PIG NUTRITION AND FEEDING

- *References: Chiba (2004; http://www.ag.auburn.edu/~lchiba/swineproduction.html) & NRC (1998). Also, see Chiba (2000) in Theodorou and France (2000).*

REPLACEMENT BOARS AND GILTS

1. Replacement Boars

A. Some considerations:

1) Consider buying a strong boar in a good body condition (including sound feet and legs) from a reliable seedstock producer (. . . known genetics and herd health) - Selection should be based on the performance record rather than placing too much emphasis on how they look.
2) Purchase boars (5.5 to 6 mo. old) at least 60 days before being used - Should not use boars before they are 7.5 to 8 mo. old.
3) Isolation - Isolate all new boars a minimum of 28 days for treatment for parasites, vaccinations, acquisition of immunity for microorganisms on the farm, and evaluation of sexual behavior (& possibly semen too).
4) In the confinement system, a boar should be housed individually, and provide 35 to 50 ft^2/pen or use 28 in. x 7 ft. stalls.
5) In non-confinement system, should have 20 ft^2 of shelter and dry sleeping area. Better to house boars individually, but if not possible then: a) boars must be reared together, and b) should provide 20-24" of feed space/boar, and one waterer/3 boars.

B. How should we feed?

1) The newly purchased boar has less appetite for the first few days because of the changes in the environment and other factors, thus, may want to obtain a bag of feed from a supplier!
2). Feed sparingly, i.e., feed ≈ 2 lb the first day and increase gradually, and feed to maintain a proper body condition, which can be done by feeding 4 lb/day.

2. Replacement Gilts

A. Some considerations:

1) Selecting gilts?

a) At birth - Ear notch at least twice as many gilts as will be needed, and keep records, and may want to foster barrows in large litters (. . . does not mean that gilts should be selected from small litters though!).
b) At weaning - Remove gilts from a list if their sows did not milk well.

c) Finishing phase - Make a final selection at 175 to 200 lb based on growth rate, backfat, mammary & skeletal systems and vulva development.

2) Early puberty

a) Most gilts reach puberty at 6-8 mo of age (avg., ≈ 200-220 days) - They should reach puberty (1st estrus and ovulation) at an early age.
b) Gilts should express one or more estrous cycles before the breeding age (7-9 mo) because may be able to increase ≈ 2 pigs/litter by breeding at 2nd estrus vs. 1st estrus!
c) Factors affecting puberty? - Genetics, season of the year (winter- and spring-born gilts tend to have delayed expression of the 1st estrus), confinement, etc.

3) Stimulate gilts or induce estrus?

a) Stimulation should precede the breeding period by 3 to 4 wk.
b) Regrouping and relocation:

(1) Gilts should weigh ≈ 200 to 230 lb (5-5½ to 6 mo of age), and start restricting energy intake by feeding 5-6 lb/day.
(2) If possible, relocate to the outside. Relocation seems to be the most important component of "transport phenomenon," and relocation within the confinement is less effective vs. moving to the outside.

c) Perhaps, use PMSG (**P**regnant **M**are **S**erum **G**onadotropin - similar to FSH) and HCG (**H**uman **C**horionic **G**onadotropin - similar to LH) to induce estrus in gilts that have not cycled.
d) Allow a fence-line contact/supervised direct mingling with a sexually active, mature boar for 15-30 min/day. Check gilts for estrus with the main criterion being a standing reaction to the pressure applied to the back with the presence of a boar.

B. How should we feed?

1) Most gilts are developed to 175-200 lb by self-feeding grower-finisher diets.
2) Should restrict energy intake after 175-200 lb, which can save feed costs and avoid unneeded weight gain to avoid a reduction in the longevity and unsoundness problems!
3) Restrict the energy intake by hand feeding 5-6 lb of balanced diet/day. Should adjust feed allowance because: a) require 10% less feed (≈ 0.5 lb less/day) in the confinement, and b) require 25% more feed (≈ 1 lb more/day) during the cold weather.
4) Flushing or high-energy feeding - End "restricted-feeding" and increase feed intake by 50 to 100% 7-10 days before breeding, which can maximize the ovulation rate!

5) A practical feeding approach?: a) Feed a grower diet until making a final selection at 175-200 lb, and, then, b) feed a lactation diet (5-6 lb/day) thereafter?

BOARS AND SOWS AT BREEDING

1. Feeding Boars?

A. When to feed?

1) They have a tendency to stop and eat spilled feed in the alley and miss sows in a "standing reaction" because of the delay!
2) Thus, boars should be fed before being used in the hand mating system.

B. How much?

1) Before the breeding period (within 2 weeks), feed 5-6 lb of a well-balanced 14% CP diet to young boars and 4-5 lb to older boars in a good body condition.
2) During the breeding period? - Depends on the work load, but increase the amount some?
3) After the breeding period? - Depends on a body condition and the idle period, but generally 4 lb of a well-balanced 14% CP diet should be sufficient.

Energy intake & return to estrus (Reese et al., 1982)

Intake	Weight change, kg	Return to estrus 7 d	14 d	21 d	70 d
8 Mcal	- 21	**50.0**	63.9	63.9	86.1
16 Mcal	-.6	**94.3**	94.3	97.1	100.0

* The 1988 NRC requirement = 17 Mcal/day.

2. Nutrition During Lactation and Return to Estrus

A. Effect of energy intake [Reese et al., 1982. JAS 55:590] - Sows must consume adequate energy for early return to estrus!
B. Effect of protein intake [Brendemuhl et al., 1987. JAS 64:1060] -Sows must consume adequate protein for early return to estrus!
C. Thus, both are important during the lactation period!

Effect of protein intake: (Brendemuhl et al., 1987)

Protein intake	Wt ∆, kg	Return to estrus 7 d	14 d	35 d
380 g/d	- 23	**63.1**	75.7	85.4
760 g/d	- 12	**82.3**	87.5	93.6

* The 1988 NRC requirement = 689 g/day.

3. Effect of Flushing After Weaning?

A. Flushing or high energy feeding 7-10 days before breeding (↑ feed intake by 50-100%) is commonly used to ↑ ovulation rate in gilts.
B. Effect on younger & older sows - See the data on "flushing & age of sows (Levis, 1986)."
C. Effect of body condition of sows - See the data on "Flushing and body condition (Levis, 1986)."

Flushing and age of sows: (Levis, 1986)

Item	Contr.	Flush.	Diff.
Return to estrus (day):			
Parity 1	7.6	6.4	+ 1.2
Parity 2-5	5.6	5.2	+ .4
Parity 5+	5.5	5.3	+ .2

- The Bottom Line?

Flushing & body condition (Levis, 1986):

Item	Contr.	Flush.	Diff.
Return to estrus (day):			
V. good	6.2	5.5	+ .7
Good	6.4	5.8	+ .6
Poor	7.6	6.7	+ .9
Pigs born alive:			
V. good	10.8	10.6	- .2
Good	10.6	10.9	+ .3
Poor	10.4	11.2	+ .8

1) Primiparous sows respond to flushing, but not sows in a good body condition. (Usually, return to estrus 4-8 d after weaning, thus, insufficient time to show response in the ovulation rate!?)
2) Feeding extra feed to very thin sows may be justified because of benefits in return to estrus and ovulation rate!
3) Older sows weaned in a good body condition? - Feeding 4 lb/day is adequate!?

4. **Antibiotics at Breeding Time?**

- For a herd with some history of breeding problems (. . . Causes? Unknown!), antibiotics may improve breeding performance, but should discontinue the use within two or three weeks after breeding.

5. **To Avoid Failure to Recycle After Weaning (e.g.)**

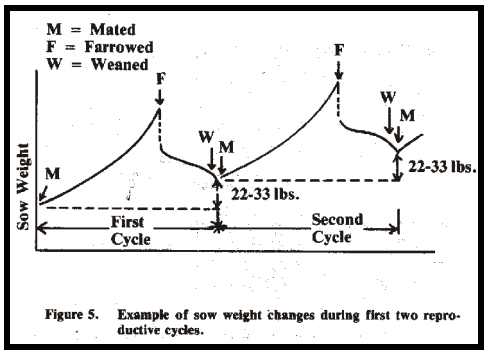


Figure 5. Example of sow weight changes during first two reproductive cycles.

A. Some nutritional considerations: (1st litter sows?)

1) During gestation, feed gilts so that they are still gaining weight (i.e., "net" body weight gain).
2) Feed a high energy diet during the first lactation.
3) Avoid high farrowing house temperatures (> 80°F) because they can reduce feed intake!
4) Not to reduce feed on thin sows before weaning.
5) Feed thin sows about 8 lb daily after weaning (especially, 1st litter sows).
8) Check the adequacy of feeding program by weighing sows at the mating time, end of the gestation phase, and weaning time.

B. Weight gain of sows - See the figure (Levis et al. NE Swine Repro. Mgt.):

1) Sows continue to mature until about 5th litter.
2) If sows are gaining about 22 to 33 pounds (from weaning to weaning) during each of 4 to 5 cycles, they are probably in a proper body condition!

GESTATING SOWS/GILTS

1. **Feeding in General**

A. Common feeding scheme:

1) Feed 4 lb of corn-soy diet containing 12.0-12.9% CP, 0.75% Ca, & 0.60% P/day.
2) Sows should be consuming 218-253 g CP, 9.4-11.4 g Lys, 13.9 g Ca, and 11.1 g P/day.
3) For thin sows (especially 1st litter sows), feed 5-6 lb/day of a corn-soy diet.

B. Adjusting feed?

1) "Bulky ingredients" - Must adjust the amount of feed offered to satisfy the required daily energy needs.
2) "Confinement" - Can be maintained in a proper condition with 0.5 lb/day less feed vs. outside because of less physical activity and relatively constant ambient temperatures regardless of the season.
3) Outdoors - Should increase feed offered by ¾ lb/day for each 20°F ↓ below the 70°F, and for thin sows, feed 1¼ lb more/day.

C. Restriction of energy intake after breeding

1) Flushing should be terminated because it: a) is costly & 2) may lead to increased embryonic loss. But, it should not be automatic . . . depends on other factors!
2) Be sure to provide an adequate amount of all other pertinent nutrients.

3. **Ways to Accomplish Restricted-Feeding?** (Make sure that each sow gets her share of feed!)

A. Individual hand-feeding:

1) Females are maintained in individual stalls, or maintained in pens but fed individually using feeding stalls - Can feed according to individual needs and also no competition for feed.
2) Feeding stalls - Should be designed to allow a group of sows to be locked in, and should not exceed 16-18 inches in width to prevent smaller gilts from turning around.

B. Group hand feeding - Feed in a group in a common trough or on a concrete slab:

1) Not preferred because of no control over sow weight and condition, i.e., no control over individual's feed intake vs. its needs.
2) The variation can be reduced by providing extra feeding space and(or) grouping females according to their age, size, and aggressiveness.

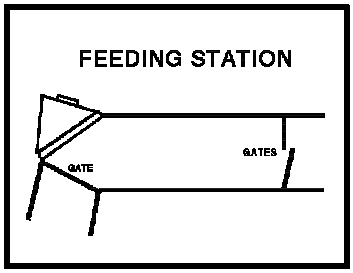
C. Interval feeding - Sows are allowed to consume 2 or 3 d of feed in one day, then wait!

1) Can adjust feed intake by controlling the time on the feeder (2 to 12 hr) or the time off the feeder (2 or 3 days). For gilts, every 3rd day feeding is not recommended.
2) If the time on the feeder is restricted, should provide one feeder hole per sow.

D. Self-feeding high-fiber diets - Generally, not recommended!

1) Can use corn stalks, straw, corn cobs, etc., but sows tend to overeat, thus, over-conditioned an feed costs also increase.
2) A variation of this would be to, e.g., feed silage, whole plant pellets, alfalfa, and others on a "free-choice" basis. Ensuring an adequate intake of the supplement can be a problem though!

