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The role of nutrition and the feeding program on gilt longevity

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Introduction

Due to reductions in longevity of sows in modern production systems, interest in nutrition programs for gilt development has increased dramatically in recent years. Because longevity is influenced by numerous overlapping variables, it is difficult to outline a single nutrition program that is best for all production systems. In this paper, we will briefly review research on the influence of nutrition on longevity in other species, discuss the most important nutrients to consider in a gilt development program, and summarize with proposed feeding strategies.

Does data from other species makes a case for energy restriction?

Research on the influence of caloric restriction on longevity in other species is impressive. **Table 1** is adapted from data summarized by Weindruch.[1] Before discussing the striking effects of caloric restriction, it must be emphasized that only energy intake was restricted and not intake of protein, fat, vitamins, or minerals. Restricting caloric intake by 30 to 50% increased the average life span by 40 to 85%. The mode of action is not exactly known, but is thought to be due to a decrease in injury to mitochondria of cells by free radicals. Free radicals are a normal byproduct of the use of nutrients and oxygen to synthesize ATP in the mitochondria. Free radicals cause damage to the mitochondria, which decreases their efficiency of ATP production. As the efficiency is reduced, a higher proportion of free radicals are produced for each ATP produced. This cycle continues, and increasing levels of free radicals are created with a dwindling supply of ATP. Eventually, as cells become less efficient, so do the tissues and organs where they reside. The body itself becomes less able to cope with challenges, such as disease or heat. Initially, the body tries to counteract these effects by detoxifying the free radicals with antioxidants and trying to repair their damage with other enzymes. However, these defense systems cannot prevent or repair all damage. Over time, the injuries accumulate until the cells and, thus, the organ and body in which they reside fails.

Because the destruction by free radicals is implicated for much of the blame in aging, individual nutrients, such as antioxidants, that help reduce levels of free radicals have been hypothesized to help increase longevity. Vitamins A, C, E, and selenium are most often discussed due to their roles in the antioxidant system in the body. These nutrients may all have roles in longevity, but caloric restriction is the only intervention known to consistently extend the mean and maximal life span in a variety of species.[2]

Do the effects of caloric restriction on aging have anything to do with gilt development?

The research trials discussed above relate to life span of non-reproducing animals. Sows are placed under the demands of increased productivity by lactating or gestating for most of their adult lives. Certainly, the caloric restriction data from other species can't be compared directly to the problem with sow mortality. Our purpose for discussing this data is that restricting energy intake is the only well-accepted means by which nutrition influences longevity.

A recent trial by NPPC provides supporting evidence that restricting nutrient intake during development may increase longevity in sows. In this trial, sows that were re-

Table 1: Average and maximal life span of various species on normal or caloric restricted diets

	Normal diet		Caloric Restricted	
Specie	Average	Maximal	Average	Maximal
White rat	23 mo	33 mo	33 mo	47 mo
Bowl spider	50 d	100 d	90 d	139 d
Guppy	33 mo	54 mo	46 mo	59 mo
Water flea	30 d	42 d	51 d	60 d
Protozoan	7 d	13 d	13 d	25 d

stricted in energy intake from 180 lb to 180 days of age had a higher proportion of sows that farrowed a litter (73 vs. 58%) and remained through four parities (56 vs. 33%) compared to sows allowed ad libitum consumption of a normal gilt development diet.[3] The results of this trial will be discussed further below.

Is nutrition during the development period clearly linked to sow longevity?

Researchers have taken several nutritional approaches to attempt to modify body composition of gilts during the development period and to measure the effects of those changes in composition on gilt productivity and longevity. As reviewed by Rozeboom,[4] the results of these trials are conflicting. Kirkwood[5] summarized the situation best when he wrote that data suggesting a relationship between body composition (backfat) at mating and longevity "merely reflect the consequences of subjecting improved pigs to conventional management." As summarized by Rozeboom, Kirkwood also indicated "When modern gilts are subjected to good management that minimizes weight and condition loss during lactation, there is no association between liveweight or backfat depth at first successful breeding and subsequent reproductive performance."

