in the airways of sections of the lungs of certain pigs by the scanning electron microscope. Even though mycoplasmal bodies were found on the cilia in the air-

**Table 1. Summary of Results of Prevention of Mycoplasmal Pneumonia in Pigs by Use of Oxytetracycline.**

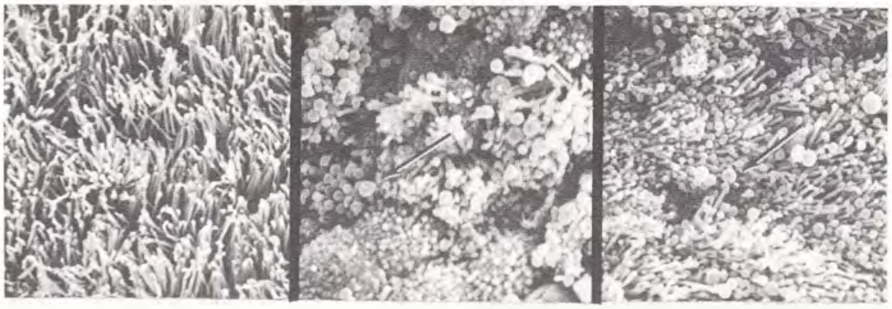
| Group No. | Treatments[a] | Weight gain lb | Lung lesions visual | Lung lesions micro | FAT[b] | SEM[c] cilia loss | SEM[c] mycoplasmal bodies |
|---|---|---|---|---|---|---|---|
| 1 | Controls | 5.68 | 0/7d | 2/7 | 3/7 | 0/7 | 2/7 |
| 2 | Inoculated with *M. hyopneumoniae* | 3.17 | 8/10 | 9/10 | 8/10 | 6/10 | 5/10 |
| 3 | Oxytetracycline, inoculated with *M. hyopneumoniae* | 4.66 | 0/11 | 1/11 | 6/11 | 0/11 | 3/11 |

[a]*See text for more details.*

[b]*Fluorescent Antibody Test.*

[c]*Scanning Electron Microscope, results of examinations of microphotographs taken of sections of airways from the lungs of the pigs.*

[d]*Zero out of 7 pigs had visual lung lesions, etc.*



A B C

**Figure 1. Scanning electron micrograph of sections of trachea of pigs magnified 2,000 times. A = Group #1 pig, control-numerous cilia; B = Group #2 pig, inoculated with *M. hyopneumoniae,* few cilia, mycoplasma bodies (see arrow); C = Group #3 pig, injected with LA-200 and inoculated with *M. hyopneumoniae,* numerous cilia, mycoplasma bodies on tips of cilia (see arrow). Photomicrograph by Tom Bargar.**

ways of some of the pigs in Groups #1 and #3, cilia were found missing only from the airways of pigs in Group #2. Despite the damage to the lung or the presence of mycoplasmal bodies on the cilia in the airways of some of the pigs, no specific antibodies to *M. hyopneumoniae* could be detected in the serum (by an indirect radioimmunoassay) of any of the pigs before or at the time of necropsy.

Oxytetracycline, as used in this study, did protect pigs against the development of mycoplasmal pneumonia. This seems even more significant when one considers that the inoculated, untreated (Group #2) pigs were comingled throughout the experiment with the inoculated oxytetracycline-injected pigs (Group #3). In many instances of a respiratory disease, pig to pig transmission is more effective in transmitting the disease than experimental intranasal inoculation. It is unusual in experimental conditions to house treated animals with untreated animals. However, the procedure used in this study may approximate the conditions which occur on farms. This study also shows the practicality of using naturally-farrowed pigs which are allowed to suckle the dam. These animals appear to respond to disease agents in a manner that is similar to farm raised pigs.

The procedures reported here may lead to a method of protecting pigs against mycoplasmal pneumonia, at least during the early critical period of their life. The level of oxytetracycline used in this study has not been approved for use in pigs and lower levels of this antibiotic have yet to be tested in this situation. At this point we do not know if the tested levels of oxytetracycline will protect the pig until market weight, or if infection with *M. hyopneumoniae* occurred in the growing phase, would this result in an economic loss. Experiments under field conditions are needed to assess the value of early treatment with oxytetracycline. Another possibility is that oxytetracycline would provide protection to pigs during the early period of natural immunization because many pigs may be infected at birth.

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*Trademark of Pfizer Inc., Terre Haute, IN.

[1]Marvin B. Rhodes is professor, Immunochemist, Merwin L. Frey is professor Emeritus, Microbiologist, Alan R. Doster is associate professor, Pathologist, Department of Veterinary Science, University of Nebraska and Homer E. Connell is research veterinarian, Pfizer, Inc. Lee's Summit, MO.

# Designing a Breeding Facility--Essential Factors

**Donald G. Levis**[1]

New breeding facilities can be constructed without a large financial investment when simply designed and when care is taken in the purchase of materials and labor. Many existing farmstead structures can be economically renovated into successful breeding facilities. For a breeding facility to function adequately, the essential factors that make a hand mating or pen mating facility work have to be used. These factors are:

(1) floor surface,
(2) gates and gate latches,
(3) animal movement,
(4) animal location,
(5) estrous detection method, especially when hand mating,
(6) animals per pen,
(7) space per animal,
(8) environmental temperature, and
(9) human safety.

When these factors are considered in the planning process, the involved work routines can be easily, quickly, and safely accomplished. Work routines that are not easily done may never be completed.

*FLOOR SURFACE.* A non-slick floor surface is essential in boar pens, breeding pens, and pens containing estrous sows. Slick breeding floors contribute to animal injury, human safety hazards, and a decrease in reproductive performance. Concrete floors can be constructed non-slick by imprinting a 5- to 6-inch wide diamond pattern one-half inch deep in the floor. Feeding on the floor when pen mating also helps keep the floor clean and dry.

*GATES AND GATE LATCHES.* Gates used to control animal flow through an alley should be designed to cut off the alley when open. It is also beneficial to have gate latches which function quickly and easily. Figure 1 shows a gate latch which works well for gates that need to swing at either end. To prevent animals from opening the gate, the first two vertical pipes next to the latch are not more than two inches apart. The gate rod should always be fastened to the gate. By using the stop feature, the rod cannot be removed from the gate. Attaching the rod to the gate allows the gate to be swung open with one hand on the gate latch while the other hand is free to hold a hurdle for animal control. Also, a gate can be easily locked open if the gate rod is on the gate.

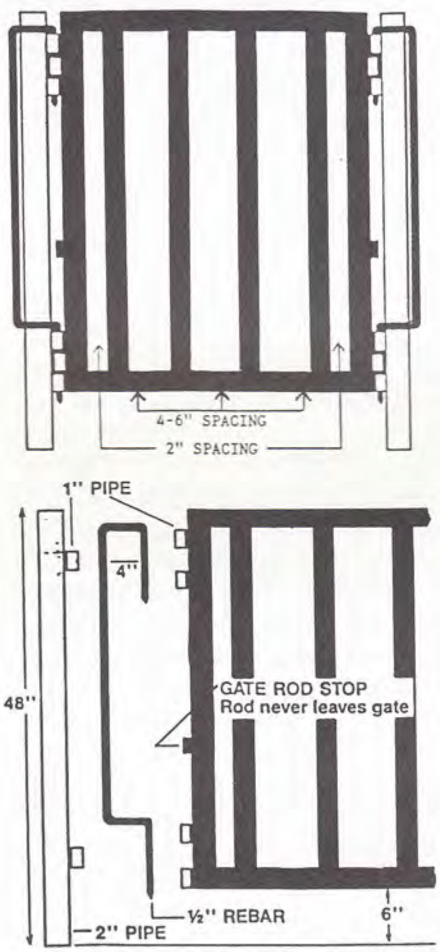



**Figure 1. Gate Latch Design**

*ANIMAL MOVEMENT.* One person should be able to easily and safely move animals without assistance. The largest risk for human injury occurs when working around boars. Human safety hazards can be reduced by:

(1) having animal flow continuous and never dead-ended,
(2) moving animals, especially boars, through narrow (28" to 42") alleys, and
(3) using hand-held hurdles.

Also, it is important to not have spilled feed in the alleys when moving animals because they will invariably stop moving to eat the feed.

*ANIMAL LOCATION.* The location of working boars, resting boars, recently weaned sows, the gilt development pool and the gilt pool for breeding will influence the "biological function" of expressing and maintaining sexual behavior. The location of boars relative to sows and gilts in the facility is especially important for initiating early puberty in gilts and detecting estrus in both sows and gilts. Therefore, resting boars should be housed in a separate area away from sows. Boars are likely to be more sexually aggressive when rested at a location away from estrous females. In addition, since the resting area is smaller, it can be economically heated or cooled when necessary.

*ESTROUS DETECTION.* Any type of close contact which allows females to receive any boar stimuli during 1 to 2 hours before checking for estrus reduces the efficiency in finding females in estrus. Therefore, to detect estrus **quicky** and **efficiently,** design the system to prevent sows or replacement gilts from receiving boar stimuli (sight, sound, and smell) for 1 to 2 hours before the actual testing for estrus. Estrous is characterized by a rigid immobilization response (standing heat) and usually not maintained for more than 10 minutes in sows and 7 minutes in gilts. A female that exhibits rigid immobilization is temporarily performing "isometrics"; therefore, she will need muscle relaxation

after a few minutes of muscle contraction.

*ANIMALS PER PEN.* When designing a facility to house boars it is best to house them individually so

(1) injuries from fighting and riding can be prevented,

(2) feed intake can be adjusted to maintain proper body condition,

(3) longevity of use can be increased,

(4) financial costs can be lowered by reduced need for replacement boars,

(5) sexual behavior can be optimized,

(6) homosexual activity is eliminated, and

(7) handling is simplified.

If boars are to be housed in groups, it is best to keep the group small, preferably 2 to 3 boars per pen. Small numbers help reduce the stress resulting from social hierarchies in the group.

When pen mating, the number of sows per pen should be five with two boars assigned to a rotation schedule. It is best to only have one boar working at a time per pen because of the subordinate and hostile relationship between boars. If groups of boars are used, still keep the ratio at 2.5 weaned sows per boar. Recently weaned sows that are housed as a group should be maintained in small groups (5 to 10 sows per pen) to help simplify handling and management.

*SPACE PER ANIMAL.* When boars are housed either as a group or individually on partially slatted floors they should be provided 35 to 50 square feet per boar. Individual stalls for large boars should be 46 inches high, 28 inches wide, and 8 feet long with at least 56 inches of slatted floor. Stall dimensions can be reduced for medium and small boars. Boars should never be individually housed in stalls or small pens with solid concrete floors. Solid concrete floors contribute to unsanitary conditions which increase bacterial contamination of the boar's preputial area.