4. **Electronic Feeders**



A. Have been developed and being used in Europe possibly because out of necessity? (e.g., High cost of feeds and pressures from the animal welfare group on the use of gestation crates!)
B. See Porcode 1(1):3 & NHF/Feb. pp 98-102 (1989):

1) Sows are housed in a group - One feeding station can serve about 50 sows, and any open buildings can be used (thus, the facility costs can be quite low!?).
2) Identification - Each sow wears an electronic responder (neck collar, ear tag, or implant), and information is stored in the computer that runs the feeder.
3) As a sow enters the feeder, computer reads her No. and meters out feed (and possibly water) based on her preset daily allowance and the amount that she's already consumed.

C. The results of preliminary studies at the U.S. Universities? - Positive results in some studies, but not in others!

5. **Some Q&A on Managing Gestating Females**

A. "*Should we increase feeding level toward the end of gestation?*" - Additional 2-3 lb in the late gestation (about 3 wk before parturition) can increase birth and weaning weights, and may increase pig survival rate. Perhaps, more beneficial for primiparous & thin sows!
B "*What are the effects of feeding fats to sows during the late gestation?*"

1) Feeding fats 1-2 wk before farrowing may increase energy reserves of pigs and fat content of milk, thus, may increase baby pig survival rate and weaning weight.
2) Can be done by feeding 5% fat for 2 wk or 10% fat for 1 wk, or top dressing with ¼ lb of melted fat/dried fat or 1 lb of ground soybeans for 2 wk before parturition. (To see beneficial effects, sows should consume 2½ lb of fat before parturition!)

C. "*Can we use raw soybeans for gestating sows?*" - Can perform as well as those fed soybean meal, and may increase birth wt and survival rate of pigs. Soybeans contain 18-19% lipids, so . . .
D. "*Will moldy feed interfere with normal reproduction?*"

1) Moldy grain/feed can reduce litter size and pig vitality at birth, result in the abnormal estrous cycle, and reduce conception rate.
2) Many are not harmful, but difficult to identify those, thus, simply too risky to feed!

E. "*When should we switch from a gestation diet to a lactation diet?*"

1) Start sows on a lactation diet after moving into the farrowing unit.
2) Feed the same amount as in the gestation phase until parturition.
3) Having constipation problems? Feed beet pulp (10%), wheat bran (15%), and other "natural laxative," but should be removed from the diet by the end of the 1st wk. An alternative is "top-dressing" the diet with bulky feed ingredient.

LACTATING SOWS

1. Lactation Phase

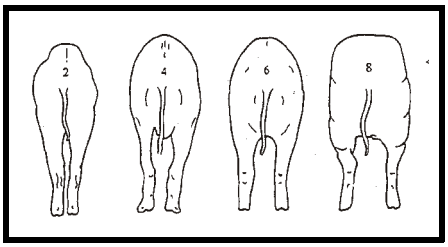
A. Probably, the most important feeding period in the sow's life because most problems in reproduction develop during this phase.

1) Problems? - Lactation failure, downer sows, anestrus, delayed return to estrus, fewer pigs in the subsequent litter, etc.
2) Why? - "Milk production!" A sudden increase in the demand for various nutrients, especially for so called "high-producing" sows!

a) No strict standard, but gilts nursing $\geq$ 9-10 pigs and sows nursing $\geq$ 10-11 pigs can be considered as "high-producing" sows.
b) Today's sows are more productive because of: (1) improved genetics, and (2) the use of "white-line, crossbred" sows.
c) Some females can produce 18-20 lb of milk per day, thus, can yield $\approx$ 1.25 lb fat and 1.0 lb of protein per day (. . . $\approx$ 6.8% fat ad 5.0% protein in milk).

B. Especially important for primiparous sows (or gilts just had pigs) because they need nutrients for both their own growth and milk production.
C. Unless adequate nutrients are consumed, can result in a depletion of body stores (mostly energy/fat and protein) because sows often use their body reserves to produce milk for pigs.

2. Body Condition of Sows



- Various visual condition scoring schemes have been used (e.g., Whittemore, 1987). Generally, classified into: 1) "Too thin" - Hips & backbone are somewhat prominent, 2) "Good" - Hips & backbone are not visible, and 3) "Too fat" - Hips & backbone cannot be felt.

3. Requirements During Lactation

Daily nutrient requirements: (NRC, 1998)

Item	Unit/day
Feed intake, kg	3.56-6.40 (5.25)
Digestible energy, Mcal	12.1-2.2
Crude protein, g	612-1,178
Lysine, g	31.6-61.9
Calcium, g	39.4
Phosphorus, g	31.5

A. The NRC (1998) daily requirements are based on sow wt. change and pig wt. gain.
B. The requirements change according to: 1) body size & reserves at the beginning of lactation, 2) the number of pigs nursing, 3) milking ability, 4) feed intake capacity, and 5) environment.
C. An example of changes in the requirement - See Stahly et al. (1990).

☛ For the optimum performance, energy and nutrients must be adjusted for various factors to ensure adequate intakes!

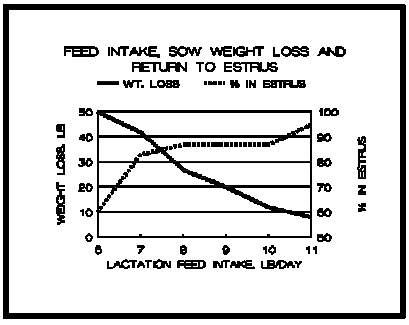
Dietary lysine for high-producing sows during lactation (Stahly et al., 1990)

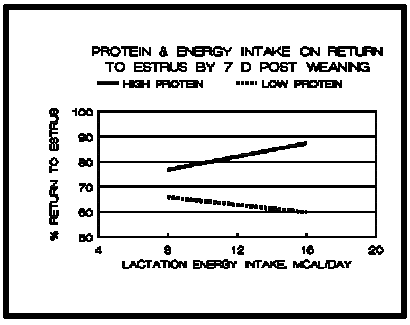
	Lysine, g/day			
Item	20	29	37	47
ME intake, Mcal/d	17.4	17.9	17.5	18.2
Sow wt. loss, lb	43.1	28.6	15.4	9.9
Litter size at weaning	10.5	10.4	10.5	10.8
Avg. weaning wt., lb	12.5	12.8	13.4	14.0
Litter wt. gain, lb	88.2	91.7	98.1	110.2

* Producing ≈ 16 lb milk/d & nursing > 10.5 pigs; The 1988 NRC Lys requirement = 31.8 g/day.

4. Inadequate Intakes During Lactation

A. Energy/protein intake and return to estrus: [e.g., Reese et al.(1982), Nelssen et al. (1985a,b), and Brendemuhl et al. (1987)]





B. Effect of energy intake during lactation on subsequent litter size - Compiled by Reese (1986). Anim. Health & Nutr./Feb. pp 22-35.
C. Inadequate energy and(or) protein intake during lactation:

Energy intake during lactation on subsequent litter size[a] (Reese, 1986)

Energy intake, Mcal ME/d	Feed intake, lb/d[b]	Litter size born
< 12	< 8	10.2
12-14	8-10	11.2
> 14	> 10	10.9

[a]Parity ranged from 1-4 & lactation length ranged from 4-8 wk; [b]Corn-soy based diet.

1) Sows mobilize fat and protein stores for milk production.
2) Results in excessive body weight loss, which can be detrimental to reproductive performance and longevity of sows!

D. Effect of Ca & P (also vitamin D) during lactation?

1) See the data by Nimmo et al. (1981. JAS 52:1330).

2) Lactating sows rely heavily on their skeleton to supply Ca and P for milk production regardless of their intakes.
3) Possible to weaken bones and become susceptible to posterior paralysis (fractured pelvis or vertebrae)and lameness (fractured femur) or stiffness, which are commonly observed within 1-4 days after weaning because of excessive fighting, exercise or activities associated with estrus.

Ca & P during gestation: (Nimmo et al., 1981)

Item	Ca/P, 13.0/10.0 g/d	Ca/P, 19.5/15.0 g/d
No. of sows	23	22
Leg problem (gestation)	5	1
Leg problem (lactation)	2	0

☛ "Repletion" or building-up Ca & P in the bone during gestation is very important!

E. For the optimum reproductive performance, in both short- and long-terms, important to maximize feed intake during lactation!

5. How to Feed Sows During Lactation?

A practical feeding scheme:

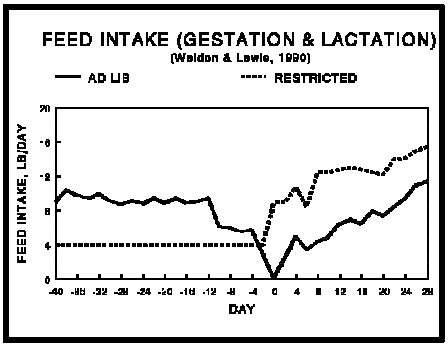
Farrowing . . . . . 2 lb/day
Day 1 . . . . . 4 lb/day
Day 2 . . . . . 8 lb/day
Day 3 . . . . . 12 lb/day
Day 4 . . . . . 12+ (full-feed)

◦ However, should be allowed to consume more if they want to do so!

A. During the first few days following the farrowing, many sows have limited appetite, thus may want to increase feed gradually.
B. After few days?

1) Should be on a "full-feed" by the end of the first week.
2) Important to provide fresh water (*ad libitum*).
3) For sows nursing 8 pigs or less, may want to feed 6 lb/day + 0.5 lb/pig.

6. Factors Affecting Feed Intake During Lactation



A. Temperature - Should keep females cool to avoid the ↓ in feed intake.
B. Eat more if hand-fed twice/day instead of once/day?
C. Switching to cubes or pellets may increase intake?
D. A wet-feeder/mixing with water to increase intake?
E. Feed intake during gestation (Weldon and Lewis, 1990. NE Swine Rep.) - Feeding too much during gestation: a) ↓ feed intake during lactation, b) ↑ feed costs, and c) can lead to various problems during the implantation (early phase) and also parturition because of obesity.

7. Other Nutritional Considerations?

A. Bulky feed ingredients such as alfalfa, what bran, an beet pulp during lactation:

1) Avoid because can: a) limit the energy intake, and b) aggravate a "heat-stress" situation because fibrous ingredients have a relatively higher heat production rate.

2) Exception? Can be used as a laxative. About 10% dietary fiber 3 to 4 d before and after farrowing, or top-dress a regular diet with a bulky feedstuff(s).

B. Dietary fat and baby pig survival

1) Producers may lose more than 25% of piglets born before weaning, and majority of losses occur during the 1st few days mostly because of starvation & crushing.

Dietary fat and baby pig survival rate: [Moser & Lewis, 1980. Feedstuffs 52(9):36]

Item	Cont.	Fat	Difference
Born alive	10.0	9.9	-0.1
No. weaned	8.1	8.4	0.3
Survival, %	82.0	84.6	2.6

* Based on 677 to 938 litters; fats/oils during the late gestation & early lactation phases.

a) Baby pigs - Only ≈ 2% body fat (mostly structural), thus, have low energy reserves.
b) Liver glycogen deplete rapidly within 12-24 h, which can lead to hypoglycemia and ↑ a chance of being crushed.
c) Little hair and fat for insulation and not much energy reserves for heat production, thus, cannot maintain a normal body temperature.