The comments of Rozeboom and Kirkwood are exactly right. You can develop gilts in a variety of manners and achieve long-term success, if they are not subjected to extreme loss of backfat in the farrowing house and during the rebreeding interval. Because many systems have difficulty preventing the extreme weight and backfat loss between farrowing and rebreeding, practical programs have resorted to breeding gilts when they are older (>210 days) and contain more backfat (>18 mm) than results from well-controlled research trials indicate are required for success.

As a summary, we would have to conclude that the evidence is not available to clearly demonstrate a consistent link between nutrition and body composition during the development period and longevity. However, the trials do indicate that chances for success may be improved when certain development practices are followed.

Which nutrients are the most important in gilt developer diets?

Because the energy and amino acid (lysine, etc.) levels have the greatest impact on rate of protein and fat deposition, they need to be considered first when formulating diets for developing gilts. Producers should understand the lean and fat deposition rates of their gilts in order to know the correct level of nutrients to supply. We have developed on-farm lean deposition curves to be able to accurately determine the amino acid requirements for a specific situation.[6] As summarized by Rozeboom,[4] gilt development diets often have been formulated to contain excess amino acid levels to encourage maximal protein deposition. Excess amino acids are wasteful, both from a cost and environmental perspective. The data from NPPC also indicates that excess amino acids may be detrimental for gilt longevity. In this trial, gilts were fed a corn-soybean meal diet formulated to 0.95% lysine or a corn-soybean meal, 5% added fat diet formulated to 0.6% lysine during the finisher period (150 to 250 lb). A third treatment was a high protein diet restricted to 4 lb/day intake. Gilts that were fed the moderate lysine level (0.6%) or were restricted in feed intake had a higher probability of remaining in the herd through four parities than gilts with ad libitum access to the 0.95% lysine diet (53 or 56% compared to 33% completed four parities). Because fewer sows completed four parities, the number of total pigs born over the four parities per gilt entered was lower (22.2 pigs) for gilts full fed the 0.95% lysine diet compared with gilts fed the 0.6% lysine diet (28.5 pigs) or gilts re-

Table 2: Recommendations for calcium and phosphorus levels for terminal pigs and developing gilts

	Terminal pigs			Replacement gilts		
Weight, lb	Calcium	Total Phos	Avail Phos	Calcium	Total Phos	Avail Phos
15 to 25	0.85	0.75	0.48	0.90	0.80	0.53
25 to 50	0.80	0.70	0.40	0.85	0.75	0.44
50 to 80	0.70	0.65	0.34	0.80	0.70	0.39
80 to 120	0.65	0.60	0.29	0.80	0.70	0.39
120 to 160	0.55	0.50	0.21	0.65	0.60	0.32
160 to 200	0.55	0.50	0.21	0.65	0.60	0.32
200 to 240	0.50	0.45	0.18	0.65	0.60	0.32
>240	0.45	0.40	0.14	0.65	0.60	0.32
After selection				0.85	0.75	0.48
Gestation				0.85	0.75	0.48
Lactation				0.90	0.80	0.48

stricted in feed intake (27.9 pigs). Clearly, there is no advantage to providing protein and lysine levels in excess of the gilts requirements.

The other main nutrients that need to be considered are the minerals critical for bone development. Practical recommendations for calcium and phosphorus levels for replacement gilts and terminal pigs are presented in **Table 2**. Replacement gilts should be fed slightly higher levels (approximately 0.1%)[7] than required for terminal pigs to meet the needs for maximum bone mineralization. The levels in **Table 2** contain a margin of safety compared to recommendations of NRC to account for lower feed intake levels typically found in the field. Similar to the information discussed for lysine, excessively high calcium and phosphorus levels are not required and lead to environmental waste. Replacement gilts also require slightly higher zinc and copper levels due to their importance in bone mineralization. Because selenium and vitamin E can be stored for use later in life, their levels should be increased during development compared to levels normally fed to terminal finishing pigs.[4] From a practical sense, the higher trace mineral and vitamin levels usually can be accomplished by using vitamin and trace mineral premixes at inclusion rates similar to those normally fed in the late nursery stage.