When housing recently weaned sows as a group, each sow should be provided 20 square feet of non-slick surface area. This amount of space is necessary to help reduce the stress involved with the riding and chasing activity of estrous sows.

*ENVIRONMENTAL TEMPERATURE.* The animals of most concern when designing a breeding facility are sows in the first 30 days of pregnancy and boars. Special consideration should be given to cooling boars, because detrimental effects of heat stress on an individual boar's fertility has a much greater effect on herd reproductive performance than heat stress on individual females. Research has shown that semen quality and possibly boar sexual behavior are affected by elevated air temperature in the boar area. Boars and recently bred sows should be cooled when the surrounding temperature is greater than 85° F. Many pork producers cool boars and recently bred sows by using an intermittent drip cooling method with fans. However, the effectiveness of drip cooling boars and recently bred sows has not been substantiated by research.

Cold stress has rarely caused direct detrimental effects on boar fertility. Detrimental effects by cold stress on boar fertility occur only when:

(1) boars become sick and have a rise in body temperature,

(2) boars are continually maintained in a cold environment which results in testicles being held close to the body cavity for warmth, or

(3) boars have encountered "frostbite" on their scrotum.

*HUMAN SAFETY.* Although the safe handling of animals in a breeding facility relies on safety precautions taken by individual workers, it is the responsibility of the facility designer to develop a floor plan which provides a safe working environment. There is no floor plan which is accident-free; however, there is less risk for human injury when a floor plan is designed to reduce stress on both humans and animals. Human and animal stress can be substantially reduced by im-

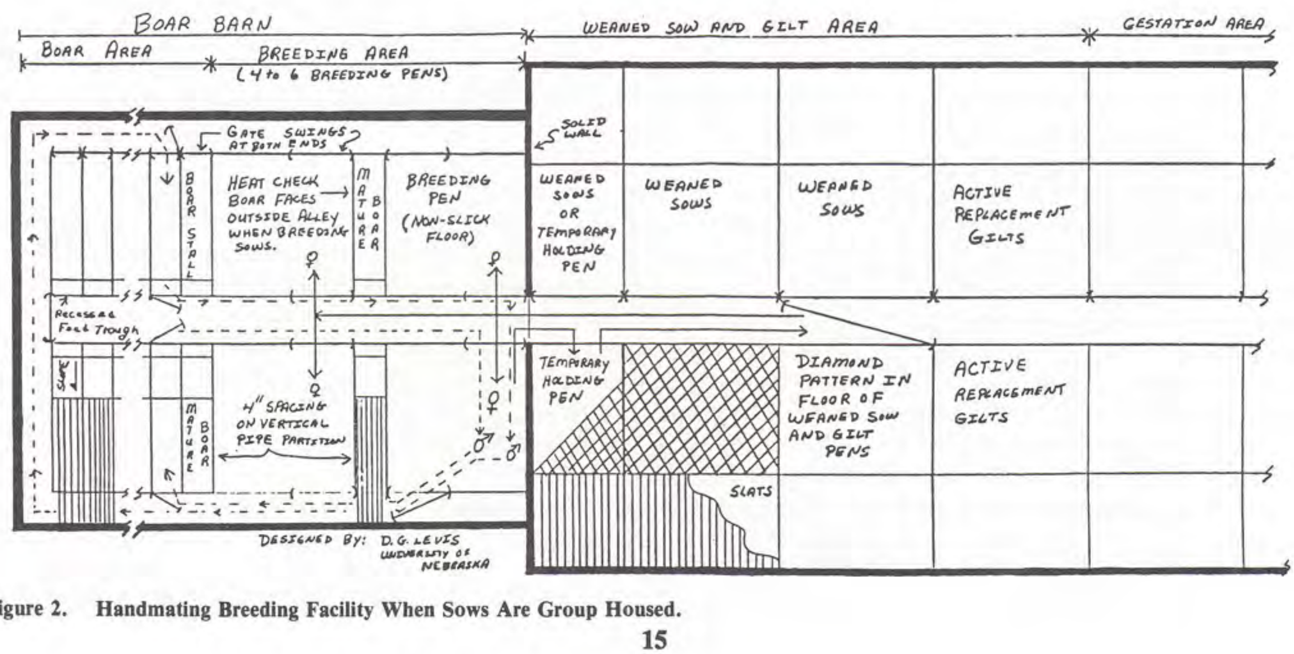



**Figure 2. Handmating Breeding Facility When Sows Are Group Housed.**

plementing the above factors when designing a breeding facility.

*FLOOR PLANS.* Figure 2 shows a floor plan that is being used for hand mating. The major components of a hand breeding facility are organized for human safety and biological function of animals. These components are:

(1) holding area for recently weaned sows,

(2) boar housing area,

(3) replacement gilt pool area,

(4) breeding pen area, and

(5) a temporary holding area for sows which have been bred or heat checked from a group pen.

This floor plan has adaptive features. For example, the boar barn can be built with

(1) weaned sows and gilts maintained outside,

(2) weaned sows and gilts kept inside and then moved outside after breeding, or

(3) the sow herd totally confined.

With careful planning, the boar barn can be attached to any type of sow housing using stalls or small pens. The boar barn is designed for flexibility in number of boars housed; therefore, it can be adapted to any size of operation.

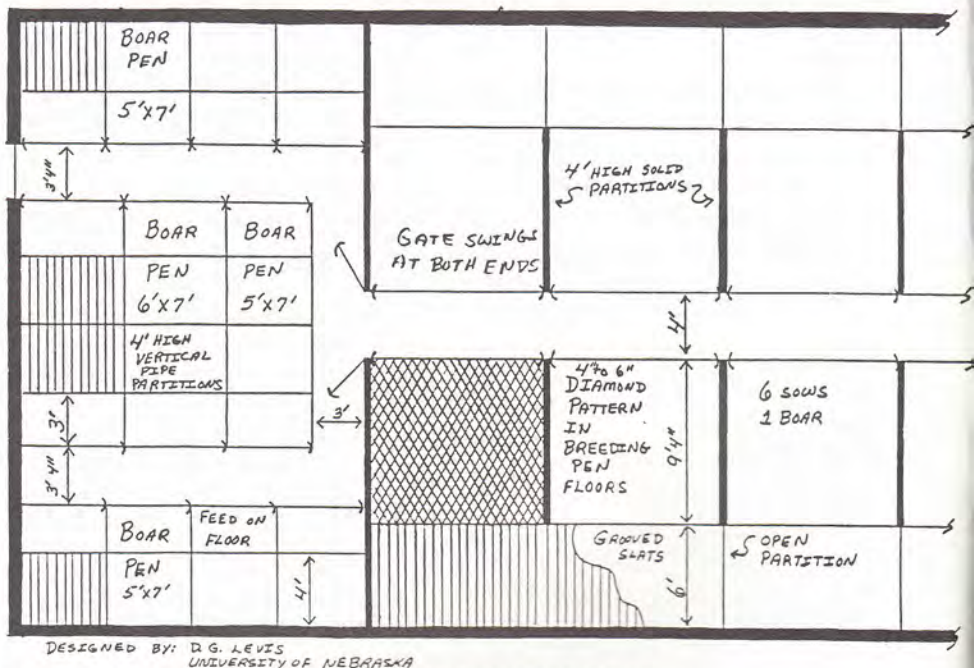



**Figure 3. Modified Open Front (Gable Roof) Pen Breeding Facility.**

Figure 3 shows a floor plan that is being used for pen mating. This modified open-front gable roof structure has been successfully used on production schedules where 42 days are allowed for breeding. The breeding period is 42 days because there is no pen mating design which can guarantee that all estrous sows will be mated on their first cycle after weaning. The resting boars are housed as a block; thus, the resting area can be closed off for heating or cooling.

[1]Donald G. Levis is Extension swine specialist, University of Nebraska South Central Research and Extension Center, Clay Center.

# Adrenaline and Gastric Secretion in PSS Pigs

**Cindy Marolf and Edd Clemens[1]**

It is known that certain genetic strains of pigs are unable to withstand various stressors including transportation, heat and handling. Exposure of these stress-susceptible animals may result in an acute shock-like syndrome which has been designated the porcine stress syndrome (PSS). This syndrome often ends in death of the animal and is responsible for substantial losses for the pork production industry.

Several researchers have documented that acute stress results in the release of adrenaline into circulation and that during the porcine stress syndrome adrenaline rises to levels well above those obtained before exposure to the stressor. Several physiological responses are associated with increased circulating levels of adrenaline. These include increased heart rate and blood pressure, smooth muscle contraction, increased heat production and blood sugar levels and the release of gastrin from the stomach with an increase in acidity of the foregut. Many of these changes can be detrimental to the animal and may result in the inability to maintain stability of its internal environment.

Fifteen normal and 12 stress-susceptible pigs were used in separate trials to determine the effects of adrenaline infusion on plasma gastrin and gastric secretions. Each pig was assigned to one of three treatments, designated as high, medium or low dose of adrenaline. Before the trial, pigs were anesthetized using methoxyflurane, a gas anesthetic which does not induce the porcine stress syndrome. A gastric cannula for collecting stomach secretions was surgically put in place as well as catheters in the carotid artery and jugular vein. The trial period was two hours in length, consisting of four 30-minute periods. The first period was a control infusion of sterile saline. The second period was 30 minutes of recovery with no infusion. In the third period, adrenaline was infused for 30 minutes. The

fourth period was a 30-minute recovery period.

During the two-hour trial, blood samples were collected at five-minute intervals from the carotid artery. Gastric secretion samples were collected at five and ten minutes after infusion, and then at ten minute intervals. Blood samples were analyzed for adrenaline and gastrin concentrations. Gastric secretions were weighed and analyzed for osmotic pressure (mOsm), pH and chloride ion concentration (meq/L).

The effects of adrenaline infusion on gastric secretion, plasma gastrin concentration, heart rate and blood pressure are reported in Table 1. The data indicate that PSS pigs are extremely sensitive to pre-trial handling, surgical preparations and the sham infusion of physiological saline. As a result, the stress response is triggered very early in the experiment, enhancing gastrin release and resulting in greater acid production and lower foregut pH. So sensitive are these pigs, that four of the 12 PSS animals died during surgery or the sham infusion period. Blood samples collected from these four animals just before death had an average gastrin concentration of 410 pg/ml, much higher than that seen in PSS pigs at the start of the trial or in normal animals during adrenaline infusion. Furthermore, while adrenaline infusion failed to elevate plasma gastrin or stomach parameters in PSS pigs above those of the normal animals, the PSS pigs did not appear to return to normal as rapidly during the recovery period following adrenaline infusion. This is indicated by a slightly elevated blood pressure and increased acidity within the foregut of these animals during this recovery period.