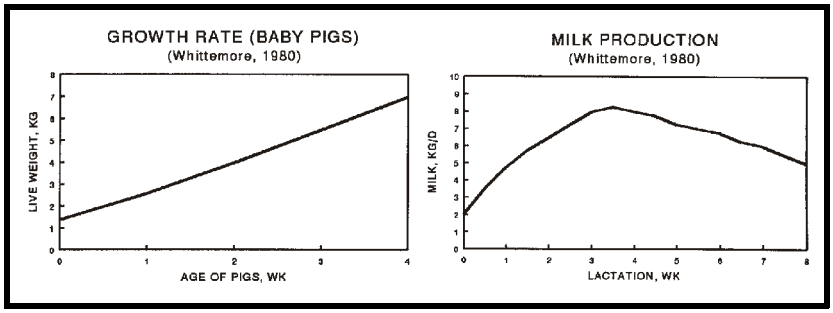
2) To increase survival rate: a) ↑ body reserves of pigs and(or) b) improve the quality of their diet (i.e., milk)! (+ other management practices!)
3) Fats and oils are highly palatable and contain 2.25 times energy vs. carbohydrates/protein, and generally ↑ energy intake during lactation.
5) Dietary fat and baby pig survival rate [. . . see the data by Moser & Lewis (1980)], and respond better if: a) Survival rate of the herd is < 80% (< 80%, 4.1% ↑& > 80%, 0.6% ↑), b) pigs weighing < 1 kg (average) at birth, c) sows consuming < 10 lb of feed/day, and d) used during the summer.
6) Possible reasons for the improvement? - Increase the fat content of milk, milk production, and slight increase in energy reserves of the newborn piglet.
7) For the best result, sows should consume at least 2.5 lb of fats before parturition, which can be done by feeding 10% dietary fat for a week or 5% dietary fat for 2 weeks before farrowing.
8) Drawbacks? - Costly, animal fats are solid at room temperature (thus, must be melted), handling problems with more than 5% in the diet, etc.

SUCKLING BABY PIGS

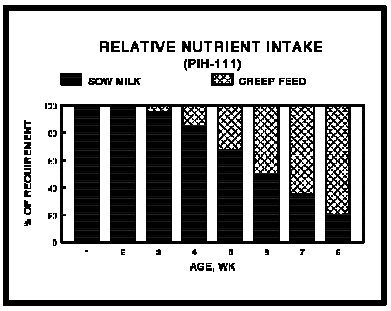
1. Creep Feeding

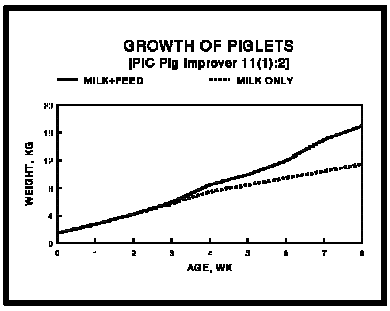
A. Growth rate of pigs and milk production: (Whittemore, 1980)

1) Piglets grow linearly after birth, ∴ the nutrient requirement also ↑ linearly!
2) Milk production peaks at 3rd or 4th week and starts to decline thereafter.
3) Thus, weaning at 3½ to 4 weeks of age or later, piglets need additional nutrients! (If weaning pigs at younger age, the value of creep feed is questionable!)



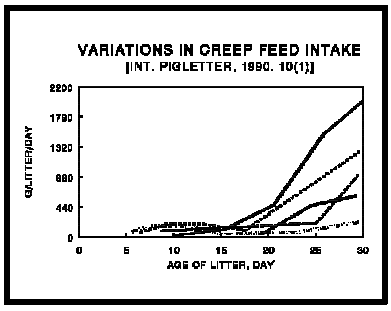
B. Relative intakes and growth of piglets

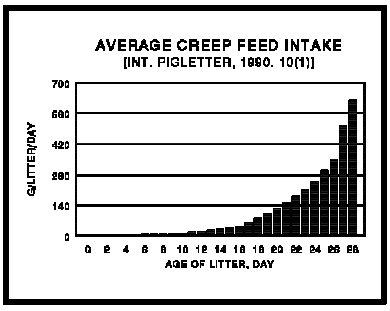




C. Creep feeding and post-weaning scours

1) May cause scours because of allergic reactions/hyper sensitivity to some proteins (& carbohydrates?) in soybean meal - Considerable variations among individuals though!
2) To avoid such problems and benefit pigs, pigs should consume > 400 grams of creep feed before weaning.
3) Creep feed consumption? - Considerable variations in creep feed intake [1990. Int. Pigletter 10(1)] & average creep feed intake [1990. Int. Pigletter 10(1)]:





- Consuming only 10 to 15 g/day before weaning at day 21, but the intake increases to 50 to 60 g/day by day 28!

D. Type of creep feed required (Table)
E. For a successful creep feeding

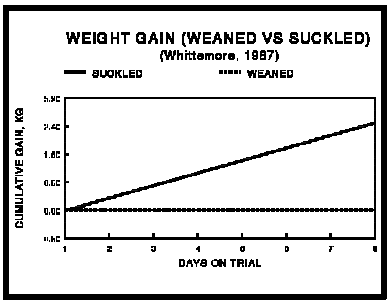
For 3 to 5 kg pigs (NRC, 1998)	
Lysine, %	1.50
Protein, %	26
Calcium, %	.90
Phosphorus, %	.70

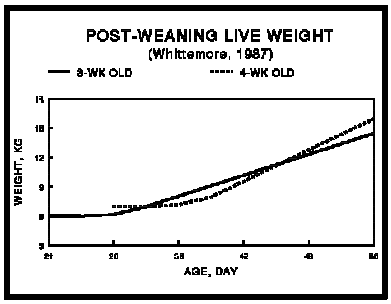
1) Try to provide fresh feed! - a) Change feed frequently, i.e., don't feed too much at once, and b) to encourage intake, feed small amounts in a shallow pan or on the floor several times/day during the first week or so.
2) Use fresh, palatable, and digestible ingredients ("special ingredients" - e.g., milk products, plasma protein, fish meal, oat groats, fats/oil, etc.) - If not, better to buy a complete diet or a base mix with several special ingredients?!

BABY PIGS

1. **Post-Weaning Lag or Growth Check & Stress**:

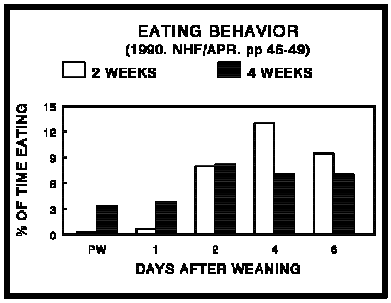
   A. Post-weaning weight and weight gain (Whittermore, 1987):

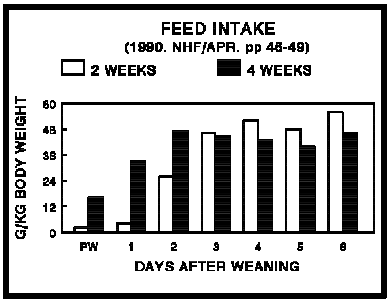


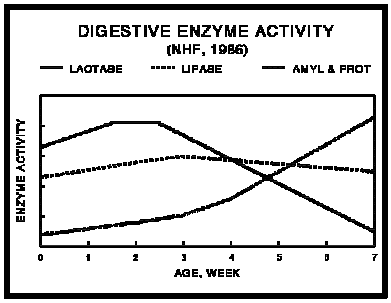


   B. Post-weaning stress - Weaning is a traumatic time for suckling piglets, and there are three types of stress: environmental, social, and nutritional.

2. **Try to Reduce "Nutritional Stress" At Weaning Time?**







   A. A sudden change to a solid diet at weaning, thus pigs just will not eat during the first day or so. [See "Eating Behavior & Feed Intake." NHF/Apr. pp 46-49 (1990)]
   B. Then, may consume a large amount - Mostly undigested, thus end up with diarrhea!?
   C. Enzymes - May not be ready for digesting a large quantity of solid feed (especially, corn-soy diets) [See "Digestive Enzyme Activity (1986. NHF/Spr. pp 23-31)"]
   D. Important to offer highly palatable/digestible diets, and may want to feed the same creep feed for about 5 d after weaning to reduce nutritional stress - But, costly though!?

3. **Stimulate Feed Intake After Weaning?**

   A. The primary reason for post-weaning lag seems to be "lack of energy intake soon after weaning!" Thus, should make efforts to let pigs eat some feed within 12 hr or so!
   B. Ways to stimulate feed intake:

      1) Hand-feed on the floor several times a day (first 2 or 3 days after weaning) because pigs are reluctant to make a trip to feeder.
      2) Check pigs often (5 to 6 times/day for about week) - Stirring them up can stimulate pigs, thus they may eat more!
      3) For early-weaned pigs (3 wk or younger), adding water to milk replacer, pre-starter diets, or mixture may enhance intake (. . . feed 5 to 6 times/day for about week).

4. **Starter Diets**

   A. Not a long ago, only one starter diet was used for baby pigs, but nowadays, it is common to use a three-phase feeding system. [e.g., Table (Luce and Maxwell, OSU)]

Table 1. Three Phase Feeding System for Early Weaned Pigs.

Phase	*Should Feed:*	*Diet Specifications*
I	First 7 to 10 days for pig weaned at 16 to 21 days. First 3 to 4 days after 22 to 28 day weaning. A pig experiencing postweaning lag.	Pelleted feed (1/8 in. pellet). 18 to 20% crude protein 1.50% total lysine
II	Day 4 to 10 postweaning. A weaned pig that has recovered from post-weaning lag. A weaned pig after it is consuming dry feed.	Feed can be in either pelleted or meal form. 17 to 20% crude protein 1.30-1.40 %* total lysine
III	Week 3 to 5 postweaning. A pig weighing between 25 and 45 lbs. A postweaning pig readily consuming feed.	Grain-soybean meal diet. Feed can be either meal or pellet 17 to 20% crude protein 1.15-1.20 %* lysine.

*High performing pigs may need the higher levels in the range shown

   B. Phase feeding:

      1) Phase I diets are often formulated without soybean meal and they are pelleted.
      2) May ↑ performance during the starter phase.
      3) Some question on the effect of improved performance on overall growth performance and cost effectiveness!

   C. Sometimes, mixing own starter diets may not be cost-effective, especially diets for very young pigs. Thus, may want to buy a complete diet or a base mix containing many special ingredients if you do not have many sows and(or) producing pigs only few times/year!

5. **Type of Ingredients/Diets** - Mostly depending on the weight and(or) age of starter pigs.

   A. 3-week-old or younger (≈ < 15 lb) - Need a complex diet!
   B. 4- to 6-week-old (up to ≈ 25 lb) - A semi-complex diet (i.e., a diet containing some milk products) or a corn-soy-based diet.

      ☛ May ↓ the performance slightly, but can be justified economically?!

C. 6-week-old or > 25 lb - Some milk products are recommended, but a simple diet (corn-soy diet) can be used.

6. Suggested Baby Pig Diets

Examples - "Diets for young pigs" (NE-SD Swine Nutrition Guide, 1995)[a]:

	Starter 1/ transition[b] (< 15 lb)	Starter 2 (15-25 lb)		Starter 3 (25-50 lb)	
Item	1	1	2	1	2
Ingredients, %					
Corn	31.45	52.50	51.10	65.25	56.90
SBM (44% CP)	8.50	22.90	23.65	30.50	31.05
Soy protein	3.00	-	-	-	-
Dried whey	27.50	15.00	15.00	-	5.00
Plasma proteins	6.00	-	-	-	-
Oat groats	12.50	-	-	-	-
Fish meal	5.00	-	4.00	-	-
Blood meal	-	2.50	-	-	-
Fat (stabilized)	3.00	3.00	3.00	-	3.00
L-lysine·HCl	0.15	0.15	0.15	0.15	0.15
DL-methionine	0.10	0.05	-	-	-
Limestone	0.45	0.60	0.40	0.75	0.70
Dical phosphate	0.80	1.65	1.05	1.60	1.45
Salt	0.10	0.20	0.20	0.30	0.30
Trace mineral	0.15	0.15	0.15	0.15	0.15
Vitamin mix	0.25	0.25	0.25	0.25	0.25
Copper sulfate	0.05	0.05	0.05	0.05	0.05
Antibiotics	1.00	1.00	1.00	1.00	1.00
Calculated analysis, %					
Lysine	1.55	1.25	1.25	1.15	1.19
Protein	22.1	18.9	19.3	19.1	19.3
Calcium	0.90	0.80	0.80	0.75	0.75
Phosphorus	0.80	0.70	0.70	0.65	0.65

[a]SBM = soybean meal; soy protein = soy protein concentrate; dried whey = edible dried whey; plasma proteins = spray-dried plasma proteins; fish meal = select menhaden fish meal; blood meal = spray-dried blood meal.