When should breeder vitamins be added to the gilt diets?

Some vitamins are used at much higher levels in sow gestation and lactation diets than in growing and finishing diets due to their importance in sow reproduction. Examples of these vitamins include folic acid, biotin, choline, carnitine, and pyridoxine. For many of these vitamins, limited research is available demonstrating their efficacy or appropriate level, much less the duration before breeding that they must be included in the diet. From a practical standpoint, we recommend including these vitamins in the diet for at least 30 days prior to breeding.

What are the practical recommendations for feeding programs for developing gilts?

Practical recommendations are outlined and offered in the appendix section below. The basis behind these proposals is to full-feed and grow gilts from weaning until approximately 150 to 180 lb depending on the feeding strategy. After this point, diets will change depending on whether they can be limit-fed or whether full feeding is required. The goal of the gilt development strategies is to mate gilts at a moderate body weight (250 to 280 lb) and allow them to continue growth through the first gestation period. The controversy with various recommendations is how to obtain the moderate body weights when breeding at 205 d or later. The suggestions in the appendix section use restricted intake or full feeding of a diet with a moderate protein level. These methods will reduce growth rate by providing lower energy or protein than required for maximal average daily gain. A third method used by some is to provide ad libitum access to a low energy diet. This option is being used successfully in some systems. The negative aspect of this approach is that the gilts tend to over-consume and total energy intake is not reduced as dramatically as desired. Also, decreasing the energy density of the diet by use of a higher fiber ingredient increases gilt development cost in most areas of the United States. One of these three approaches should be used to reduce growth rates to the desired level to achieve the overall goal: Mate gilts at a moderate body weight and allow continued growth through the first gestation period.

Regardless of which development program is used, gilts should be fed an increased amount of feed (6 lb or greater) for the last 14 to 21 days before mating to obtain the flushing response. After mating, they should be limit fed to approximately 4 lb/day for the first 7 to 14 days to prevent increased embryo mortality. After this point, gilts should be fed the appropriate amount of feed to target the desired weight at farrowing. The gilt feeding program outlined in the appendix below uses a target farrowing weight of approximately 450 lb.

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Appendix: Theory for proposed gilt development programs

Gilt development continues to be a concern as swine farms have implemented various strategies for raising gilts. An even bigger problem is that many farms do not have a strategy for gilt development. One of the reasons for confusion is the lack of agreement on the goals for body composition and age at breeding. The purpose of the following gilt development strategies is an attempt to standardize gilt development to relatively easy to follow programs.

The guiding theory behind these three gilt development strategies is that gilts should be mated at a moderate body weight and allowed to continue growth through the first gestation period.

This goal was selected after reviewing the different gilt development strategies that appear to work well in research and production settings. Most research suggests that gilts mated at 205 days of age or older should be restricted in growth during the development period. In contrast to this approach, Super Pollo (a production company in Chile) has achieved great success when breeding young gilts (average age=188 d; eligible at 180 d). With their approach, target gilt weight is approximately 265 lb at 180 days of age. Extremely rapid growth (>1.9 lb/d) is needed to reach this target weight. Gilts would have to be full-fed and allowed a low stress environment (extra sq. ft and low stocking density) to achieve this goal. Many systems can't achieve this growth rate. Thus, gilt breeding must take place at a later age (>205 d) to prevent gilts from being too light without enough body reserves.

The three strategies explicated below are briefly described as follows:

Programs for breeding at >205 d of age

1. Restricted intake from 180 lb to 190 d of age, or
2. Ad lib intake of diet with a moderate protein level from 150 to 250 lb

Program for breeding at 180 d of age

3. Full feed diets for maximal growth

The preferred program for breeding at 205 d of age or later is the restricted intake program. Because limiting intake is not possible in many systems, the alternative program of full feeding a diet with a moderate protein level is offered. The intent of this program is to decrease growth by feeding a lysine level slightly below that required for maximal growth.