The results of this study may help us understand the mechanisms which lead to death in porcine stress susceptible pigs as well as normal animals.

[1]Cindy Marolf is graduate student and Edd Clemens is professor, Department of Animal Science.

## PLASMA GASTRIN CONCENTRATION

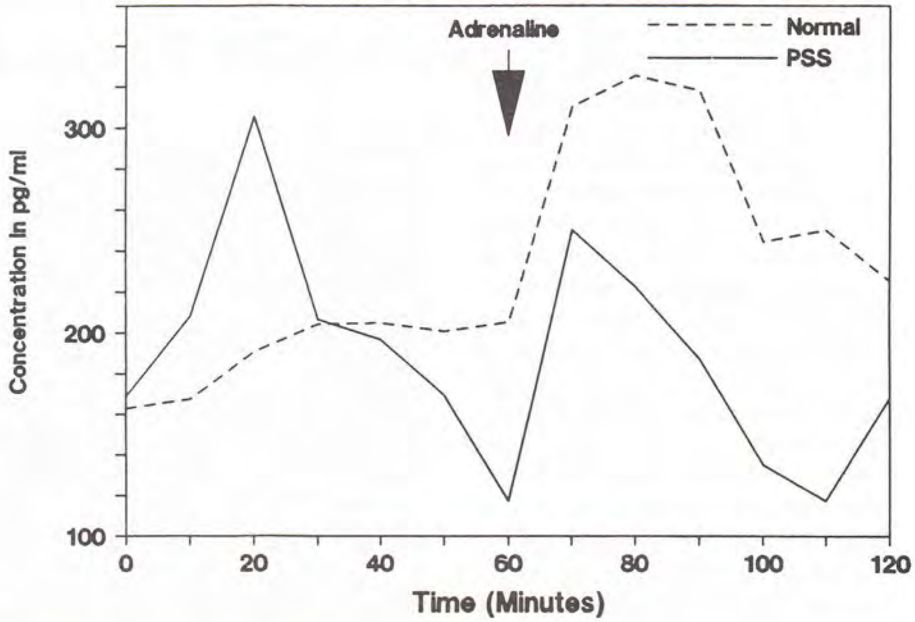
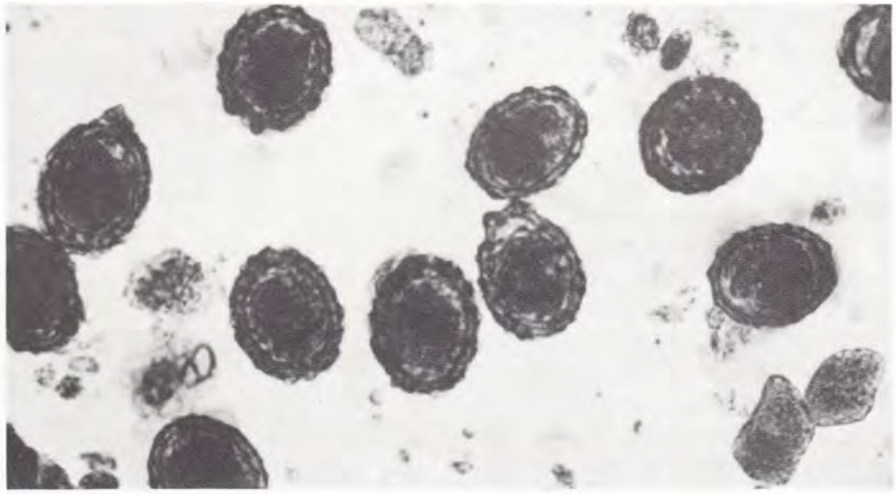



**Table 1. The Effects of Adrenaline Infusion on Heart Rate, Blood Pressure, Gastric Secretion, and Plasma Gastrin Concentration.**

| | PERIOD | | | |
|---|---|---|---|---|
| | Sham Infusion | Sham Recovery | Adrenaline Infusion | Adrenaline Recovery |
| Heart Rate (Beats/Min) | | | | |
| Normal: | 144 | 154 | 196 | 152 |
| PSS: | 116 | 115 | 196 | 142 |
| Blood Pressure (mm Hg) | | | | |
| Normal: | 111/81 | 120/92 | 183/145 | 109/83 |
| PSS: | 118/97 | 122/99 | 201/167 | 113/84 |
| Gastric pH | | | | |
| Normal: | 8.09 | 8.20 | 7.6 | 7.48 |
| PSS: | 5.75 | 6.48 | 7.37 | 6.31 |
| Gastric Chloride Ion Concentration (meq/L) | | | | |
| Normal: | 116 | 122 | 140 | 131 |
| PSS: | 105 | 118 | 135 | 132 |
| Gastric Secretion Weight (g) | | | | |
| Normal: | 3.92 | 3.26 | 1.55 | 3.34 |
| PSS: | 3.29 | 2.43 | 1.06 | 2.18 |
| Plasma Gastrin (pg/ml) | | | | |
| Normal: | 182 | 204 | 318 | 240 |
| PSS: | 222 | 149 | 220 | 140 |

# Controlling Internal Parasites in Commingled Feeder Pigs

**Michael C. Brumm and Donald L. Ferguson**[1]



Many times feeder pig finishers purchase pigs of unknown origin and health status. While appearing healthy, these pigs often harbor internal parasites that potentially limit performance and profit. This experiment was conducted to evaluate the effect of various deworming treatments on commingled feeder pig performance.

Two trials were conducted using a total of 287 commingled feeder pigs purchased through a broker from auction markets in southern Missouri. Upon arrival, pigs were randomly assigned to three experimental treatments with four pens per treatment per trial. The experimental treatments were:

1) control no dewormers;

2) Fenbendazole at 1.36 mg/lb body weight/day in the feed offering for three days beginning at arrival and again for three days six weeks after arrival;

3) Levamisole hydrochloride in the drinking water on day two post-arrival and dichlorvos in the feed four weeks later.

Pigs were housed in partially slatted modified open front (MOF) facilities with 12 pigs per pen (8 $ft^2$/pig).

Three pigs per pen were randomly selected for collection of fecal samples on days 0, 1, 14 and 49 in both trials and day 118 in trial 1 and day 111 in trial 2. Fecal samples were collected from the same pigs throughout the trials and examined for the presence and number of selected internal parasites eggs. All pigs were fed a commercial, 17 percent crude protein feeder pig receiving diet for the first two weeks after arrival, followed by a 16 percent grower diet until 125 pounds and a 14 percent finisher diet until marketing. All diets contained Mecadox (50 g/T) until 75 lbs, body weight, followed by Lincomycin (40 g/T) until day 111.

**Table 1. Effect of anthelmintic regimens on pig performance.**

| | Treatment | | | |
|---|---|---|---|---|
| Item | Control | Fenbendazole | Levamisole/ Dichlorvos | SE |
| No. pens[a] | 8 | 8 | 8 | |
| Pig weight, lb | | | | |
| Initial | 42.5 | 42.4 | 42.7 | |
| 119 days[b] | 202.4 | 207.2 | 208.5 | 1.7 |
| ADG, lbs[b] | 1.34 | 1.38 | 1.39 | .01 |
| ADF, lbs | 4.23 | 4.30 | 4.38 | .05 |
| F/G | 3.15 | 3.11 | 3.14 | .02 |

[a]Twelve pigs per pen.

[b]Control vs anthelmintics ($P < .05$).

### Results

Both dewormer regimens resulted in an increased rate of gain and heavier pigs at 119 days post arrival than the untreated control (Table 1). While there were no trial by anthelmintic regimen interactions, an outbreak of Pasturella pneumonia six days after arrival in trial 2 severely limited overall pig performance. There were no differences in feed intake among the experimental treatments, although there was a trend for the anthelmintic treated pigs to consume more feed. From the fecal samples collected on days 0 and 1, it is evident that the commingled feeder pigs arrived at the research unit with a heavy infestation of internal parasites. The majority of the parasites were either *Ascaris Suum* (roundworm) or *Trichuris Suis* (whipworm) (Table 2). A single treatment with fenbendazole or levamisole hydrochloride at arrival effectively reduced the roundworm load observed on day 14. Since levamisole hydrochloride does not have a labeled claim for whipworm control, the difference between dewormers on d 14 whipworm observations was expected.

**Table 2. Results of fecal examinations on selected days for selected internal parasites.**

| Period | Item | Treatment | | | SE |
|---|---|---|---|---|---|
| | | Control | Fenbendazole | Levamisole/ Dichlorvos | |
| Arrival (day 0,1) | | | | | |
| | Eggs per Gram | 724 | 150 | 470 | 312 |
| | *A. Suum* | 688 | 70 | 350 | 310 |
| | *T. Suis* | 27 | 75 | 117 | 33 |
| 14 D | | | | | |
| | Eggs per Gram[a] | 591 | 2 | 46 | 240 |
| | *A. Suuma* | 551 | 1 | 1 | 238 |
| | *T. Suis*[b] | 36 | 1 | 45 | 15 |
| 49 D | | | | | |
| | Eggs per Gram | 901 | <1 | <1 | 480 |
| | *A. Suum* | 875 | 0 | <1 | 488 |
| | *T. Suis*[c] | 20 | <1 | 0 | 6 |
| 111-118 D | | | | | |
| | Eggs per Gram[d] | 323 | 2 | 1 | 81 |
| | *A. Suum*[d] | 297 | 2 | 1 | 77 |
| | *T. Suis* | 13 | <1 | 0 | 7 |

[a]Control vs anthelmintics (P < .07).

[b]Fenbendazole vs Levamisole/Dichlorvos (P < .05).

[c]Control vs anthelmintics (P < .05).

[d]Control vs anthelmintics (P < .005).

Treatment of the Levamisole pigs (4 weeks post-arrival) with dichlorvos, a product approved for whipworm control reduced the parasite load as observed on day 49. Recontamination was not a problem, as indicated by the 111-118 day observations. While the control pigs continued to have a heavy infestation of internal parasites, pigs examined on both worming regimens had almost no internal parasites eggs in their feces.

These results document the effect of a heavy infestation of internal parasite on commingled feeder pig performance. They also demonstrate the importance of taking label claims into consideration when using dewormers. Levamisole hydrochloride was not effective in reducing the number of whipworms, but when followed by dichlorvos, the infestation was reduced to a level similar to fenbendazole treated pigs.