[b]Provide a total of 4 lb/pig (at least 3 lb after weaning) to pigs > 13 lb at weaning, but < 28 days of age.

7. Feed Ingredients and Additives

A. Protein sources in general:

1) Milk products (dried skim milk and whey):

a) Very good ingredients for weanling pigs because: (1) no need for an adaptation period, (2) highly palatable, (3) contain a highly available source of energy, lactose, and (4) "efficient" utilization of milk proteins.
b) Form a "curd" in the stomach by coagulation of milk proteins by "rennin" (or chymosin) produced in the gastric mucosa: (Concentration/activity of rennin ↓ with age!)

(1) A curd can stay in the stomach longer, which can stimulate acid secretion, thus, enhancing the activation of proteases (i.e., pepsin, which is produced as pepsinogen or proenzyme).
(2) Causes stomach to release nutrients very slowly, ∴ better utilization!

2) Soy proteins do not form a curd and acid secretion is very slow, ∴ less enzyme activation, and some components may be harmful to pigs because of, for instance, allergic reactions!
3) Soy protein concentrate (being used by the Food Industry)? - Potentially harmful carbohydrates (raffinose, stachyose, etc., in which galactose is joined by α-1,4-galactosidic linkage) are removed, thus, may improve palatability and availability. But, they are expensive, and pigs' response is very inconsistent!

B. Some protein sources/supplements for baby pigs:

1) Fish meal - Cost and quality of fish products vary greatly, and limit to a maximum of 5% (depending on the quality) because of palatability issue.
2) Dried whey:

a) Most commonly used in starter diets.
b) Because of variations in the quality (Table), try to use only edible grade, which are higher in lysine and lower in ash & salt compared with feed grade, especially for newly weaned pigs.
c) Tan/brown in color means "overheating" and it has less available lysine.

Composition of dried whey:

Item	Low	High	Mean
Moisture, %	4.5	9.7	6.4
Protein, %	5.3	13.2	11.8
Lysine %	.32	1.12	.85
Calcium, %	.43	1.35	.71
Salt, %	2.2	3.9	2.8

3) Dried plasma protein, which are highly palatable and may have some role in the immune status of young pigs, can be an alternative to milk products?

C. Alternative grains (other than corn and milo):

1) Oats - Use ≤ 20% because of high-fiber/low-energy content.
2) Barley - Use ≤ 20-25% because of a palatability problem and also low in energy.
3) Wheat - Use ≤ 30-35% because of a palatability problem. Also, avoid fine grinding!

D. Fats/oils:

1) Palatable, excellent sources of energy, and reduce dustiness in feeds & buildings.
2) Fats are cheaper vs. oils, but have to be melted before incorporating into the diet.
3) Oils are easier to mix vs. fats, but still need extra time, and they are rather expensive.
4) In a high-milk diet, may or may not see beneficial effects of fats/oils.

5) Medium-chained fatty acids (MCT; contain 8-14 carbons, and, e.g., coconut oil contains ≈ 60% MCT):

    a) Research interest in recent years.
    b) Highly digestible vs. long-chained fatty acids because MCT may be absorbed without micelle formation.
    c) May improve the performance slightly, but very expensive and may not be justified economically?

E. Organic acids:

1) European producers have been trying to acidify starter diets for some time, and fumaric acid, citric acid & others may be effective in improving performance.
2) How do they work?

    a) Acidic diets can ↓ stomach pH (more acidic), which can ↑ activation of pepsin, ↓ rate of passage, and keep pathogenic bacteria in check.
    b) May prevent overeating because acids are slightly unpalatable, ∴ avoid overloading the digestive system, which can lead to less diarrhea.

3) Does it pay?

    a) Inclusion of 1½ to 3% fumaric or citric acid (60¢ to $1/lb) costs additional $30 to 60/ton. If pigs are healthy and growing well, may not see obvious responses!
    b) To offset $60/ton, need a sizable performance improvement, thus may not be beneficial unless problems exist!

F. Probiotics - A mixture(s) of bacteria, yeasts and(or) other microorganisms (MO), and may competitively inhibit undesirable MO, thus helping desirable MO. However, its effect on pig performance has been very inconsistent!

G. Flavors - Being used by the feed industry to enhance feed intake and(or) cover up odors (e.g., odor of fish meal), but adding flavors for pigs or producers? (Pigs have a different No. of taste buds.)

H Enzymes:

1) Included in the diet to assist digestive process . . . Remember that the young pig's digestive system is not fully competent, thus the idea is excellent!
2) The response has been very inconsistent:

    a) One of the reasons? - Heat processing! Baby pig diets are often pelleted or crumbled, thus the effectiveness may depend a method of incorporation!?
    b) Exception? The use of β-glucanase, which can breakdown β-glucan (e.g., 5-8% in barley), has been resulted a very consistent response!

I. Antimicrobial agents - Usually included in baby pig diets to improve pig performance. (Please see "Feed Additives" in Section 18!)

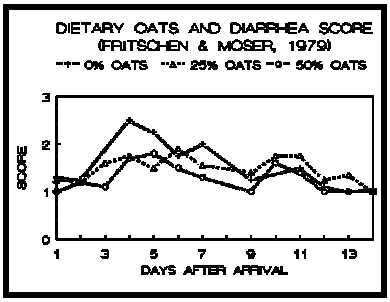
FEEDER PIGS

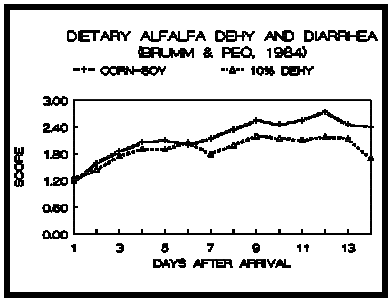
1. Most Common Problem?

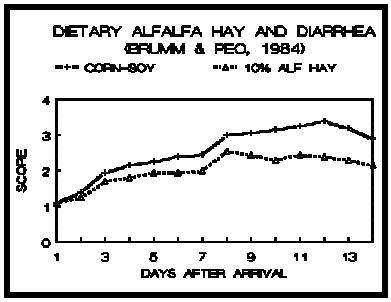
- Most common problem among newly arrived pigs is diarrhea - Can be caused by bacteria/virus infections, or non-disease factors such as nutrition or stress.

2. To Prevent/Alleviate Diarrhea Through Nutritional Means

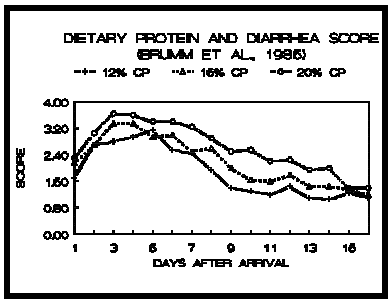
A. Use of fibrous ingredients - Inclusion of fibrous ingredients in receiving diets is one way to alleviate problems with diarrhea in newly arrived feeder pigs.







1) Oats [Figure (Fritschen & Moser, 1979. NE Swine Rep.)] - ↑ dietary oats (≈ 11% fiber) can delay and reduce incidence of diarrhea, but ↓ pig performance with 50% oats. Thus, 25% may be the optimum?!
2) Dehydrated alfalfa & alfalfa hay (Brumm & Peo, 1984. NE Swine Rep.) - No adverse effects on pig performance, and 10% alfalfa may ↓ severity of scours!



B. Dietary protein

1) It is a common practice among feeder pig finishing operators to reduce dietary CP content of receiving diets to alleviate diarrhea.
2) Effect of dietary CP content (Brumm et al., 1985. NE Swine Rep.):

   a) Fairly common to feed a diet with 16% CP to pigs weighing 40 to 110 lb.
   b) 12% dietary CP - May have a positive effect on diarrhea scores, but may not be sufficient to support the optimum gain or efficiency.

Numerical Goals (PIH-100)

Item	Excellent	Possible*
Weight gain, lb/day	> 1.40	1.58
Age at 230 lb, days	< 182	165
Efficiency (F:G)	< 3.40	3.00
Loin muscle, sq.in.	> 5.4	5.6
Avg. Backfat, in	< 1.1	1.0
Mortality, %	< 2.0	1.5

* Can get, 1.8-2.0 lb/day weight gain, > 6 sq. in. LMA, and < 1 in. BF via genetic & nutritional management though!

c) 20% dietary CP - Tendency for pigs to have higher diarrhea scores, but similar performance to those fed a 16% CP during the initial 16 days.

☛ The bottom line? - Not necessary to reduce the CP content of receiving diets!

GROWER-FINISHER PIGS

1. General Goals During the Grower-Finisher Phase?

A. Time - Produce the maximum amount of pork with the least time possible!
B. Inputs - Spend minimum dollars possible on feed to achieve the first goal! (Doesn't necessary mean the cheapest feed though!)
C. Quality - Maximize the quality of final products!

2. Alternative Energy Sources

A. Relative feeding values (corn = 100%): (NE Swine Diet Suggestion, 1992)

Ingredient	Feeding value[a]	Maximum recommended percent of complete diet[b] Starter	G-F	Gestation	Lactation	Remarks
Alfalfa, dehy	75-85	0	5	25	10	Low energy, high in B vitamins
Alfalfa hay, early bloom	75-85	10	10	66	10	Low energy, high in B vitamins
Bakery waste, dehy	95-100	20	40	40	40	High energy, about 13% fat
Barley (48 lb/bu)	90-100	25	85	90	80	Low energy
Beet pulp	70-80	0	0	10	10	Bulky, high fiber, laxative
Corn & cob meal	80-90	0	0	70	10	Bulky, low energy
Corn distiller grains, dehy	115-130	5	15	40	10	B vitamin source, low lysine
Corn gluten feed	75-85	5	10	90	10	Dry pelleted source preferred
High lysine corn	100-105	60	90	90	90	Test lysine level
Corn silage (20-30% DM)	20-30	0	0	90	0	Bulky, low energy, for sows only
Fat (stabilized)	185-210	5	5	5	5	High energy, reduces dust
Hominy feed	100-105	0	60	60	60	Subject to rancidity
Millet, proso	90-95	40	75	90	40	Low lysine
Milo	95-97	60	85	90	80	Low lysine
Molasses (77% DM)	55-65	5	5	5	5	Energy source, used in pelleting
Oats (36 lb/bu)	85-95	15	20	70	10	May ↓ gut edema & nutritional scours
High protein oats	90-100	20	50	70	10	May ↓ gut edema & nutritional scours
Oat groats	110-115	20	85	90	90	Palatable, but expensive
Potatoes (22% DM)	20-25	0	25	80	0	Should be cooked, low protein
Rye	85-90	0	25	20	20	Watch for ergot toxicity
Triticale	90-95	20	75	90	40	Watch for ergot toxicity
Wheat bran	60-65	0	0	30	10	Bulky, High fiber, Laxative
Wheat, hard	100-105	35	85	40	40	Avoid fine grinding
Wheat middlings	110-125	5	15	30	10	Partial grain substitute

[a]Value apply when ingredients fed at no more than the maximum recommended % of diet; Ranges presented to compensate for quality variation. [b]Higher levels may be fed, but the performance may decrease.

☞ e.g., Milo - Feeding value is 95% of corn, thus, economically replace corn when the price of milo is less than 95% of corn.