Remember: Nutrition is secondary to proper management. Several basic management criteria should be met in gilt development with the following guidelines:

- Gilts should enter the herd at a young age (SEW or 50 lb) to allow adequate time for acclimation.
- Boar exposure should begin at 140 to 150 days of age. Boar contact must be direct, daily contact of at least 15 minutes.
- Estrus must be recorded to ensure breeding at second or later estrus and to know when movement to stalls should occur.
- Provide extra space during development (12 to 15 sq. ft after 140 d of age).
- Move to gestation crates 14 to 21 days prior to mating.

Gilt Development Program for Breeding at Greater than 205 d

Protocol for restricted feeding
Weaning until 180 lb

- Full-feed normal gilt development diets (examples in **Table 3**)
- Gilts should reach 180 lb at about 130 to 140 d of age

180 lb until 190 d of age (14 days prior to being eligible for breeding)

- Feed 4 lb/day of restricted gilt diet (example in **Table 3**)

190 days of age until bred

- Feed 6 lb/day of normal gestation diet

Protocol for full-fed gilts
Weaning until 150 lb

- Full-feed normal gilt development diets (examples in **Table 4**)
- Gilts should reach 150 lb at about 110 to 120 d of age

150 lb until 250 lb

- Full-feed gilt developer diets with moderate protein levels (examples in **Table 4**)

250 lb until 190 days of age

- Feed 4.5 lb/day of normal gestation diet

190 days of age until bred

- Feed 6 lb/day of normal gestation diet

Gilt development program for breeding at 180 d

Protocol for full-fed gilts
Weaning until eligible for breeding at 180 days of age

- Full-feed normal gilt development diets (examples in **Table 5**)
- Gilts should reach 150 lb at about 110 to 120 d of age

180 days of age until bred

- Feed 6 lb/day of normal gestation diet

Feed intake pattern in gestation for gilts

Immediately after first mating until week 2 (day 12)

- Feed 4 lb/d to all gilts

Day 12 to 96 of gestation

- Feed according to weight at breeding (**Table 6**)

Day 96 of gestation until farrowing

- Feed 6 lb/d to all gilts

Table 3: Example diets for restricted-fed gilts

	Three phase			**Two phase**		**Restricted**
	50	75	130	50	100	180
Ingredient	75	130	180	100	180	240
Corn or milo	1346	1453	1563	1381	1528	1439
Soybeanmeal,46.5%	585	480	370	550	405	490
MonocalciumP,21%P	29	29	29	29	29	29
Limestone	20	20	20	20	20	20
Salt	7	7	7	7	7	7
Vitamin premix	3	3	3	3	3	5
Trace mineral premix	3	3	3	3	3	3
Sow add pack	---	---	---	---	---	5
Lysine HCl	3	3	3	3	3	0
TOTAL	2000	2000	2000	2000	2000	2000
Lysine, %	1.15	1.00	0.85	1.10	0.90	0.90
Isoleucine:lysine,%	77%	79%	81%	77%	80%	89%
Leucine:lysine,%	164%	176%	191%	167%	185%	197%
Methionine:lysine,%	27%	28%	30%	27%	30%	32%
Met&Cys:lysine,%	56%	58%	62%	57%	61%	66%
Threonine:lysine,%	65%	67%	69%	66%	68%	75%
Tryptophan:lysine,%	22%	23%	23%	23%	23%	26%
Valine:lysine,%	85%	88%	92%	86%	90%	99%
ME, kcal/lb	1,468	1,469	1,468	1,468	1,468	1,466
Protein, %	19.8	17.8	15.8	19.1	16.5	18.0
Calcium, %	0.77	0.75	0.73	0.76	0.74	0.75
Phosphorus, %	0.70	0.68	0.66	0.69	0.67	0.68
Available phosphorus, %	0.39	0.38	0.38	0.39	0.38	0.39
Lysine:calorie, g/mcal	3.55	3.09	2.63	3.40	2.78	2.79
Feed budget, lb/pig	55	140	150	120	230	4lb/day