In conclusion, both deworming treatments were effective in reducing the number of internal parasites, resulting in improved rates of gain compared to commingled feeder pigs given no anthelmintic. When feeder pigs are purchased from unknown sources, producers should assume they have a variety of internal parasites and choose a deworming product which is effective against a wide variety of parasites.

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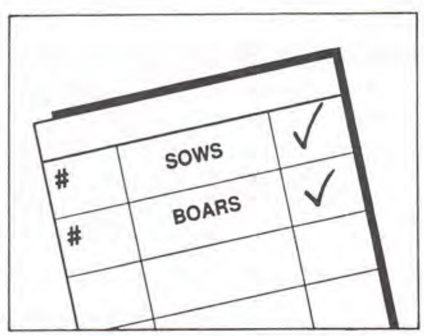
# Effect of Herd Size and Mating Practice on Breeding Herd Structure

**W. T. Ahlschwede**[1]

It is generally understood that as pork producers increase the size of their breeding herd, certain economies of size can result. One presumed economy of size is that each boar can serve more sows. Once bred, sows are not available for rebreeding for five months or so. But, boars can be used for breeding every week. Presumably, one could increase the number of sow groups without increasing the number of boars, resulting in a reduced boar cost per litter produced. Similarly, hand mating is represented as offering opportunities to make more optimum use of boar power than pen mating. It would seem that both increasing herd size and hand mating would increase the sow-to-boar ratio, resulting in an economic advantage. Further economies might be realized if larger herds were able to extend the herd life of purchased boars, or if hand mating resulted in longer boar use.

This study was undertaken to determine if herd size or mating practice had an effect on the efficiency of boar use as measured by sow to boar ratio or by boar turnover rate.

Nebraska pork producers were interviewed at five Extension-sponsored meetings during February and




March of 1988. Producers were approached and asked to answer a short series of questions. Complete answers were received from 132 producers. Approximately 20 producers responded at each of four Whole Hog Days and 50 at the Nebraska Pork Industry Exposition. The

questions asked were:

1) How many sows do you have?

2) How many boars do you have?

3) How many of the boars were added during the last 12 months?

4) Are your sows inside or outside?

5) Do you hand mate or pen mate?

Question 4 turned out to be ambiguous. The responses were quite variable, and generally not interpretable. Question 4 was discarded.

**Table 1. Distribution of herds by number of sows.**

| Sow number | Number of herds |
|---|---|
| 1 - 49 | 28 |
| 50 - 99 | 44 |
| 100 - 149 | 37 |
| 159 - 199 | 11 |
| 200 - 299 | 5 |
| 300 - 399 | 3 |
| 400 - 499 | 2 |
| 500 - 599 | 1 |
| 600 - 699 | 2 |
| 700 - 799 | 1 |
| 800 - 899 | 2 |
| 900 - 1000 | 1 |
| 1000 - 1050 | 2 |

Sow herd size ranged from 10 sows to 1005 sows (Table 1) in the survey group. The average number of sows was 150.7 (Table 2.) Half of the herds had 90 or fewer sows. Half of the total inventory of sows in the survey group were in herds of 200 or more. The average sow to boar ratio was 17.8 sows per boar. On the average, 63.6 percent of the boars in the herd had been added during the last 12 months. Thirty five of the herds (26.5%) practiced hand mating.

To evaluate the effect of herd size on sow to boar ratio and boar turnover rate, regressions on sow number were calculated. The regression of sow to boar ratio on sow number was 0.001, indicating that the number of sows per boar did not increase as sow herd size increased. However, as herd size increased, annual boar turnover decreased by 3.37 percent per hundred sow increase. Herd size for producers practicing hand mating was nearly triple that of producers which pen mated, 288 vs. 101 sows (Table 2.) In total sow numbers, the 35 herds which hand mated accounted for 51 percent of the sows. Although there was a tendency for those practicing hand mating to have fewer sows per boar and to turn over fewer boars per year, the two groups were not different for sow to boar ratio or for boar turnover rate.

**Table 2. Descriptive statistics for the sample.**

| | PEN MATING | HAND MATING | ALL HERDS |
|---|---|---|---|
| No of herds | 97 | 35 | 132 |
| No of sows, avg | 101.1 | 288.1 | 150.7 |
| Sows per boar, avg | 18.1 | 16.1 | 17.8 |
| Boar turnover % | 64.6 | 60.9 | 63.6 |
| Smallest herd | 10 | 20 | 10 |
| Largest herd | 750 | 1005 | 1005 |

These results indicate that for the producers who responded, neither larger herd size nor hand mating resulted in breeding herd efficiences as measured by sow-to-boar ratio. Larger herds had a more favorable boar turnover rate. Producers who were larger and who hand mated may have had other breeding herd efficiency advantages, but they were not covered in the survey. Herds which farrow more litters per sow per year might have boar use advantages. Similarily, herds which wean more pigs per litter might have lower boar costs per pig produced.

The results do suggest differences in boar turnover rate related to herd size. Given the average turnover rate of 63.6 percent and herd size of 150 sows, a herd of 450 sows would be expected to have a turnover rate of 53.5 percent annually. This represents a reduction by 16 percent in annual boar purchases. No difference was found for mating practice.

Concern is often expressed by pork producers with smaller herds that larger herds have advantages because of the larger size. In this case, larger herds are not enjoying an advantage in sow-to-boar ratio. The larger herds did have an advantage in boar turnover rate. The economic advantage of a higher sow-to-boar ratio would be expected to be similar to the advantage of a lower boar turnover rate. Managers of small operations can take some comfort that larger units are not using all of the efficiency opportunities larger herd size affords.

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# Characterization of Follicular Development in High Ovulating and Control Line Gilts

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

Ovulation rate (number of eggs produced) sets the upper limit for litter size and is an important component of variation in litter size in pigs. Genetic selection (9 generations) for high ovulation rate in the UNL Gene Pool population increased ovulation rate by 3.7 ova over controls and established that ovulation rate is a moderately heritable (approximately 40%) trait. However, the physiological basis of the increase in ovulation rate produced by genetic selection and the physiological factors that regulate ovulation rate characteristic of the species are not clearly understood.

### Follicle Populations

Wisconsin researchers previously demonstrated that breeds or lines of pigs expressing higher ovulation rates have greater numbers of maturing follicles at all stages of the estrous cycle than breeds with lower ovulation rates. However, high ovulating Select line gilts from the UNL gene pool population were not observed to have greater numbers of surface follicles than control line gilts on days 3, 15 or 19 of the estrous cycle. The numbers of large follicles (>7 mm) on day 19 were similar for the lines, but did not correspond to the observed ovulation rate of either line. This suggests that gilts from both lines continue to recruit follicles after day 19 (d 19). Recruitment must be greater in Select line gilts after d 19 to produce the observed advantage in ovulation rate. This may be facilitated by the longer estrous cycle (1.5 d) expressed by Select line gilts.

The experiment reported here was designed to more completely characterize the pattern of follicular development during the period of the estrous cycle preceding ovulation. Equal numbers of gilts from the high ovulating Select (S) and Control (C) lines were checked daily for estrus with mature boars and randomly assigned within line for ovary recovery on d 18, d 19, d 20 or d 21 of the estrous cycle. There were 8-10 gilts per line each day. Each ovary was weighed and counts were made of the number of corpora albicantia (CA, reflective of number of follicles ovulated during the previous estrus) and numbers of large (follicles >7 mm diameter, reflective of number of follicles that are destined to ovulate at the ensuing estrus) and medium surface follicles (follicles 3 to 6.9 mm diameter, the pool of growing follicles from which the large follicles are recruited).

**Table 1. Line differences in ovarian characteristics during the follicular phase of the estrous cycle.**

| Ovarian characteristics | Line | Estrous cycle, d 18 | 19 | 20 | 21 | Av |
|---|---|---|---|---|---|---|
| Ovarian wt, g | S | 15.6 | 14.6 | 20.7 | 18.2 | 17.3 |
| | C | 14.0 | 12.5 | 12.2 | 11.6 | 12.6 |
| No. CA | S | 16.1 | 17.3 | 18.4 | 19.7 | 17.9 |
| | C | 14.3 | 13.7 | 13.5 | 13.5 | 13.8 |
| No. lrg fol. (>7 mm) | S | 8.1 | 15.2 | 20.3 | 23.6 | 16.8 |
| | C | 9.8 | 10.4 | 15.5 | 14.6 | 12.6 |
| No. med fol. (3-6.9 mm) | S | 36.5 | 23.8 | 10.5 | 19.8 | 22.6 |
| | C | 30.2 | 21.9 | 5.7 | 9.9 | 16.9 |

Overall, Select line gilts had heavier ovaries (4.7 g) and expressed higher ovulation rate (4.0 more CA) than Control line gilts (Table 1). Number of medium follicles did not differ between lines. Both lines showed dramatic decreases in number of medium-sized follicles between d 18 and d 20 followed by a small increase between d 20 and d 21 (Fig. 1). Numbers of large follicles were comparable on d 18, but Select

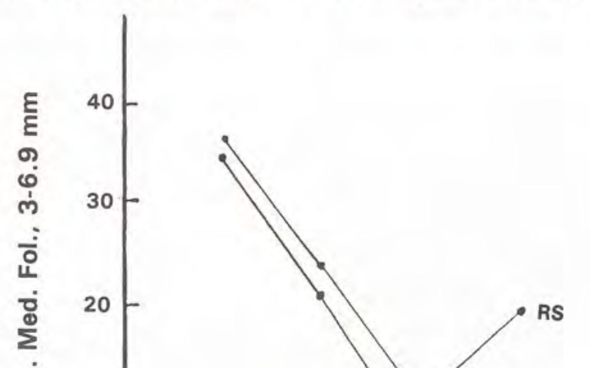


**Figure 1. Number of Medium Follicles.**

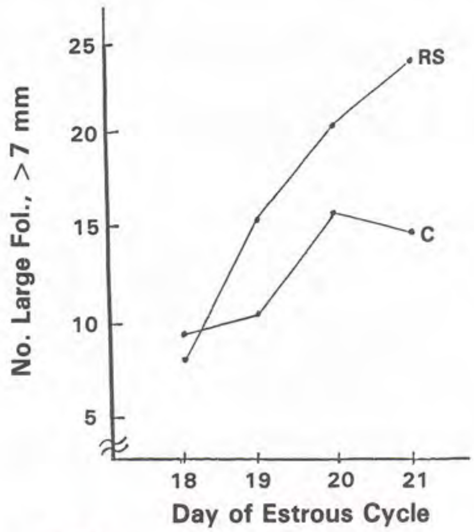


**Figure 2. Number of Large Follicles.**

line gilts developed greater numbers of large follicles each day after d 19 (Fig. 2). The number of large follicles increased in a linear fashion after d 18 peaking in number on d 21 in Select line gilts. Control line gilts developed large follicles at a slower rate and peaked in number on d 20, one day earlier than Select line gilts. No further increase in number of large follicles was observed on d 21. Recruitment of large follicles for ovulation apparently occurs over a more prolonged period in Select than Control line gilts.