B. How to use alternative sources?

1) Substitute on the pound-for-pound basis within the limit. Exceptions? Using ingredients low in the amino acids such as fat, corn silage, corn-corn cob meal, etc.
2) Reformulate the diet on the lysine basis - Can effectively utilize wheat, barley & others that are relatively high in Lys, thus can ↓ protein supplements.

3. **Alternative Amino Acid Sources**

A. Some by-products of oil extractions:

1) Peanut meal - Low in lysine (1.4-1.7%), and contains 5-7% fat, thus may cause rancidity problems?
2) Rapeseed meal - Low in lysine (2.1-2.3%), and the quality is influenced by glucosinolate content (goitrogenic).
3) Canola (**Can**ada **O**il-**L**ow **A**cid) meal is produced from rapeseed low in undesirable substances (erucic acid in the oil & glucosinolate in the meal), and its protein value is 75-85% of SBM (lb-for-lb basis).
4) Sunflower meal is high in the fiber content (≈ 12%) & low in lysine (≈ 1.7%), thus should not replace more than 20-30% of SBM, and also should be used only for pigs > 75-100 lb?

B. Suggested range of commonly protein sources: (KSU Swine Nutr. Guide, 1983)

Source	% of complete diet				% of suppl.
	Starter	G-F	Gest.	Lact.	
Alfalfa, dehy	0-5	0-20	0-75	0-10	0-20
Alfalfa hay	0-5	0-20	0-75	0-10	0-20
Cottonseed meal	0-2	0-5	0-5	0-5	0-20
Fish solubles, dr.	0-3	0-3	0-3	0-3	0-5
Meat & bone meal	0-5	0-5	0-5	0-5	0-30
Soybean meal	0-25	0-20	0-25	0-25	0-85
Tankage	0-5	0-5	0-5	0-5	0-30
Whey, dried	0-20	0-20	0-5	0-5	0-20
Yeast, brewers dr.	0-3	0-3	0-3	0-3	0-5

C. Alternative protein sources: (KSU Swine Nutr. Guide, 1983)

Source	Protein, %	Lysine, %	Relative value as a lysine source	
			%	Pounds[a]
Soybean meal	44	2.86	100	100
Soybean meal	47.5	3.18	111	90
Alfalfa meal	17	.73	26	385
Cottonseed meal	41	1.51	53	187
Wheat bran	15	.59	21	476
Wheat middlings	16	.69	24	417
Yeast, brewers dried	45	3.23	112	89
Fish meal	60	5.44	190	53
Fish soluble, dried	54	1.73	60	167

Meat & bone meal	50	2.60	91	110
Skim milk, dried	33	2.40	84	119
Tankage	60	3.00	105	95
Whey, dried	12	.97	34	294

[a]Pounds required to replace 100 lb of 44% SBM.

☞ e.g., The relative value of 47.5% CP SBM is 111% of 44% SBM. If 44% SBM is $200/ton, then the value of 47.5% SBM is $222/ton. Thus, if the price of 47.5% SBM is < $222, better to use 47.5% SBM!

4. Other Feed Ingredients

A. High lysine corn:

1) Higher in most indispensable amino acids vs normal corn (e.g., Lys content is ≈ 0.38% for high lysine corn vs. 0.25% for normal corn).
2) No differences in performance if diets are formulated based on lysine, thus can save protein supplements, however, when using high lysine corn:

   a) Analysis is important because of the variation in the lysine content!
   b) Should be ground coarsely because it become powdery easily during grinding!

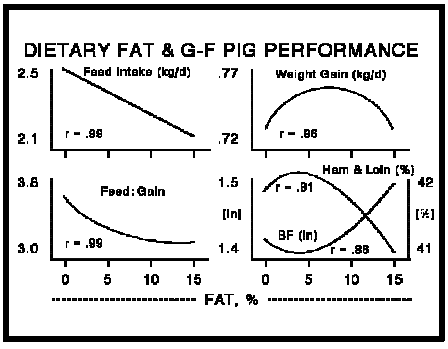
B. High moisture grains:

1) Can save drying costs and ↓ harvest-loss.
2) Similar feeding value to dry grain on the dry matter basis, but because of the moisture content, the quantity of grains in the diet must be increased accordingly:

Conversion factors (NE Swine Diet Suggestion, 1992):

15% no ∆	17% . . . . ↑ 2.4%	19% . . . . ↑ 4.9%
21% ↑ 7.6%	23% . . . . ↑ 10.4	25% . . . . ↑ 13.3%
27% ↑ 16.4%.		

3) Feeding to pigs less than 40 lb is not recommended.
4) Prepare diets frequently to prevent spoilage, i.e., every one or two days?



C. Fats or lipids:

1) Typical performance responses to dietary fats - See the summary [Moser, 1977. Feedstuffs 49(15):20].

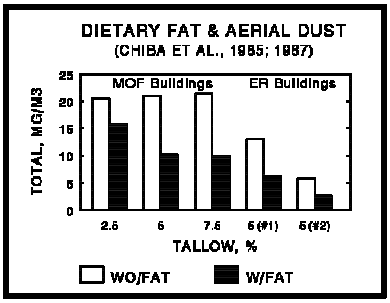
   a) May or may not improve weight gain, but consistently improve feed efficiency.
   b) Generally, can expect 2% improvement with 1% ↑ in dietary fat. (Lipids are utilized more efficiently during the summer vs winter!)

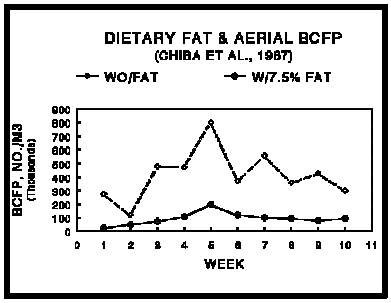
c) Generally, no adverse effects on the carcass quality, but may ↑ carcass fat with > 5% dietary fat.

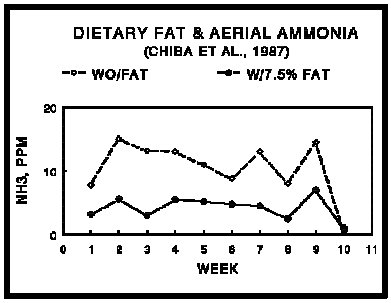
2) Effects of dietary fat on the environment:

a) Dust: (1) can be nuisance, (2) has adverse effects on buildings, ventilation ducts, motors, thermostats, timer, etc, (3) has adverse effects on humans (& pigs - e.g., eye irritation, headache, coughing, chest tightness, stuffy nose, shortness of breath, etc.), and (4) aerial particles can be a possible carrier of M.O. and harmful gases (particles > 5 μ are especially dangerous because can penetrate into a deeper portion of the respiratory tract!).

b) Effects of dietary fat on aerial dust, NH_3 & M.O. concentrations (Chiba et al., 1985. JAS 61:763 & Chiba et al., 1987. Trans. ASAE 30:464) - Simply adding lipids to diets can improve environment for both humans & pigs!







3) Additional benefits of dietary fat?

a) ↓ wear on mixing/handling machineries by its lubricating action.
b) Facilitate the pelleting process - ↓ power requirement.
c) ↑ palatability of feed.
d) ↓ feed wastage during handling/feeding process.
e) ↓ feed or particle separation, thus all pigs can receive a uniform diet.

4) Fats/oils should be stabilized with an antioxidant(s)!

D. Whole soybeans:

1) Depending on the price of soybean/oil and soybean meal, the use of whole soybeans can be economical from time to time.
2) Contain 32-37% protein and 18-19% fat, thus whole soybeans can be a good source of both amino acids and lipids!
3) The results of many studies indicate that the processed whole soybeans can be used as a replacement for SBM!

E. Crystalline amino acids:

1) At present, feed grade Lys, Thr & Trp (& Met has been available for a long time) are commercially available.
2) Economical? - Yes & No depending on the price of grains and supplemental protein sources. (Table.)

☞ Lys is often economical to use, but Trp and Thr are rather expensive at this time, and probably not!

Value of using synthetic lysine: (NHF, 1990)

	44% SBM, $/ton						
Corn, $/bu	160	165	170	175	180	185	190
2.00	1.51	1.60	1.68	1.76	1.85	1.93	2.01
2.10	1.45	1.54	1.62	1.70	1.79	1.87	1.95
2.20	1.40	**1.48**	1.56	1.65	1.73	1.81	1.90
2.30	1.34	1.42	1.51	1.59	1.67	1.76	1.84
2.40	1.28	1.36	1.45	1.53	1.61	1.69	1.78
2.50	1.23	1.31	1.39	1.48	1.56	1.64	1.73
2.60	1.17	1.25	1.33	1.42	1.50	1.58	1.67
2.70	1.11	1.19	1.27	1.36	1.44	1.52	1.61
2.80	1.05	1.13	1.21	1.30	1.38	1.46	1.55
2.90	.99	1.07	1.15	1.24	1.32	1.40	1.49
3.00	.93	1.01	1.09	1.18	1.26	1.34	1.43

* e.g., At $2.20/bu corn & $165/ton SBM, can ↓ the cost of diets if the price of Lys is ≤ $1.48/lb.

3) Commonly used methods:

a) For 44% SBM - 3 lb of L-Lys·HCl (78% Lys) plus 97 lb of corn to replace 100 lb of SBM.
b) For 48% SBM - 3.2 lb of Lys + 96.8 lb of corn to replace 100 lb of SBM.

4) Amino acids to replace protein supplements? (Lewis, 1989. NE Swine Rep.)

	Corn-SBM (+) control	Corn (-) control	Corn+ Lys & Trp	Corn+Lys, Trp & Thr
Initial wt, lb	133	132	132	132
Final wt, lb	247	213	239	237
Feed intake, lb/d	6.60	4.73	5.91	5.55
Weight gain, lb/d	1.75	.70	1.19	1.30
Feed:gain	3.77	6.79	4.98	4.28
Dressing %	75.5	74.0	74.7	74.9
Backfat, in	1.22	1.38	1.34	1.29
Lean, %	54.9	53.0	53.4	54.1

▸ May have the potential, but need more research on this area!

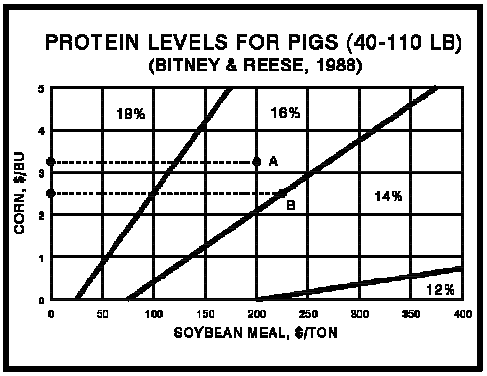
5. Economical Dietary Protein?

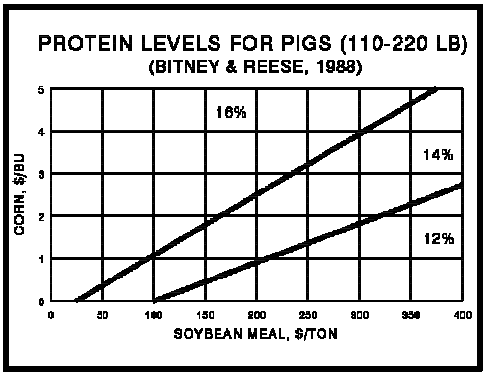
A. Both overfeeding or underfeeding protein can ↑ total production costs!

1) Underfeeding - ↓ growth performance & carcass quality.
2) Overfeeding - ↑ feed cost without affecting the performance.