Table 4: Example diets for full-fed gilts bred at greater than 205 d of age

	Three phase			Three phase with fat		
	50	90	150	50	90	150
Ingredient	90	150	250	90	150	250
Corn or Milo	1346	1457	1773	1346	1457	1630
Soybean meal, 46.5%	585	478	157	585	478	200
Choice White Grease	---	---	---	---	---	100
Monocalcium P, 21% P	29	27	27	29	27	27
Limestone	20	20	18	20	20	18
Salt	7	7	7	7	7	7
Vitamin premix	3	3	5	3	3	5
Trace mineral premix	3	3	3	3	3	3
Sow add pack	---	---	5	---	---	5
Lysine HCl	3	3	3	3	3	3
TOTAL	2000	2000	2000	2000	2000	2000
Lysine, %	1.15	1.00	0.55	1.15	1.00	0.60
Isoleucine:Lysin, %	77%	79%	91%	77%	79%	86%
Leucine:Lysine, %	164%	176%	248%	164%	176%	226%
Methionine:lysine, %	27%	28%	37%	27%	28%	34%
Met & Cys:Lysine, %	56%	58%	75%	56%	58%	70%
Threonine:Lysine, %	65%	67%	76%	65%	67%	73%
Tryptophan:lysine, %	22%	23%	25%	22%	23%	24%
Valine:Lysine, %	85%	88%	107%	85%	88%	101%
ME, kcal/lb	1,468	1,469	1,467	1,468	1,469	1,572
Protein, %	19.8	17.8	11.8	19.8	17.8	12.2
Calcium, %	0.77	0.73	0.65	0.77	0.73	0.65
Phosphorus, %	0.70	0.66	0.60	0.70	0.68	0.60
Available phosphorus, %	0.39	0.36	0.34	0.39	0.36	0.34
Lysine:Calorie, g/mcal	3.55	3.09	1.70	3.55	3.09	1.73
Feed budget	90	165	390	90	165	350

Table 5: Example diets for full-fed gilts bred at 180 d of age

	Four phase				Three phase		
	50	75	130	180	50	100	180
Ingredient	75	130	180	250	100	180	250
Corn or milo	1346	1458	1567	1665	1381	1532	1665
Soybean meal, 46.5%	585	475	370	265	550	405	265
Monocalcium P, 21% P	29	29	25	25	29	25	25
Limestone	20	20	20	20	20	20	20
Salt	7	7	7	7	7	7	7
Vitamin premix	3	3	3	5	3	3	5
Trace mineral premix	3	3	3	3	3	3	3
Sow add pack	---	---	---	5	---	---	5
Lysine HCl	3	3	3	3	3	3	3
TOTAL	2000	2000	2000	2000	2000	2000	2000
Lysine, %	1.15	1.00	0.85	0.70	1.10	0.90	0.70
Isoleucine:lysine, %	77%	79%	81%	85%	77%	80%	85%
Leucine:lysine, %	164%	176%	191%	213%	167%	185%	213%
Methionine:lysine, %	27%	28%	30%	33%	27%	30%	33%
Met & Cys:lysine, %	56%	58%	62%	67%	57%	61%	67%
Threonine:lysine, %	65%	67%	69%	72%	66%	68%	72%
Tryptophan:lysine, %	22%	23%	23%	24%	23%	23%	24%
Valine:lysine, %	85%	88%	92%	97%	86%	90%	97%
ME, kcal/lb	1,468	1,469	1,468	1,460	1,468	1,468	1,461
Protein, %	19.8	17.8	15.8	13.8	19.1	16.5	13.8
Calcium, %	0.77	0.75	0.70	0.68	0.76	0.72	0.68
Phosphorus, %	0.70	0.68	0.62	0.60	0.69	0.65	0.60
Available phosphorus, %	0.39	0.38	0.34	0.33	0.39	0.36	0.33
Lysine:calorie, g/mcal	3.55	3.09	2.63	2.18	3.40	2.78	2.17
Feed budget	55	140	150	250	120	230	250

Table 6: Feed intake for days 12 to 96 of gestation[A]

Gilt weight at breeding	**lb/day**
230 to 250 lb	6.0
250 to 270 lb	5.5
270 to 290 lb	5.0
290 to 310 lb	4.5

[A]Assumes a target of 450 lb at farrowing and a milo-soybean meal diet with no added fat