Similar findings have been reported in sheep for the high fecundity Romanov (3.1 ovulation rate) and low fecundity Ile de France (1.4 ovulation rate) breeds. It has also been reported that the higher ovulating Booroola Merino breed of sheep requires less time to recruit follicles from the small follicle pool and that the larger follicles are responsive to gonadotropic hormone stimuli over a more prolonged period than the low fecundity Merino breed. Whether this is the case in high ovulating Select line pigs remains to be determined.

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# Value of Estimated Breeding Values

**Rodger K. Johnson, Tom Socha, John Keele and Larry Young[1]**

Currently, breeding values for pigs are estimated primarily from the phenotype of the individual. If breeders are selecting for leaner animals, backfat is measured on all the candidates for selection and the leanest ones are chosen to be breeders.

Phenotype is a good predictor of breeding value when the heritability of the trait being selected for is high. But, when heritability is intermediate to low, accuracy of estimating breeding value will be increased by using information on relatives.

Several kinds of relatives exist. There are the closely related collateral relatives—the full-sibs and half-sibs within the same generation and contemporary group. A contemporary group is all individuals of the same sex, born within a short period of time and managed alike until all records of performance, e.g., days to 230 lbs or backfat at 230 lbs, are obtained for individuals of the group.

The group probably contains several half-sib families (individuals by the same sire) which usually have more than one full-sib family (litter mates) within them. Every individual within this group is a candidate for selection. To use relatives' records in selection decisions, the record of each individual is expressed as a deviation from the group average and an index that estimates the breeding value of each individual is calculated. This index is $I = b_1(P-CG) + b_2(FS-CG) + b_3(HS-CG)$ where P is the phenotype of the individual, FS is

the average of its full-sibs, HS is the average of its halfsibs and CG is the average for the contemporary group.

We have known for many years that this index should rank animals for selection more accurately than their phenotype. The problem is that the index is more complicated. The coefficients $b_1$ to $b_3$ are the weightings given to each piece of information. They depend on the heritability of the trait and on the degree to which sibs resemble each other due to common environmental effects. Thus, these weights are different for each trait for which an animal would be indexed. Furthermore, the number in the family determines how well the average genetic value of the family is estimated. When family size is small, more weight is given to the animals' phenotype than to family average. Because individuals come from many different sizes of families, the coefficients vary from one individual to another, even for the same trait. Until recently, little selection has been based on a family index because calculations are tedious when done by hand or with a calculator. Computers have made the calculations simple.

This index uses only colateral relatives (siblings in the same contemporary group). But, information may be available on many other relatives of the candidates for selection. Sibs may exist in other contemporary groups. Parents, grandparents and more distantly related ancestors each provide some information about the breeding value of an individual. These ancestors have progeny which are cousins, uncles, aunts, etc. in the current generation. Because many of these relatives made a record in different generations, years and contemporary groups, all of these effects must be adjusted for before their records can be used to evaluate individuals in the current generation.

Computationally, the problem of using all relatives, collateral, ancestral, and progeny, is much more difficult than the simple index described above. The method which does this is called BLUP (Best Linear Unbiased Prediction). BLUP uses the relationships of all individuals back to some base year in the evaluation. Dairy and beef industries have used this method for some time. Previously, these evaluations could be done only with large, high-speed, mainframe computers. Central processing of records, commonplace for dairy for many years and to a lesser extent for beef breeds, was essential to do BLUP calculations.

Programs to do BLUP on microcomputers are not available today, but modern microcomputers have the capacity and the programs will likely be available soon. Evaluations by BLUP will have the highest correlation with the pig's true breeding value. But such genetic evaluations will be more complex and perhaps more expensive. Pig breeders need to know the relative accuracy of genetic evaluation based on phenotype, Index and BLUP and the differences among them in expected annual rates of genetic improvement to decide which method to use. The purpose of this paper is to report the results of a study done to compare phenotype, Index and BLUP as methods to rank pigs for selection using growth and backfat data from Nebraska seedstock herds.

### Data and Methods

Birth records of 203,869 purebred pigs from five Hampshire, one Duroc and six Yorkshire herds were obtained from the Nebraska SPF Swine Accrediting Agency. Pigs were born between 1960 and 1986. The traits considered were days to 220 lbs and average backfat probe at 220 lbs.

Breeding values were estimated for each pig based on its own deviation from the contemporary group average (P), an index of its own deviation and the deviations of its full-sib and half-sib family averages (I), and BLUP, using all relatives back to 1960.

To evaluate the sensitivity of the results to the value of heritability used, I and BLUP were computed with two different heritabilities. One set of heritabilities was estimated from the data, and the other set was .35 for days to 220 lbs. and .40 for Backfat as recommended in the National Swine Improvement Federation guidelines (NSIF, 1987). A value of .05 was chosen for $c^2$, the proportion of the phenotypic variance due to environmental effects common to litter mates.

Methods were compared based on the correlation between the predicted breeding value of a parent and the average phenotype of its progeny within a contemporary group. Agreement between the three methods of evaluation was assessed by calculating the correlation among the estimates of breeding values. The first correlation, between parents and offspring, tells which method was best for ranking candidates as potential parents and the second correlation, among methods, gives an indication of the extent to which candidates rank differently by the three methods.

### Results

Table 1 gives the estimates of heritability obtained in this study. The general conclusion of swine geneticists is that heritability of days to 220 lbs is near .35 and is .40 for backfat. Values obtained from the study are all less than these values. There are several possible reasons estimates of heritability might be lower in these seedstock herds than in experimental herds, from which most of the estimates in NSIF came. One is that the estimates are biased down by selection of progeny to be tested. Of the total number of pigs with birth records, 72 percent had a record for days to 220 lbs and 45 percent had a record for backfat. We calculated that at most, heritabilities could be biased downwards due to selection by 17 percent for days to 220 lbs and 26 percent for backfat. Reducing the NSIF values by these amounts gives values of .29 for days to 220 lbs and .30 for backfat, values still larger than those obtained from the study.

Selection of progeny to be tested

does not explain completely the discrepancy between values of heritability. More than likely the lower estimates are due to more heterogeneous environments for SPF pigs than for those in experimental herds. Also contemporary groups are probably less correctly specified in seedstock than in experimental herds. These factors would inflate the environmental variance and reduce heritability. Because heritability of the same trait may differ among herds, it is important to know how sensitive complex evaluations are to values of heritability.

*Agreement among methods.* Correlations among methods of predicting breeding values are in Table 2. Evaluations based on P and I ranked animals similarly. Correlations pooled across breeds ranged from .79 for evaluations of dams for backfat to .95 for evaluations of sires for days to 220 lbs. Thus, if high ranking animals are selected, selection based on P and I would select many of the same animals. On the other hand, rankings by BLUP were quite different from those by P and I. As expected, evaluations by BLUP were closer to those by I than by P, but these lower correlations mean there would be less overlap between BLUP and I and BLUP and P than between I and P in the animals selected.

Use of the higher NSIF heritabilities resulted in higher correlations among the methods. This simply means closer agreement among the methods when calculations are done with higher heritabilities. It does not mean that the methods give more accurate rankings.

*Prediction of Progeny Performance.* Correlations between progeny average and predicted breeding value of parent are in Table 3. Phenotype and Index were similar as predictors of progeny performance. Thus, in herds with family structures similar to those of these Nebraska SPF herds, there would be no advantage in using the more complicated family index over the individual's phenotype in ranking pigs for selection.

**Table 1. Estimates of Heritability**

| | Days to 220 lbs | | Backfat | |
|---|---|---|---|---|
| Breed | heritability | SE | heritability | SE |
| Hampshire | .11 | .05 | .16 | .04 |
| Duroc | .25 | .01 | .22 | .01 |
| Yorkshire | .22 | .04 | .10 | .03 |
| Pooled | .22 | .01 | .21 | .01 |
| NSIF | .35 | | .40 | |

**Table 2. Correlations Among Methods of Predicting Breeding Values of Parents**

| | *Estimated heritability* | | | *NSIF heritability* | | |
|---|---|---|---|---|---|---|
| | Phenotype with index | Phenotype with BLUP | Index with BLUP | Phenotype with index | Phenotype with BLUP | Index with BLUP |
| ***Breed*** | Sires (Days to 100 kg) | | | | | |
| Hampshire | .91 | .39 | .56 | .97 | .67 | .74 |
| Duroc | .94 | .62 | .65 | .96 | .67 | .69 |
| Yorkshire | .96 | .69 | .67 | .98 | .78 | .79 |
| Pooled | .95 | .64 | .67 | .96 | .70 | .72 |
| | Dams (Days to 100 kg) | | | | | |
| Hampshire | .91 | .53 | .66 | .94 | .76 | .79 |
| Duroc | .90 | .76 | .81 | .93 | .81 | .84 |
| Yorkshire | .89 | .63 | .69 | .93 | .73 | .76 |
| Pooled | .88 | .69 | .76 | .93 | .78 | .81 |
| | Sires (Backfat) | | | | | |
| Hampshire | .87 | .58 | .72 | .95 | .72 | .80 |
| Duroc | .91 | .61 | .70 | .95 | .72 | .78 |
| Yorkshire | .82 | .62 | .58 | .93 | .81 | .77 |
| Pooled | .89 | .60 | .68 | .95 | .72 | .76 |
| | Dams (Backfat) | | | | | |
| Hampshire | .84 | .64 | .69 | .93 | .78 | .80 |
| Duroc | .85 | .67 | .75 | .92 | .80 | .84 |
| Yorkshire | .77 | .55 | .63 | .92 | .75 | .77 |
| Pooled | .79 | .62 | .72 | .92 | .78 | .81 |