B. The most economical level? (Bitney & Reese, 1988. NE Swine Rep.)

CP, %	ADG, lb	F:G	Feed, lb	Days	Costs/cwt gain, $ Feed	N-feed	Total
11	1.14	4.56	456	88	25.86	8.80	34.60
12	1.37	4.11	411	73	24.21	7.30	31.51
13	1.47	3.81	381	68	23.39	6.80	30.19
14	1.59	3.60	360	63	22.73	6.30	29.03
15	1.66	3.49	349	60	22.80	6.00	28.80
16	***1.66***	***3.49***	***349***	***60***	***23.56***	***6.00***	***29.56***
17	1.66	3.49	349	60	24.33	6.00	30.33
18	1.66	3.49	349	60	25.09	6.00	31.09
19	1.66	3.49	349	60	25.86	6.00	31.86
20	1.66	3.49	349	60	26.61	6.00	32.61





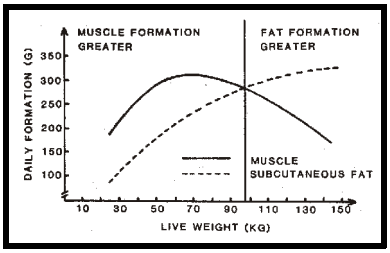
1) Point A - 16% CP diet is the most economical!
2) Point B, the boundary line, has alternatives: a) Feed higher protein - May reach market weights sooner with the same cost, b) Feed higher protein for a lower weight range & lower protein for a higher weight range, c) Feed an average of the two, and d) No problem with facility, feed lower protein.

6. Improving the Final Product, Pork?

Item	Avg Hog	High-Lean
Live wt, lb	244	245
Carcass wt, lb	181	185
Percent lean	46	58
Live price, $/cwt	44	44
Carcass price (75% yield), $/cwt	59	59
Base carcass value, $	106.79	109.15
Premium/discount for % lean, $	-1.36	+10.64
Price paid to producer, $	105.43	119.79
Slaughter cost, $	13.50	13.50
Total cost to packer, $	118.93	133.29
Pork cut value, $	117.52	139.70
Gain/loss to packer, $	-1.41	+6.41

A. General

1) Because of consumer demands for lean meats, need to improve leanness of pigs.
2) High-lean pigs can be beneficial for both producers (a higher base carcass value + premiums) and packers (a higher value for pork cuts). [Table - NHF 38(7):17 (1993)]
3) Excess consumption of energy? Finisher pigs have a propensity to consume energy in excess of their needs for "optimum" protein accretion, resulting in excess fat accretion! [Figure (Just, 1984. JAS 58:740)]



B. How to improve leanness?

1) A proper nutritional management - Mostly, amino acid and energy contents:

   a) Provide adequate protein or amino acids - According to some, in addition to satisfying the energy needs, pigs may eat to satisfy the Lys requirements. Thus, if the Lys content is too low, they may over-consume energy.
   b) Provide a proper balance of protein/amino acid & energy - e.g., Pigs eat less high-energy diet, thus may not consume enough amino acids for protein accretion if the amino acid-energy proportion is not appropriate.

2) Reducing energy intake of pigs:

a) Limit feeding:

Item	Ad lib	85%	70%
20 to 110 kg:			
ADG, kg	85	.75	.59
ADFI, kg	2.99	2.50	2.11
Feed:gain	3.53	3.26	3.60
At 110 kg:			
LMA, cm^2	34.3	34.7	40.3
Avg. BF, cm	4.00	3.22	2.78
Lean cut, %	58.3	60.7	61.5
Water, %	44.7	47.6	48.2
Protein, %	14.4	15.9	17.5
Eth. Ext., %	40.9	36.6	32.6

(1) Extensively used in Europe, Australia & other countries to improve the efficiency of feed utilization and carcass leanness!
(2) Example - "Effect of restricted-feeding on pigs (20-110 kg; Haydon et al., 1989. JAS 67:1916).
(3) Useful? (+) - Can ↑ leanness /↓ fat content of carcass, but (-) - ↓ weight gain, ∴ ↑ the feeding period, & (-) a practical feeding method (i.e., feeding *per se* and ensuring daily allowances for each pig) can be a problem.

b) Use of fibrous ingredients - The pig's ingestive capacity is limited, thus possible to reduce energy intake by increasing dietary bulk.

(1) Often improve leanness, but also reduce weight gain.
(2) Some concerns/questions - Adverse effects on digestibility of other nutrients & also, variations among various fibers as a source of energy.

3) Repartitioning agents:

Responses to pST & β-agonists (% change vs control): (1988. HFM/Dec. pp 39-41)

Item	β-agonists	pST
ADG	+ 8	+ 22
F:G	- 10	- 28
Feed intake	- 5	- 13
Dressing %	+ 1.4	-
Loin muscle	+ 12	+ 14
Backfat	- 12	- 26
Lean	+ 8	+ 21
Protein depo.	-	+ 31
Ash depo.	-	+ 8
Heat prod.	-	+ 8
ME_m	-	+ 17

1) Effective in improving growth performance and carcass characteristics! (Table)
2) Partitions nutrients away from fat deposition, thus more nutrients are used for lean muscle production.
3) Examples of repartitioning agents:

a) GH or pST (porcine somatotropin) - Increases muscle production & reduces fat deposition.
b) Beta adrenergic agonists - Similar to catecholamine (epinephrine, norepinephrine & dopamine) and examples include ractopamine, cimaterol, clenbuterol, and isoproterenol, which may or may not increase muscle production but reduce fat deposition.

4) Questions/problems:

a) Effectiveness may be depending on the type of pigs (genotypes & sex) & diets (especially, amino acids).
b) Cost-effectiveness?
c) pST - Must be injected or implanted (daily, weekly or whatever).
d) Consumer perception - Consumers have negative perceptions on the use of hormones or feed additives for animal production!

NUTRIENT REQUIREMENT TABLES
(Based on NRC, 1998)

1. Table 1. DIETARY Amino Acid Requirements of Growing Pigs (Ad Lib; 90% DM)[a]

	Body Weight (kg)					
	3-5	5-10	10-20	20-50	50-80	80-120
Average weight in range (kg)	4	7.5	15	35	65	100
DE content of diet (kcal/kg)	3,400	3,400	3,400	3,400	3,400	3,400
ME content of diet (kcal/kg)[b]	3,265	3,265	3,265	3,265	3,265	3,265
Estimated DE intake (kcal/day)	855	1,690	3,400	6,305	8,760	10,450
Estimated ME intake (kcal/day)[b]	820	1,620	3,265	6,050	8,410	10,030
Estimated feed intake (g/day)	250	500	1,000	1,855	2,575	3,075
Crude protein (%)[c]	26.0	23.7	20.9	18.0	15.5	13.2
Amino acid requirement[d]:						
True ileal digestible basis (%)						
Arginine	0.54	0.49	0.42	0.33	0.24	0.16
Histidine	0.43	0.38	0.32	0.26	0.21	0.16
Isoleucine	0.73	0.65	0.55	0.45	0.37	0.29
Leucine	1.35	1.20	1.02	0.83	0.67	0.51
Lysine	***1.34***	***1.19***	***1.01***	***0.83***	***0.66***	***0.52***
Methionine	0.36	0.32	0.27	0.22	0.18	0.14
Methionine + cystine	0.76	0.68	0.58	0.47	0.39	0.31
Phenylalanine	0.80	0.71	0.61	0.49	0.40	0.31
Phenylalanine + tyrosine	1.26	1.12	0.95	0.78	0.63	0.49
Threonine	0.84	0.74	0.63	0.52	0.43	0.34
Tryptophan	0.24	0.22	0.18	0.15	0.12	0.10
Valine	0.91	0.81	0.69	0.56	0.45	0.35
Apparent ileal digestible basis (%)						
Arginine	0.51	0.46	0.39	0.31	0.22	0.14
Histidine	0.40	0.36	0.31	0.25	0.20	0.16
Isoleucine	0.69	0.61	0.52	0.42	0.34	0.26
Leucine	1.29	1.15	0.98	0.80	0.64	0.50
Lysine	***1.26***	***1.11***	***0.94***	***0.77***	***0.61***	***0.47***
Methionine	0.34	0.30	0.26	0.21	0.17	0.13
Methionine + cystine	0.71	0.63	0.53	0.44	0.36	0.29
Phenylalanine	0.75	0.66	0.56	0.46	0.37	0.28
Phenylalanine + tyrosine	1.18	1.05	0.89	0.72	0.58	0.45
Threonine	0.75	0.66	0.56	0.46	0.37	0.30
Tryptophan	0.22	0.19	0.16	0.13	0.10	0.08
Valine	0.84	0.74	0.63	0.51	0.41	0.32
Total basis (%)[e]						
Arginine	0.59	0.54	0.46	0.37	0.27	0.19
Histidine	0.48	0.43	0.36	0.30	0.24	0.19
Isoleucine	0.83	0.73	0.63	0.51	0.42	0.33
Leucine	1.50	1.32	1.12	0.90	0.71	0.54
Lysine	***1.50***	***1.35***	***1.15***	***0.95***	***0.75***	***0.60***
Methionine	0.40	0.35	0.30	0.25	0.20	0.16
Methionine + cystine	0.86	0.76	0.65	0.54	0.44	0.35
Phenylalanine	0.90	0.80	0.68	0.55	0.44	0.34
Phenylalanine + tyrosine	1.41	1.25	1.06	0.87	0.70	0.55
Threonine	0.98	0.86	0.74	0.61	0.51	0.41
Tryptophan	0.27	0.24	0.21	0.17	0.14	0.11
Valine	1.04	0.92	0.79	0.64	0.52	0.40

[a]Mixed gender (1:1 ratio of barrows to gilts) of pigs with high-medium lean growth rate (325 g/day of carcass fat-free lean) from 20 to 120 kg body weight.

[b]Assumes that ME is 96% of DE. In corn-soybean meal diets of these crude protein levels, ME is 94-96% of DE.

[c]Crude protein levels apply to corn-soybean meal diets. In 3-10 kg pigs fed diets with dried plasma and/or dried milk products, protein levels will be 2-3% less than shown.

[d]Total amino acid requirements are based on the following types of diets: 3-5 kg pigs, corn-soybean meal diet that includes 5% dried plasma and 25-50% dried milk products; 5-10 kg pigs, corn-soybean meal diet that includes 5 to 25% dried milk products; 10-120 kg pigs, corn-soybean meal diet.

[e]The total lysine percentages for 3-20 kg pigs are estimated from empirical data. The other amino acids for 3-20 kg pigs are based on the ratios of amino acids to lysine (true digestible basis); however, there are very few empirical data to support these ratios. The requirements for 20-120 kg pigs are estimated from the growth model.