**Table 3. Correlations of Average Phenotype of Progeny with Predicted Breeding Value of Sire or Dam**

| | Estimated heritability | | | NSIF heritability | | |
|---|---|---|---|---|---|---|
| Breed | Phenotype | Index | BLUP | Phenotype | Index | BLUP |
| | Sires (Days to 100 kg) | | | | | |
| Hampshire | .22 | .24 | .32 | .22 | .23 | .31 |
| Duroc | .14 | .14 | .20 | .14 | .14 | .19 |
| Yorkshire | .09 | .09 | .16 | .09 | .09 | .15 |
| Pooled | .15 | .15 | .21 | .15 | .15 | .20 |
| | Dams (Days to 100 kg) | | | | | |
| Hampshire | .07 | .09 | .10 | .07 | .08 | .10 |
| Duroc | .16 | .15 | .19 | .16 | .15 | .19 |
| Yorkshire | .09 | .08 | .12 | .09 | .09 | .12 |
| Pooled | .12 | .12 | .15 | .12 | .12 | .15 |
| | Sires (Backfat) | | | | | |
| Hampshire | .22 | .23 | .25 | .22 | .23 | .25 |
| Duroc | .17 | .19 | .25 | .17 | .19 | .25 |
| Yorkshire | .10 | .07 | .13 | .10 | .08 | .10 |
| Pooled | .16 | .18 | .24 | .16 | .18 | .23 |
| | Dams (Backfat) | | | | | |
| Hampshire | .10 | .10 | .13 | .10 | .10 | .12 |
| Duroc | .12 | .12 | .16 | .12 | .12 | .16 |
| Yorkshire | .11 | .08 | .11 | .10 | .09 | .10 |
| Pooled | .11 | .10 | .14 | .11 | .11 | .13 |

In light of the high correlation between rank of individuals based on phenotype and index, it was no surprise that these two methods were equal in predicting performance of offspring. In these herds, the average number of pigs per full-sib family within contemporary groups was about 3 and the average number per half-sib family ranged from 6 to 11 for the three breeds. This analysis indicated that there was little information to be gained using phenotypes of this small number of siblings in selection. The main reason is probably that the number of pigs per contemporary group, which ranged from 32 to 64, was too small. The index was not accurately adjusted for differences among contemporary groups. An assumption necessary for use of a family index is that contemporary group averages are known without error. These averages will never be known exactly, but as group size increases the impact on accuracy of violations of this assumption is lessened.

Averaged across breeds and assuming the NSIF heritabilities, the correlation of progeny average with BLUP of sire was 33 percent higher for days to 100 kg and 44 percent higher for backfat than the correlation of progeny average with phenotypic deviation of sire. The advantage of BLUP for dams was 25 percent higher for days to 100 kg and 18 percent higher for backfat than the correlation with phenotypic deviation of dam.

**Conclusions**

Response would be greater from selection using best linear unbiased predictions (BLUP) than from selection on phenotype or the sib-index. The advantage would be greater for sires than for dams. There was no evidence that the sib-index was more accurate than phenotypic deviations.

Quantitative genetics theory suggests that the correlation of BLUP of a parent with its progeny average is higher than the correlation of phenotype of a parent with its progeny average if

1) $h^2$ and $c^2$ are known without error,

2) all relationships among animals are known, and

3) that the records upon which previous selection was based are included in the analysis.

Some causes of pre-test selection in the populations of the current study are

1) sale of pigs prior to completion of the test,

2) failure to probe small pigs, and

3) castration of small or unsound pigs prior to the test.

The records upon which pre-test selection was based were not included in the present analyses. These results indicate that

1) the differences in accuracy among BLUP, index, and phenotype are quite insensitive to the value of $h^2$ used in computing BLUP or index, and

2) BLUP is more highly correlated with progeny average than sib index or phenotype even when we know that some pedigree information was missing and that some pretest selection occurred.

In short, we conclude that BLUP is robust to violations in some of the assumptions underlying its theory and is the best method of evaluating candidates for selection. In herds in which size of contemporary groups and number of sibs is similar to that of these herds, rate of genetic change would be increased by about 30 percent per year.

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[1]Rodger K. Johnson is professor, Department of Animal Science. Thomas Socha is secretary-manager of Nebraska SPF Accrediting Agency. John Keele is research animal scientist and Larry Young is research geneticist at the Roman L. Hruska Meat Animal Research Center, Clay Center, NE.

# Nutrient Composition of Pork

**Chris R. Calkins**[1]

With growing interest in nutritional composition of the foods we eat, there is a need for reliable, accurate information. The United States Department of Agriculture presents composition of pork products in Agricultural Handbook 8-10, published in 1983 which is an update of data presented in Agriculture Handbook No. 8 in 1963. This paper is presented to enhance access to and condense the nutritional information found in Handbook 8-10.

**Methodology**

These data represent analyses conducted on retail cuts from 11 pork carcasses and 60 loins. The composition was weighted to represent the 1983 distribution of pork carcasses in each USDA grade (71.7, 24.2 and 3.7% US No. 1, 2 and 3, respectively) (prior to change in USDA grading system). Cuts were analyzed raw and after cooking. Roasting consisted of cooking to 167° F at 325° F. The spareribs were braised for 90 minutes in an oven at 350° F.

Nutritional composition was determined by actual measurement of each component. In the 1963 data set, many of the nutrients were estimated on the basis of protein content.

Agricultural Handbook 8-10 actually contains much more information than what is presented here. Additional cooking methods were used for some cuts and amino acid composition is reported. Composition from roasted cuts is shown here because it was the cooking method applied to the most cuts, thereby allowing direct comparisons to be made.

**Caution**

One caution must be noted. The handbook states "All retail cut items in the table are cooked without removal of the separable fat, if any. Therefore, data in the table may not be applicable to meat that is cooked after being trimmed of all visible fat". Refer to the 1988 Swine Report (page 21) for recent data from the University of Nebraska on the effect of trimming fat before cooking on pork composition.

**Conversion to a 3-ounce portion**

The nutrients contents reported here are per 100 grams, as was reported in Handbood 8. To express composition on the basis of a 3-ounce serving each of the figures presented here should be multiplied by 0.85 to convert from 100 grams to 3 ounces.

[1]Chris R. Calkins is associate professor, Department of Animal Science.

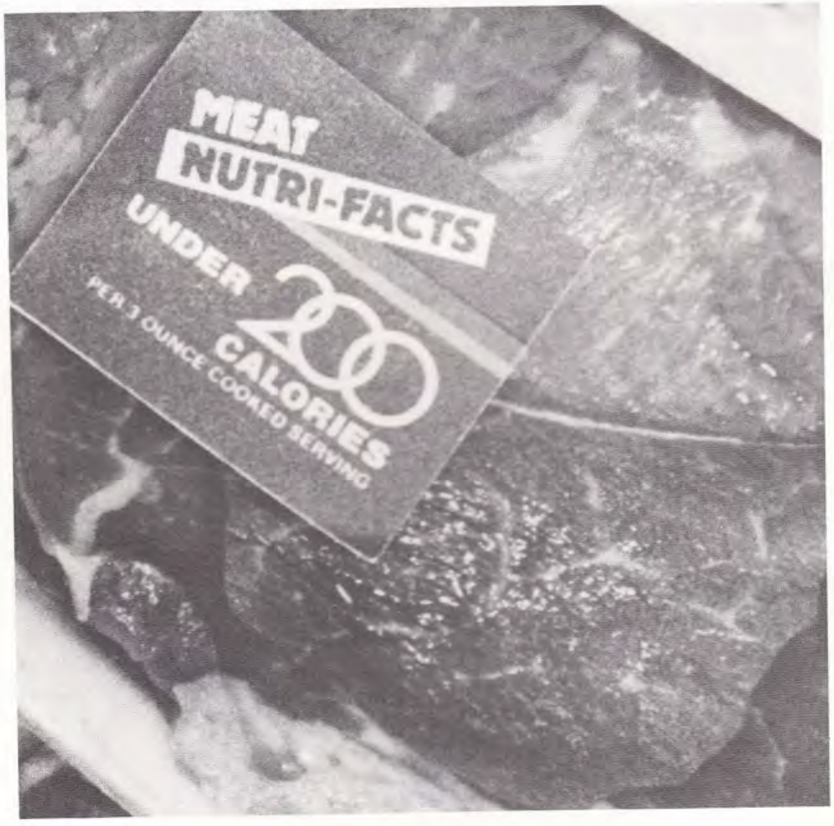

**Table 1. Proximate analysis of raw (or unheated) separable lean from pork (per 100 g).**

| Cut | Water (g) | Food energy (kcal) | Protein (g) | Total lipid (fat; g) | Ash (g) |
|---|---|---|---|---|---|
| *FRESH CUTS* | | | | | |
| Composite[a] | 71.95 | 147 | 20.22 | 6.75 | 1.04 |
| Leg: whole | 72.90 | 136 | 20.48 | 5.41 | 1.05 |
| rump | 72.78 | 138 | 21.00 | 5.34 | 1.08 |
| shank | 72.83 | 139 | 20.62 | 5.63 | 1.03 |
| Loin: whole | 70.55 | 156 | 20.68 | 7.54 | 1.05 |
| blade | 69.32 | 182 | 19.27 | 11.03 | 1.00 |
| center loin | 70.00 | 159 | 22.04 | 7.15 | 1.10 |
| center rib | 69.56 | 161 | 21.80 | 7.53 | 0.98 |
| sirloin | 72.13 | 151 | 21.06 | 6.75 | 1.09 |
| tenderloin | 74.78 | 112 | 20.99 | 2.47 | 1.76 |
| top loin | 69.56 | 161 | 21.80 | 7.53 | 0.98 |
| Shoulder:whole | 72.05 | 154 | 19.34 | 7.87 | 1.01 |
| arm picnic | 73.13 | 140 | 19.75 | 6.16 | 1.01 |
| blade, Boston | 71.15 | 165 | 19.01 | 9.28 | 1.02 |
| Spareribs[b] | 56.88 | 286 | 17.09 | 23.60 | 0.91 |
| *CURED CUTS* | | | | | |
| Bacon | 31.58 | 556 | 8.66 | 57.54 | 2.13 |
| Ham:boneless, | | | | | |
| extra lean[c,d] | 70.52 | 131 | 19.35 | 4.96 | 4.21 |
| boneless, regular[c,d] | 64.64 | 182 | 17.56 | 10.57 | 4.11 |
| whole, fully cooked[c] | 68.26 | 147 | 22.32 | 5.71 | 3.66 |

[a]Composite of leg, loin and shoulder.

[b]Edible portion (lean and fat).

[c]Unheated, not raw.

[d]Includes data for hams with added water.

**Table 2. Mineral content (mg) of raw (or unheated) separable lean from pork (per 100 g)**

| Cut | Ca | Fe | Mg | P | K | Na | Zn | Cu | Mn |
|---|---|---|---|---|---|---|---|---|---|
| *FRESH CUTS* | | | | | | | | | |
| Composite[a] | 7 | 1.02 | 23 | 224 | 358 | 64 | 2.45 | 0.082 | 0.013 |
| Leg: whole | 6 | 1.01 | 25 | 229 | 369 | 55 | 2.27 | 0.075 | 0.029 |
| rump | 6 | 0.87 | 25 | 230 | 376 | 69 | 1.96 | 0.077 | 0.010 |
| shank | 7 | 0.94 | 25 | 226 | 340 | 67 | 2.31 | 0.075 | 0.014 |
| Loin: whole | 7 | 0.85 | 23 | 230 | 353 | 64 | 2.14 | 0.075 | 0.014 |
| blade | 13 | 0.99 | 20 | 206 | 351 | 65 | 2.83 | 0.077 | 0.013 |
| center loin | 5 | 0.84 | 23 | 206 | 362 | 66 | 1.67 | 0.063 | 0.015 |
| center rib | 9 | 0.77 | 22 | 241 | 423 | 45 | 1.62 | 0.060 | 0.010 |
| sirloin | 5 | 0.81 | 27 | 223 | 373 | 50 | 1.77 | 0.080 | 0.014 |
| tenderloin | 7 | 1.31 | 23 | 239 | 362 | 49 | 2.06 | 0.078 | 0.015 |
| top loin | 9 | 0.77 | 22 | 241 | 423 | 45 | 1.62 | 0.060 | 0.010 |
| Shoulder:whole | 6 | 1.22 | 21 | 211 | 347 | 76 | 3.04 | 0.099 | 0.013 |
| arm picnic | 6 | 1.19 | 21 | 218 | 341 | 82 | 2.86 | 0.097 | 0.013 |
| blade, Boston | 6 | 1.24 | 21 | 206 | 353 | 70 | 3.20 | 0.100 | 0.012 |
| Spareribs[b] | 7 | 0.99 | 22 | 239 | 259 | 76 | 2.70 | 0.085 | 0.010 |
| *CURED CUTS* | | | | | | | | | |
| Bacon | 7 | 0.60 | 9 | 142 | 139 | 685 | 1.15 | 0.064 | 0.007 |
| Ham:boneless, | | | | | | | | | |
| extra lean[c,d] | 7 | 0.76 | 17 | 218 | 350 | 1,429 | 1.93 | 0.074 | 0.033 |
| boneless, regular[c,d] | 7 | 0.99 | 19 | 247 | 332 | 1,317 | 2.14 | 0.099 | 0.031 |
| whole, fully cooked[c] | 7 | 0.81 | 18 | 232 | 371 | 1,516 | 2.04 | 0.079 | 0.035 |

[a]Composite of leg, loin and shoulder.

[b]Edible portion (lean and fat).

[c]Unheated, not raw.

[d]Includes data for hams with added water.

**Table 3. Vitamin content of raw (or unheated) separable lean from pork (per 100 g).**

| Cut | Ascorbic Acid (mg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | Pantothenic acid (mg) | Vitamin $B_6$ (mg) | Folacin (mcg) | Vitamin $B_{12}$ (mcg) | Vitamin A (IU) |
|---|---|---|---|---|---|---|---|---|---|
| *FRESH CUTS* | | | | | | | | | |
| Composite[a] | 0.9 | 0.904 | 0.275 | 5.061 | 0.795 | 0.47 | 6 | 0.79 | 6 |
| Leg: whole | 0.9 | 0.875 | 0.228 | 5.338 | 0.805 | 0.50 | 9 | 0.71 | 6 |
| rump | 1.3 | 1.023 | 0.285 | 5.138 | 0.790 | 0.45 | 5 | 0.72 | 6 |
| shank | 0.9 | 0.890 | 0.277 | 4.605 | 0.811 | 0.51 | 5 | 0.69 | 6 |
| Loin: whole | 0.9 | 1.007 | 0.300 | 5.403 | 0.814 | 0.53 | 5 | 0.86 | 7 |
| blade | 0.8 | 0.808 | 0.279 | 4.324 | 0.757 | 0.49 | 4 | 0.84 | 7 |
| center loin | 1.0 | 1.216 | 0.224 | 5.133 | 0.854 | 0.54 | 5 | 0.58 | 7 |
| center rib | 0.3 | 0.856 | 0.268 | 5.036 | 0.766 | 0.47 | 7 | 0.53 | 6 |
| sirloin | 0.9 | 1.086 | 0.292 | 4.407 | 0.828 | 0.63 | 5 | 0.69 | 7 |
| tenderloin | 0.9 | 0.974 | 0.281 | 4.429 | 0.904 | 0.52 | 5 | 0.81 | 6 |
| top loin | 0.3 | 0.856 | 0.268 | 5.036 | 0.766 | 0.47 | 7 | 0.53 | 6 |
| Shoulder:whole | 0.9 | 0.831 | 0.314 | 4.291 | 0.760 | 0.48 | 4 | 0.84 | 6 |
| arm picnic | 0.9 | 0.874 | 0.306 | 4.628 | 0.776 | 0.49 | 4 | 0.73 | 5 |
| blade, Boston | 0.8 | 0.796 | 0.321 | 4.012 | 0.747 | 0.35 | 4 | 0.92 | 7 |
| Spareribs[b] | —— | 0.619 | 0.273 | 4.860 | 0.793 | 0.42 | 4 | 0.87 | 11 |
| *CURED CUTS* | | | | | | | | | |
| Bacon | 21.7[e] | 0.368 | 0.104 | 2.776 | 0.352 | 0.14 | 2 | 0.93 | 0 |
| Ham:boneless, | | | | | | | | | |
| extra lean[c,d] | 26.3[e] | 0.932 | 0.223 | 4.838 | 0.466 | 0.46 | 4 | 0.75 | 0 |
| boneless, regular[c,d] | 27.7[e] | 0.863 | 0.252 | 5.251 | 0.447 | 0.34 | 3 | 0.83 | 0 |
| whole, fully cooked[d] | —— | 0.932 | 0.226 | 5.252 | 0.538 | 0.53 | 4 | 0.87 | —— |

[a]Composite of leg, loin and shoulder.

[b]Edible portion (lean and fat).

[c]Includes data for hams with added water.

[d]Unheated, not raw.

[e]Values based on products containing added ascorbic acid or sodium ascorbate. Some products may not contain added ascorbic acid or sodium ascorbate and their ascorbic acid content would be negligible; refer to ingredient listing on label.

**Table 4. Lipid composition of raw (or unheated) separable lean from pork (per 100 g).**

| Cut | Saturated fatty acids (g) | Monounsaturated fatty acids (g) | Polyunsaturated fatty acids (g) | Cholesterol (mg) |
|---|---|---|---|---|
| *FRESH CUTS* | | | | |
| Composite[a] | 2.34 | 3.06 | 0.71 | 65 |
| Leg: whole | 1.88 | 2.45 | 0.57 | 68 |
| rump | 1.85 | 2.42 | 0.56 | 61 |
| shank | 1.95 | 2.55 | 0.59 | 60 |
| Loin: whole | 2.61 | 3.42 | 0.79 | 60 |
| blade | 3.82 | 5.00 | 1.16 | 64 |
| center loin | 2.48 | 3.24 | 0.75 | 63 |
| center rib | 2.61 | 3.41 | 0.79 | 55 |
| sirloin | 2.34 | 3.06 | 0.71 | 63 |
| tenderloin | 0.85 | 1.12 | 0.26 | 65 |
| top loin | 2.61 | 3.41 | 0.79 | 55 |
| Shoulder:whole | 2.72 | 3.57 | 0.82 | 67 |
| arm picnic | 2.14 | 2.79 | 0.65 | 65 |
| blade, Boston | 3.21 | 4.21 | 0.97 | 68 |
| Spareribs[b] | 9.34 | 10.66 | 2.20 | 78 |
| *CURED CUTS* | | | | |
| Bacon | 21.26 | 26.33 | 6.75 | 67 |
| Ham:boneless, | | | | |
| extra lean[c,d] | 1.62 | 2.35 | 0.48 | 47 |
| boneless, regular[c,d] | 3.39 | 4.95 | 1.21 | 57 |
| whole, fully cooked[c] | 1.92 | 2.62 | 0.66 | 52 |

[a]Composite of leg, loin and shoulder.

[b]Edible portion (lean and fat).

[c]Unheated, not raw.

[d]Includes data for hams with added water.

**Table 5. Proximate analysis of cooked separable lean from pork (per 100 g).**

| Cut | Cooking Method | Water (g) | Food energy (kcal) | Protein (g) | Total lipid (fat; g) | Ash (g) |
|---|---|---|---|---|---|---|
| ***FRESH CUTS*** | | | | | | |
| Composite[a] | Roasted | 58.97 | 233 | 27.04 | 13.04 | 1.10 |
| Leg: whole | Roasted | 59.70 | 220 | 28.32 | 11.03 | 1.11 |
| rump | Roasted | 59.26 | 221 | 29.14 | 10.66 | 1.18 |
| shank | Roasted | 60.43 | 215 | 28.21 | 10.50 | 1.05 |
| Loin: whole | Roasted | 58.08 | 240 | 26.90 | 13.90 | 1.12 |
| blade | Roasted | 55.81 | 279 | 24.68 | 19.30 | 1.05 |
| center loin | Roasted | 57.26 | 240 | 28.49 | 13.08 | 1.17 |
| center rib | Roasted | 56.96 | 245 | 28.21 | 13.80 | 1.04 |
| sirloin | Roasted | 58.73 | 236 | 27.49 | 13.17 | 1.16 |
| tenderloin | Roasted | 65.16 | 166 | 28.79 | 4.81 | 1.25 |
| top loin | Roasted | 56.96 | 245 | 28.21 | 13.80 | 1.04 |
| Shoulder:whole | Roasted | 58.84 | 244 | 25.38 | 14.99 | 1.06 |
| arm picnic | Roasted | 60.27 | 228 | 26.68 | 12.62 | 1.06 |
| blade, Boston | Roasted | 57.72 | 256 | 24.36 | 16.84 | 1.07 |
| Spareribs[b] | Braised | 40.42 | 397 | 29.06 | 30.30 | 1.12 |
| ***CURED CUTS*** | | | | | | |
| Bacon | Cooked[d] | 12.94 | 576 | 30.45 | 49.24 | 6.78 |
| Ham:boneless, | | | | | | |
| extra lean[c] | Roasted | 67.67 | 145 | 20.93 | 5.53 | 4.37 |
| boneless, regular[c] | Roasted | 64.54 | 178 | 22.62 | 9.02 | 3.96 |
| whole, fully cooked | Roasted | 65.78 | 157 | 25.05 | 5.50 | 3.74 |

[a]Composite of leg, loin and shoulder.

[b]Edible portion (lean and fat).

[c]Includes data for hams with added water.

[d]Roasted, broiled or pan-fried.