2. Table 2. DIETARY Amino Acid Requirements of Growing Pigs with Different Lean Growth Rates (Ad Lib; 90% DM)[a]

Body weight range:	50-80 kg Body Weight						80-120 kg Body Weight					
Lean gain (g/day):	300	300	325	325	350	350	300	300	325	325	350	350
Gender:	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt
Average weight in range (kg)	65	65	65	65	65	65	100	100	100	100	100	100
DE content of diet (kcal/kg)	3,400	3,400	3,400	3,400	3,400	3,400	3,400	3,400	3,400	3,400	3,400	3,400
ME content of diet (kcal/kg)[b]	3,265	3,265	3,265	3,265	3,265	3,265	3,265	3,265	3,265	3,265	3,265	3,265
Estimated DE intake (kcal/day)	9,360	8,165	9,360	8,165	9,360	8,165	11,150	9,750	11,150	9,750	11,150	9,750
Estimated ME intake (kcaL/day)[b]	8,985	7,840	8,985	7,840	8,985	7,840	10,705	9,360	10,705	9,360	10,705	9,360
Estimated feed intake (g/day)	2,750	2,400	2,755	2,400	2,755	2,400	3,280	2,865	3,280	2,865	3,280	2,865
Crudeprotein (%)[C]	14.2	15.5	14.9	16.3	15.6	17.1	12.2	13.2	12.7	13.8	13.2	14.4
Amino acid requirements[d]:												
True ileal digestible basis (%)												
Arginine	0.20	0.23	0.22	0.26	0.25	0.28	0.13	0.15	0.15	0.17	0.16	0.19
Histidine	0.18	0.21	0.20	0.23	0.21	0.24	0.14	0.16	0.15	0.18	0.17	0.19
Isoleucine	0.32	0.36	0.34	0.39	0.37.	0.42	0.25	0.29	0.27	0.31	0.29	0.33
Leucine	0.58	0.66	0.62	0.72	0.67	0.77	0.45	0.51	0.48	0.55	0.52	0.59
Lysine	***0.58***	***0.66***	***0.62***	***0.71***	***0.67***	***0.76***	***0.45***	***0.51***	***0.48***	***0.55***	***0.52***	***0.59***
Methionine	0.16	0.18	0.17	0.19	0.18	0.21	0.12	0.14	0.13	0.15	0.14	0.16
Methionine + cystine	0.34	0.39	0.36	0.42	0.39	0.44	0.27	0.31	0.29	0.33	0.31	0.35
Phenylalanine	0.34	0.39	0.37	0.42	0.40	0.46	0.27	0.30	0.29	0.33	0.31	0.35
Phenylalanine + tyrosine	0.54	0.62	0.59	0.67	0.63	0.72	0.43	0.49	0.46	0.52	0.49	0.56
Threonine	0.37	0.43	0.40	0.46	0.43	0.49	0.30	0.34	0.32	0.37	0.34	0.39
Tryptophan	0.11	0.12	0.11	0.13	0.12	0.14	0.08	0.10	0.09	0.10	0.10	0.11
Valine	0.39	0.45	0.42	0.48	0.45	0.52	0.30	0.35	0.33	0.38	0.35	0.40
Apparent ileal digestible basis (%)												
Arginine	0.19	0.21	0.21	0.24	0.23	0.26	0.12	0.13	0.13	0.15	0.15	0.17
Histidine	0.17	0.20	0.19	0.21	0.20	0.23	0.14	0.15	0.15	0.17	0.16	0.18
Isoleucine	0.29	0.34	0.31	0.36	0.34	0.39	0.23	0.26	0.24	0.28	0.26	0.30
Leucine	0.56	0.64	0.60	0.69	0.65	0.74	0.43	0.50	0.47	0.53	0.50	0.57
Lysine	***0.53***	***0.61***	***0.57***	***0.66***	***0.61***	***0.71***	***0.41***	***0.47***	***0.44***	***0.51***	***0.47***	***0.54***
Methionine	0.15	0.17	0.16	0.18	0.17	0.20	0.12	0.13	0.13	0.14	0.13	0.15
Methionine + cystine	0.31	0.36	0.34	0.39	0.36	0.41	0.25	0.29	0.27	0.31	0.29	0.33
Phenylalanine	0.32	0.36	0.34	0.39	0.37	0.42	0.24	0.28	0.26	0.30	0.28	0.32
Phenylalanine + tyrosine	0.50	0.58	0.54	0.62	0.58	0.67	0.39	0.45	0.42	0.49	0.45	0.52
Threonine	0.32	0.37	0.35	0.40	0.37	0.43	0.26	0.30	0.28	0.32	0.30	0.34
Tryptophan	0.09	0.10	0.10	0.11	0.10	0.12	0.07	0.08	0.07	0.09	0.08	0.09
Valine	0.36	0.41	0.38	0.44	0.41	0.47	0.28	0.32	0.30	0.34	0.32	0.37
Total basis (%)[c]												
Arginine	0.24	0.27	0.26	0.29	0.28	0.32	0.16	0.18	0.18	0.20	0.19	0.22
Histidine	0.21	0.24	0.23	0.26	0.24	0.28	0.17	0.19	0.18	0.20	0.19	0.22
Isoleucine	0.36	0.41	0.39	0.45	0.42	0.48	0.29	0.33	0.31	0.35	0.33	0.37
Leucine	0.61	0.71	0.67	0.77	0.72	0.83	0.46	0.54	0.50	0.58	0.54	0.63
Lysine	***0.67***	***0.76***	***0.72***	***0.82***	***0.77***	***0.88***	***0.53***	***0.60***	***0.57***	***0.64***	***0.60***	***0.69***
Methionine	0.17	0.20	0.19	0.21	0.20	0.23	0.14	0.15	0.15	0.17	0.16	0.18
Methionine + cystine	0.38	0.44	0.41	0.47	0.44	0.50	0.31	0.35	0.33	0.38	0.35	0.40
Phenylalanine	0.38	0.44	0.41	0.47	0.44	0.51	0.29	0.34	0.32	0.36	0.34	0.39
Phenylalanine + tyrosine	0.61	0.70	0.65	0.75	0.70	0.80	0.48	0.54	0.51	0.59	0.55	0.63
Threonine	0.44	0.50	0.47	0.54	0.51	0.58	0.36	0.41	0.38	0.44	0.41	0.46
Tryptophan	0.12	0.14	0.13	0.15	0.14	0.16	0.10	0.11	0.10	0.12	0.11	0.13
Valine	0.45	0.51	0.48	0.55	0.52	0.59	0.35	0.40	0.38	0.43	0.40	0.46

[a]Average lean growth rates of 300, 325, and 350 g/day of carcass fat-free lean represent pigs with medium, high-medium, and high lean growth rates from 20 to 120 kg body weight.

[b]Assumes that ME is 96% of DE.

[c]Crude protein and total amino acid reqnirements are based on a corn-soybean meal diet.

dEstimated from the growth model.

3. Table 3. DIETARY Mineral, Vitamin, and Fatty Acid Requirements of Growing Pigs (Ad Lib; 90% DM)[a]

	Body Weight (kg)					
	3-5	5-10	10-20	20-50	50-80	80-120
Average weight in range (kg)	4	7.5	15	35	65	100
DE content of diet (kcal/kg)	3,400	3,400	3,400	3,400	3,400	3,400
ME content of diet (kcal/kg)[b]	3,265	3,265	3,265	3,265	3,265	3,265
Estimated DE intake (kcal/day)	855	1,690	3,400	6,305	8,760	10,450
Estimated ME intake (kcal/day)[b]	820	1,620	3,265	6,050	8,410	10,030
Estimated feed intake (g/day)	250	500	1,000	1,855	2,575	3,075
Requirements (% or amount/kg of diet):						
Mineral elements						
Calcium (%)[c]	0.90	0.80	0.70	0.60	0.50	0.45
Phosphorus, total (%)[c]	0.70	0.65	0.60	0.50	0.45	0.40
Phosphorus, available (%)[c]	0.55	0.40	0.32	0.23	0.19	0.15
Sodium (%)	0.25	0.20	0.15	0.10	0.10	0.10
Chlorine (%)	0.25	0.20	0.15	0.08	0.08	0.08
Magnesium (%)	0.04	0.04	0.04	0.04	0.04	0.04
PotasSium (%)	0.30	0.28	0.26	0.23	0.19	0.17
Copper (mg)	6.00	6.00	5.00	4.00	3.50	3.00
Iodine (mg)	0.14	0.14	0.14	0.14	0.14	0.14
Iron (mg)	100	100	80	60	50	40
Manganese (mg)	4.00	4.00	3.00	2.00	2.00	2.00
Selenium (mg)	0.30	0.30	0.25	0.15	0.15	0.15
Zinc (mg)	100	100	80	60	50	50
Vitamins						
Vitamin A (IU)[d]	2,200	2,200	1,750	1,300	1,300	1,300
Vitamin D3 (IU)[d]	220	220	200	150	150	150
Vitamin E (IU)[d]	16	16	11	11	11	11
Vitamin K (menadione) (mg)	0.50	0.50	0.50	0.50	0.50	0.50
Biotin (mg)	0.08	0.05	0.05	0.05	0.05	0.05
Choline (g)	0.60	0.50	0.40	0.30	0.30	0.30
Folacin (mg)	0.30	0.30	0.30	0.30	0.30	0.30
Niacin, available (mg)[e]	20.00	15.00	12.50	10.00	7.00	7.00
Pantothenic acid (mg)	12.00	10.00	9.00	8.00	7.00	7.00
Riboflavin (mg)	4.00	3.50	3.00	2.50	2.00	2.00
Thiamin (mg)	1.50	1.00	1.00	1.00	1.00	1.00
Vitamin B_6 (mg)	2.00	1.50	1.50	1.00	1.00	1.00
Vitamin B_{12} (µg)	20.00	17.50	15.00	10.00	5.00	5.00
Linoleic acid (%)	0.10	0.10	0.10	0.10	0.10	0.10

[a]Pigs of mixed gender (1:1 ratio of barrows to gilts). The requirements of certain minerals and vitamins may be slightly higher for pigs having high lean growth rates (> 325 g/day of carcass fat-free lean), but no distinction is made.

[b] Assumes that ME is 96% of DE. In corn-soybean meal diets, ME is 94-96% of DE, depending on crude protein level of the diet.

[c]The percentages of calcium., phosphorus, and available phosphorus should be increased by 0.05 to 0.1 percentage points for developing boars and replacement gilts from 50 to 120 kg body weight.

[d]Conversions: 1 IU vitamin A = 0.344 µg (g retinyl acetate; 1 IU vitamin D_3 = 0.025 µg cholecalciferol; 1 IU vitamin E = 0.67 mg of D-α-tocopherol or 1 mg of DL-α-tocopheryl acetate.

[e]The niacin in corn, grain sorghum, wheat, and barley is unavailable. Similarly, the niacin in by-products made from these cereal grains is poorly available unless the by-products have undergone a fermentation or wet-milling process.

4. Table 4. DAILY Amino Acid Requirements of Gestating Sows (90% DM)[a]

	Body Weight at Breeding (kg)					
	125	150	175	200	200	200
	Gestation Weight Gian (kg)[b]					
	55	45	40	35	30	35
	Anticipated Pigs in Litter					
	11	12	12	12	12	14
DE content of diet (kcal/kg)	3,400	3,400	3,400	3,400	3,400	3,400
ME content of diet (kcal/kg)[c]	3,265	3,265	3,265	3,265	3,265	3,265
Estimated DE intake (kcal/day)	6,660	6,265	6,405	6,535	6,115	6,275
Estimated ME intake (kcal/day)[c]	6,395	6,015	6,150	6,275	5,870	6,025
Estimated feed intake (kg/day)	1.96	1.84	1.88	1.92	1.80	1.85
Crude protein (%)[d]	12.9	12.8	12.4	12.0	12.1	12.4
Amino acid requirements:						
True ileal digestible basis (g/day)						
Arginine	0.8	0.1	0.0	0.0	0.0	0.0
Histidine	3.1	2.9	2.8	2.7	2.5	2.7
Isoleucine	5.6	5.2	5.1	5.0	4.7	5.0
Leucine	9.4	8.7	8.3	7.9	7.4	8.1
Lysine	***9.7***	***9.0***	***8.7***	***8.4***	***7.9***	***8.5***
Methionine	2.7	2.5	2.4	2.3	2.2	2.3
Methionine + cystine	6.4	6.1	6.1	6.0	5.7	6.1
Phenylalanine	5.7	5.2	5.0	4.8	4.6	4.9
Phenylalanine + tyrosine	9.5	8.9	8.6	8.4	7.9	8.5
Threonine	7.3	7.0	6.9	6.9	6.6	7.0
Tryptophan	1.9	1.8	1.7	1.7	1.6	1.7
Valine	6.6	6.1	5.9	5.7	5.4	5.8
Apparent ileal digestible basis (g/day)						
Arginine	0.6	0.0	0.0	0.0	0.0	0.0
Histidine	2.9	2.7	2.6	2.5	2.4	2.6
Isoleucine	5.1	4.8	4.7	4.5	4.3	4.6
Leucine	9.2	8.4	8.1	7.7	7.3	7.9
Lysine	***8.9***	***8.2***	***7.9***	***7.6***	***7.2***	***7.7***
Methionine	2.5	2.4	2.3	2.2	2.1	2.2
Methionine + cystine	6.0	5.7	5.7	5.6	5.3	5.7
Phenylalanine	5.2	4.8	4.6	4.4	4.2	4.5
Phenylalanine + tyrosine	8.8	8.2	8.0	7.7	7.3	7.9
Threonine	6.3	6.0	6.0	6.0	5.7	6.1
Tryptophan	1.6	1.5	1.4	1.4	1.3	1.4
Valine	6.0	5.6	5.4	5.2	4.9	5.3
Total basis (g/day)						
Arginine	1.3	0.5	0.0	0.0	0.0	0.0
Histidine	3.6	3.4	3.3	3.2	3.0	3.2
Isoleucine	6.4	6.0	5.9	5.7	5.4	5.8
Leucine	9.9	9.0	8.6	8.2	7.7	8.3
Lysine	***11.4***	***10.6***	***10.3***	***9.9***	***9.4***	***10.0***
Methionine	2.9	2.7	2.6	2.6	2.4	2.6
Methionine + cystine	7.3	7.0	6.9	6.8	6.5	6.9
Phenylalanine	6.3	5.8	5.6	5.4	5.0	5.4
Phenylalanine + tyrosine	10.6	9.9	9.6	9.4	8.9	9.5
Threonine	8.6	8.3	8.3	8.2	7.8	8.3
Tryptophan	2.2	2.0	2.0	1.9	1.8	2.0
Valine	7.6	7.0	6.8	6.6	6.2	6.7