**Table 6. Mineral content (mg) of cooked[a] separable lean from pork (per 100 g).**

| Cut | Ca | Fe | Mg | P | K | Na | Zn | Cu | Mn |
|---|---|---|---|---|---|---|---|---|---|
| ***FRESH CUTS*** | | | | | | | | | |
| Composite[b] | 8 | 1.25 | 22 | 258 | 365 | 69 | 3.47 | 0.112 | 0.027 |
| Leg: whole | 7 | 1.12 | 25 | 281 | 373 | 64 | 3.26 | 0.108 | 0.037 |
| rump | 7 | 1.14 | 29 | 285 | 391 | 65 | 3.01 | 0.109 | 0.026 |
| shank | 7 | 1.11 | 25 | 278 | 360 | 64 | 3.45 | 0.108 | 0.034 |
| Loin: whole | 9 | 1.15 | 22 | 254 | 367 | 69 | 3.04 | 0.101 | 0.016 |
| blade | 14 | 1.25 | 17 | 201 | 346 | 68 | 3.59 | 0.099 | 0.013 |
| center loin | 6 | 1.09 | 21 | 219 | 362 | 69 | 2.28 | 0.081 | 0.016 |
| center rib | 11 | 1.00 | 21 | 256 | 423 | 46 | 2.22 | 0.078 | 0.011 |
| sirloin | 10 | 1.09 | 24 | 252 | 370 | 62 | 2.49 | 0.106 | 0.028 |
| tenderloin | 9 | 1.54 | 25 | 288 | 538 | 67 | 3.00 | 0.160 | 0.039 |
| top loin | 11 | 1.00 | 21 | 256 | 423 | 46 | 2.22 | 0.078 | 0.011 |
| Shoulder:whole | 8 | 1.52 | 20 | 231 | 352 | 76 | 4.24 | 0.129 | 0.026 |
| arm picnic | 9 | 1.42 | 20 | 247 | 351 | 80 | 4.07 | 0.128 | 0.041 |
| blade, Boston | 7 | 1.60 | 20 | 219 | 353 | 73 | 4.37 | 0.129 | 0.014 |
| Spareribs[c] | 47 | 1.85 | 24 | 261 | 320 | 93 | 4.60 | 0.142 | 0.014 |
| ***CURED CUTS*** | | | | | | | | | |
| Bacon | 12 | 1.61 | 24 | 336 | 486 | 1,596[e] | 3.26 | 0.170 | 0.041 |
| Ham:boneless, | | | | | | | | | |
| extra lean[d] | 8 | 1.48 | 14 | 196 | 287 | 1,203 | 2.88 | 0.079 | 0.054 |
| boneless, regular[d] | 8 | 1.34 | 22 | 281 | 409 | 1,500 | 2.47 | 0.145 | 0.041 |
| whole, fully cooked | 7 | 0.94 | 22 | 227 | 316 | 1,327 | 2.57 | 0.087 | 0.016 |

[a]See Table 5 to identify cooking method.

[b]Composite of leg, loin and shoulder.

[c]Edible portion (lean and fat).

[d]Includes data for hams with added water.

[e]Range is 1,030 to 2,670 mg per 100 g.

**Table 7. Vitamin content of cooked[a] separable lean from pork (per 100 g).**

| Cut | Ascorbic Acid (mg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | Pantothenic acid (mg) | Vitamin $B_6$ (mg) | Folacin (mcg) | Vitamin $B_{12}$ (mcg) | Vitamin A (IU) |
|---|---|---|---|---|---|---|---|---|---|
| *FRESH CUTS* | | | | | | | | | |
| Composite[b] | 0.4 | 0.693 | 0.356 | 5.077 | 0.783 | 0.42 | 8 | 0.83 | 8 |
| Leg: whole | 0.4 | 0.690 | 0.349 | 4.935 | 0.670 | 0.45 | 12 | 0.72 | 7 |
| rump | 0.2 | 0.762 | 0.356 | 5.020 | 0.750 | 0.30 | 6 | 0.73 | 9 |
| shank | 0.4 | 0.633 | 0.344 | 4.881 | 0.685 | 0.46 | 6 | 0.71 | 7 |
| Loin: whole | 0.3 | 0.800 | 0.360 | 5.970 | 0.640 | 0.45 | 6 | 0.93 | 7 |
| blade | 0.3 | 0.574 | 0.342 | 4.664 | 0.528 | 0.44 | 5 | 0.80 | 8 |
| center loin | 0.4 | 0.908 | 0.261 | 5.457 | 0.652 | 0.45 | 1 | 0.60 | 8 |
| center rib | 0.4 | 0.639 | 0.312 | 5.355 | 0.581 | 0.40 | 9 | 0.55 | 8 |
| sirloin | 0.3 | 0.795 | 0.334 | 5.552 | 0.629 | 0.42 | 6 | 0.78 | 7 |
| tenderloin | 0.4 | 0.940 | 0.390 | 4.709 | 0.687 | 0.42 | 6 | 0.55 | 7 |
| top loin | 0.4 | 0.639 | 0.312 | 5.355 | 0.581 | 0.40 | 9 | 0.55 | 8 |
| Shoulder:whole | 0.3 | 0.584 | 0.364 | 4.306 | 0.580 | 0.40 | 5 | 0.88 | 7 |
| arm picnic | 0.3 | 0.578 | 0.357 | 4.314 | 0.592 | 0.41 | 5 | 0.78 | 7 |
| blade, Boston | 0.3 | 0.590 | 0.370 | 4.300 | 0.570 | 0.30 | 5 | 0.96 | 7 |
| Spareribs[c] | — | 0.408 | 0.382 | 5.475 | 0.750 | 0.35 | 4 | 1.08 | 10 |
| *CURED CUTS* | | | | | | | | | |
| Bacon | 33.5[e] | 0.692 | 0.285 | 7.322 | 1.055 | 0.27 | 5 | 1.75 | 0 |
| Ham:boneless, | | | | | | | | | |
| extra lean[d] | 21.0[e] | 0.754 | 0.202 | 4.023 | 0.403 | 0.40 | 3 | 0.65 | 0 |
| boneless, regular[d] | 22.7[e] | 0.730 | 0.330 | 6.150 | 0.720 | 0.31 | — | 0.70 | 0 |
| whole, fully cooked | — | 0.680 | 0.254 | 5.020 | 0.498 | 0.47 | 4 | 0.70 | — |

[a]See Table 5 to identify cooking method.

[b]Composite of leg, loin and shoulder.

[c]Edible portion (lean and fat).

[d]Includes data for hams with added water.

[e]Values based on products containing added ascorbic acid or sodium ascorbate. Some products may not contain added ascorbic acid or sodium ascorbate and their ascorbic acid content would be negligible; refer to ingredient listing on label.

**Table 8. Lipid composition of cooked[a] separable lean from pork (per 100 g).**

| Cut | Saturated fatty fatty acids (g) | Monounsaturated fatty acids (g) | Polyunsaturated fatty acids (g) | Cholesterol (mg) |
|---|---|---|---|---|
| *FRESH CUTS* | | | | |
| Composite[b] | 4.49 | 5.86 | 1.58 | 93 |
| Leg: whole | 3.80 | 4.96 | 1.34 | 94 |
| rump | 3.67 | 4.79 | 1.29 | 96 |
| shank | 3.62 | 4.72 | 1.27 | 92 |
| Loin: whole | 4.79 | 6.24 | 1.68 | 90 |
| blade | 6.65 | 8.68 | 2.34 | 89 |
| Center loin | 4.51 | 5.88 | 1.58 | 91 |
| Center rib | 4.76 | 6.21 | 1.67 | 79 |
| sirloin | 4.54 | 5.92 | 1.60 | 90 |
| tenderloin | 1.66 | 2.16 | 0.58 | 93 |
| top loin | 4.76 | 6.21 | 1.67 | 79 |
| Shoulder:whole | 5.17 | 6.74 | 1.82 | 97 |
| arm picnic | 4.35 | 5.67 | 1.53 | 95 |
| blade, Boston | 5.80 | 7.57 | 2.04 | 98 |
| Spareribs[c] | 11.76 | 14.17 | 3.51 | 121 |
| *CURED CUTS* | | | | |
| Bacon | 17.42 | 23.69 | 5.81 | 85 |
| Ham:boneless, | | | | |
| extra lean[d] | 1.81 | 2.62 | 0.54 | 53 |
| boneless, regular[d] | 3.12 | 4.44 | 1.41 | 59 |
| whole, fully cooked | 1.84 | 2.53 | 0.63 | 55 |

[a]See Table 5 to identify cooking method.

[b]Composite of leg, loin and shoulder.

[c]Edible portion (lean and fat).

[d]Includes data for hams with added water.

# PEO RETIREMENT

Ernie Peo, longtime swine nutritionist in the Animal Science Department at the University of Nebraska, retired July 1, 1988. Ernie was an outstanding teacher and advisor to students and a friend and advisor to the pork-producing industry. His accomplishments have been recognized at the University of Nebraska by students and faculty, by various Nebraska organizations and nationally by Oklahoma State University with the Graduate of Distinction Award in 1986 and as a Fellow by the American Society of Animal Science. Ernie's contributions and leadership are much appreciated by his colleagues.

The following is the citation to Dr. Peo by the American Society of Animal Science in 1984 when he was named a Fellow, recognizing his long and distinguished career in Animal Science:

**Ernest J. Peo, Jr.** was born in Watertown, New York, April 21, 1925. After graduation from Adams High School, he enlisted in the Marine Corps and served in Okinawa during World War II. After the service he farmed in Okalhoma. In 1949 he enrolled in Syracuse University and later transferred to Oklahoma State University where he received his B.S. and M.S. degrees in Animal Science. A Ph.D. degree in swine nutrition was received from Iowa State University in 1956. He has been on the Animal Science faculty at the University of Nebraska since 1956. Professor Peo has been deeply involved in swine nutrition research and teaching at both the graduate and undergraduate levels. He was a recipient of the all-University Distinguished Teaching Award in Biological Science in 1972 and the University of Nebraska Livestock Service Award in 1976. Dr. Peo was instrumental in developing the Animal Science Ph.D. program at Nebraska. He has served as a major advisor for 12 Ph.D. and 23 M.S. students. He has authored or co-authored 74 journal articles, 122 journal abstracts and 106 semi-technical publications. His research has made significant contributions toward a better understanding of swine nutrition. He has provided strong leadership at the department and university-wide levels. One of Dr. Peo's greatest assets is his ability to motivate people. This is apparent with students and new faculty. He has served as a catalyst and motivating force in guiding students who have subsequently distinguished themselves. Dr. Peo served as Nonruminant Nutrition Section Editor on the Editorial Board of the Journal of Animal Science. He and his wife, Mary, have one son, Rick, who is an assistant city attorney for Lincoln.

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