[a]Daily intakes of DE and feed and the amino acid requirements are estimated by the gestation model.
[b]Weigbt gain includes maternal tissue and products of conception.
[c]Assumes that ME is 96% of DE.
[d]Crude protein and total amino acid requirements are based on a corn-soybean meal diet.

5. Table 5. DAILY Amino Acid Requirements of Lactating Sows (90% DM)[a]

	Sow Postfarrowing Weight (kg)					
	175	175	175	175	175	175
	Anticipated Lactational Weight Change (kg)[b]					
	0	0	0	-10	-10	-10
	Daily Weight Gain of Pigs (g)[b]					
	150	200	250	150	200	250
DE content of diet (kcal/kg)	3,400	3,400	3,400	3,400	3,400	3,400
ME content of diet (kcal/kg)[c]	3,265	3,265	3,265	3,265	3,265	3,265
Estimated DE intake (kcal/day)	14,645	18,205	21,765	12,120	15,680	19,240
Estimated ME intake (kcal/day)[c]	14,060	17,475	20,895	11,635	15,055	18,470
Estimated feed intake (kg/day)	4.31	5.35	6.40	3.56	4.61	5.66
Crude protein (%)[d]	16.3	17.5	18.4	17.2	18.5	19.2
Amino acid requirements:						
True ileal digestible basis (g/day)						
Arginine	15.6	23.4	31.1	12.5	20.3	28.0
Histidine	12.2	17.0	21.7	10.9	15.6	20.3
Isoleucine	17.2	23.6	30.1	15.6	22.1	28.5
Leucine	34.4	48.0	61.5	31.0	44.5	58.1
Lysine	***30.7***	***42.5***	***54.3***	***27.6***	***39.4***	***51.2***
Methionine	8.0	11.0	14.1	7.2	10.2	13.2
Methionine + cystine	15.3	20.6	26.0	13.9	19.2	24.5
Phenylalanine	16.8	23.3	29.7	14.9	21.4	27.9
Phenylalanine + tyrosine	34.6	47.9	61.1	31.4	44.6	57.8
Threonine	19.5	26.4	33.3	17.7	24.6	31.5
Tryptophan	5.5	7.6	9.7	5.2	7.3	9.4
Valine	25.8	35.8	45.8	23.6	33.6	43.6
Apparent ileal digestible basis (g/day)						
Arginine	14.6	22.0	29.3	11.7	19.1	26.4
Histidine	11.5	16.0	20.5	10.2	14.7	19.2
Isoleucine	15.9	21.9	27.9	14.5	20.5	26.5
Leucine	33.0	45.9	58.7	29.7	42.6	55.4
Lysine	***28.4***	***39.4***	***50.4***	***25.5***	***36.5***	***47.5***
Methionine	7.6	10.5	13.4	6.8	9.7	12.6
Methionine + cystine	14.2	19.2	24.1	12.9	17.8	22.8
Phenylalanine	15.5	21.6	27.6	13.8	19.9	25.9
Phenylalanine + tyrosine	32.3	44.7	57.1	29.3	41.7	54.1
Threonine	17.1	23.1	29.2	15.5	21.6	27.7
Tryptophan	4.7	6.6	8.4	4.5	6.3	8.1
Valine	23.6	32.8	42.0	21.6	30.8	40.0
Total basis (g/day)						
Arginine	17.4	25.8	34.3	14.0	22.4	30.8
Histidine	13.8	19.1	24.4	12.2	17.5	22.8
Isoleucine	19.5	26.8	34.1	17.7	25.0	32.3
Leucine	37.2	52.1	67.0	33.7	48.6	63.5
Lysine	***35.3***	***48.6***	***61.9***	***31.6***	***44.9***	***58.2***
Methionine	8.8	12.2	15.6	7.9	11.3	14.6
Methionine + cystine	17.3	23.4	29.4	15.7	21.7	27.8
Phenylalanine	18.7	25.9	33.2	16.6	23.9	31.1
Phenylalanine + tyrosine	38.7	53.4	68.2	35.1	49.8	64.6
Threonine	23.0	31.1	39.1	20.8	28.8	36.9
Tryptophan	6.3	8.6	11.0	5.9	8.2	10.6
Valine	29.5	40.9	52.3	26.9	38.4	49.8

[a]Daily intakes of DE and feed and the amino acid requirements are estimated by the lactation model.
[b]Assumes 10 pigs per litter and a 21-day lactation period.
[c]Assumes that ME is 96% of DE. In corn-soybean meal diets of these crude protein levels, ME is 95-96% of DE.
[d]Crude protein and total amino acid requirements are based on a corn-soybean meal diet.

6. Table 6. DIETARY Mineral, Vitamin, and Fatty Acid Requirements of Gestating and Lactating Sows (90% DM)[a]

	Gestation	Lactation
DE content of diet (kca1/kg)	3,400	3,400
ME content of diet (kca1/kg)[b]	3,265	3,265
DE intake (kcal/day)	6,290	17,850
ME intake (kcal/day)[b]	6,040	17,135
Feed intake (kg/day)	1.85	5.25
Requirements (% or amount/kg of diet):		
Mineral elements		
Calcium (%)	0.75	0.75
Phosphorus, total (%)	0.60	0.60
Phosphorus, available (%)	0.35	0.35
Sodium (%)	0.15	0.20
Chlorine (%)	0.12	0.16
Magnesium (%)	0.04	0.04
Potassium (%)	0.20	0.20
Copper (mg)	5.00	5.00
Iodine (mg)	0.14	0.14
Iron (mg)	80	80
Manganese (mg)	20	20
Selenium (mg)	0.15	0.15
Zinc (mg)	50	50
Vitamins		
Vitamin A (IU)[c]	4,000	2,000
Vitamin D3 (IU)[c]	200	200
Vitamin E (IU)[c]	44	44
Vitamin K (menadione) (mg)	0.50	0.50
Biotin (mg)	0.20	0.20
Choline (g)	1.25	1.00
Folacin (mg)	1.30	1.30
Niacin, available (mg)[d]	10	10
Pantothenic acid (mg)	12	12
Riboflavin (mg)	3.75	3.75
Thiamin (mg)	1.00	1.00
Vitamin B_6 (mg)	1.00	1.00
Vitamin B_{12} (µg)	15	15
Linoleic acid (%)	0.10	0.10

[a]The requirements are based on the daily consumption of 1.85 and 5.25 kg of feed, respectively. If lower amounts of feed are consumed, the dietary percentage may need to be increased.

[b]Assumes that ME is 96% of DE.

[c]Conversions: 1 IU vitamin A = 0.344 µg retinyl acetate; 1 IU vitamin D3 = 0.025 µg cholecalciferol; 1 IU vitamin E = 0.67 mg of D-α-tocopherol or 1 mg of DL-α-tocopheryl acetate.

[d]The niacin in corn, grain sorghum, wheat, and barley is unavailable. Similarly, the niacin in by-products made from these cereal grains is poorly available unless the by-products have undergone a fermentation or wet-milling process.

7. Table 7. DIETARY and DAILY Amino Acid, Mineral, Vitamin, and Fatty Acid Requirements of Sexually Active Boars (90% DM)[a]

	Dietary Requirement		Daily Requirement	
DE content of diet (kcal/kg)	3,400		3,400	
ME content of diet (kcal/kg)	3,265		3,265	
DE intake (kcal/day)	6,800		6,800	
ME intake (kcal/day)	6,530		6,530	
Feed intake (kg/day)	2.00		2.00	
Crude protein (%)	13.0		13.0	
	% or Amount/kg of Diet		Amount/day	
Amino acids (total basis)[b]				
Arginine	-		-	
Histidine	0.19	%	3.8	g
Isoleucine	0.35	%	7.0	g
Leucine	0.51	%	10.2	g
Lysine	***0.60***	***%***	***12.0***	***g***
Methionine	0.16	%	3.2	g
Methionine + cystine	0.42	%	8.4	g
Phenylalanine	0.33	%	6.6	g
Phenylalanine + tyrosine	0.57	%	11.4	g
Threonine	0.50	%	10.0	g
Tryptophan	0.12	%	2.4	g
Valine	0.40	%	8.0	g
Mineral elements				
Calcium	0.75	%	15.0	g
Phosphorus, total	0.60	%	12.0	g
Phosphorus, available	0.35	%	7.0	g
Sodium	0.15	%	3.0	g
Chlorine	0.12	%	2.4	g
Magnesium	0.04	%	0.8	g
Potassium	0.20	%	4.0	g
Copper	5	mg	10	mg
Iodine	0.14	mg	0.28	mg
Iron	80	mg	160	mg
Manganese	20	mg	40	mg
Selenium	0.15	mg	0.3	mg
Zinc	50	mg	100	mg
Vitamins				
Vitamin A[c]	4,000	IU	8,000	IU
Vitamin D3[c]	200	IU	400	IU
Vitamin E[c]	44	IU	88	IU
Vitamin K (menadione)	0.50	mg	1.0	mg
Biotin	0.20	mg	0.4	mg
Choline	1.25	g	2.5	g
Folacin	1.30	mg	2.6	mg
Niacin, available[d]	10	mg	20	mg
Pantothenic acid	12	mg	24	mg
Riboflavin	3.75	mg	7.5	mg
Thiamin	1.0	mg	2.0	mg
Vitamin B_6	1.0	mg	2.0	mg
Vitamin B_{12}	15	µg	30	µg
Linoleic acid	0.1	%	2.0	g

[a]The requirements are based on the daily consumption of 2.0 kg of feed. Feed intake may need to be adjusted, depending on the weight of the boar and the amount of weight gain desired.

[b] Assumes a corn-soybean meal diet. The lysine requirement was set as 0.60% (12.0 g/day). Other amino acids were calculated using ratios (total basis) similar to those for gestating sows.

[c]Couversions: 1 IU vitamin A = 0.344 µg retinyl acetate; 1 IU vitamin D_3 = 0.025 µg cholecalciferol; 1 IU vitamin E = 0.67 mg of D-α-tocopherol or 1 mg of DL-α-tocopheryl acetate.

[d]The niacin in corn, grain sorghum, wheat, and barley is unavailable. Similarly, the niacin in by-products made from these cereal grains is poorly available uuless the by-products have undergone a fermentation or wet-milling process.