NUTRITION IN GENERAL

INTRODUCTION

1. Water

A. One of the most important nutrients required by animals, and perhaps “the” most
important nutrient!?:

1) “Body water” - Embryo, 95%; at birth, 75-80%; at market weight, 45-50%.
2) Starving animals may lose nearly all of body fat, ½ of body protein & 40% of body
weight, and they can still live!
3) Loss of body water:
   a) “4-5%” - Can result in loss of appetite, and animals become restless.
   b) “6-8%” - Can result in metabolic disorders!
   c) “15-20%” - Can result in death!

♫ The animal can live up to 100 days (perhaps, stretching a little!) without food, but only
5-6 days without water!

B. Functions:

1) Involved in the body temperature regulation.
2) An universal solvent - nutrients must be solubilized for digestion/absorption.
3) Has ionizing power - important in biochemical reactions!
4) Involved in transport of nutrients/waste products.
5) Lubricates the body.
6) Provides cushions to organs, fetuses, etc. &
   many other functions.

C. Requirements - Vary!

1) Generally, pigs consume ≈ twice as much water
as dry feed.
2) May require ≥ five times during summer months.

D. Water - “Forgotten Nutrient!?”

1) Water to feed ratios & pig performance - See a
figure.
2) Water hardness & a guide for use of saline water:
   [See tables - Thulin and Brumm, 1991. In: Miller et
   al. (Ed.). Swine Nutrition. Butterworth-Heinemann,
   Boston]
3) Factors affecting water intake and pig performance:

Effects of water & ambient temperatures and water quality on water intake, and the effect of flow rate on drinking time, water intake & performance:

<table>
<thead>
<tr>
<th>Water hardness:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (CaCO₃, ppm)</td>
<td>Soft</td>
</tr>
<tr>
<td>0-60</td>
<td>61-120</td>
</tr>
</tbody>
</table>

A guide for use of saline water for swine (TDS = total dissolved solids):

<table>
<thead>
<tr>
<th>TDS, ppm</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3000</td>
<td>Should be satisfactory for swine. May cause temporary, mild diarrhea in some pigs.</td>
</tr>
<tr>
<td>3000-5000</td>
<td>Generally satisfactory. Temporary diarrhea and water refusal initially when pigs are not accustomed to them. May cause increased water consumption.</td>
</tr>
<tr>
<td>5000-7000</td>
<td>May be used with reasonable safety for growing-finishing pigs. Should avoid the use of these approaching higher levels for pregnant or lactating sows.</td>
</tr>
<tr>
<td>&gt; 7000</td>
<td>Considerable risk may exist with pregnant or lactating sows, or with pigs subjected to heat stress, water loss, or disease conditions.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>H₂O temp.</th>
<th>Cool (22°C)</th>
<th>Hot (35/25°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11°C</td>
<td>3.3</td>
<td>10.5</td>
</tr>
<tr>
<td>30°C</td>
<td>3.9</td>
<td>6.6</td>
</tr>
</tbody>
</table>

* Based on pigs weighing 45-90 kg.

2. Carbohydrates

A. General:

1) Make up 75% of the dry matter in most plants.

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2) The main form of energy source in swine diets.
3) Very little storage in animal's body.

B. Utilization:

1) Cellulose & hemicellulose are not utilized well by pigs, especially by young pigs.
2) Sugar and starch are readily digested by pigs, but, except lactose (& also glucose), young pigs (i.e., nursing & newly weaned pigs) cannot utilize carbohydrates well!

C. Functions:

1) Serve as the 1° source of energy.
2) Involved in heat production, i.e., involved in the body temperature regulation.
3) Fibers can serve as a laxative.
4) Surpluses are converted to body fats, which are energy reserves in the body.

3. Fats/Lipids

A. General:

1) Contain 2.25 x energy vs CH₂O.
2) Act as a carrier of nutrients (e.g., fat-soluble vitamins).
3) A source of essential fatty acids.
4) Some characteristics/advantages? - Highly palatable, ↓ dust in feed & buildings, lubricate equipment, facilitate pelleting process, ↓ feed wastage, etc.

B. Deficiency (i.e., “fatty acid” deficiency, thus not as a source of energy):

1) Can cause skin lesions - Loss of hair, scaly, dandruff-like dermatitis to necrotic lesions and skin eruptions.
2) Can retard the sexual maturity.
3) Can impair the GI system development.

C. Fatty acid requirement:

1) 0.03% linoleic acid - May be sufficient for normal growth but insufficient for normal skin development.
2) Requirement? - Probably between 0.03 and 0.22% of the diet, and the 1998 NRC recommendation is 0.1% of the diet.

Typical grain-soy diets contain adequate amounts to meet the linoleic acid requirement!

4. Protein

A. Proteins or amino acids are required for muscle & milk production, and serving as a component of hide, hoof, hair, hormones, enzymes, blood, etc., thus affecting almost every bodily function!!

B. Pigs must consume protein continuously to build new tissues (growth & reproduction) and(or) to repair worn-out tissues. If not, proteins are mobilized from various tissues to maintain the function/ integrity of more vital tissues/organs!

C. Amino acids - Can be classified into two categories:
1) Indispensable amino acids - Cannot be produced or the rate of synthesis is inadequate to meet the needs. ∴ must be supplied via diets. Include, Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, (Arginine,) Leucine, Lysine.

2) Dispensable amino acids - Can be produced from other amino acids or other nutrients in sufficient quantity to satisfy bodily functions.

C. Proteins or amino acids can be used as a source of energy, but they are expensive energy sources, and also cannot be utilized efficiently compared with carbohydrates or lipids!

5. Minerals

A. Functions:
   1) Structural components, i.e., bones, teeth, etc.
   2) “Homeostasis” - Osmotic pressure, ionic equilibrium, and acid-base balance.
   3) “Function of cell membranes” - Permeability, nerve impulse, Na-K pump, etc.
   4) Involved in enzymatic functions - Can serve as a co-factor of many enzymes and(or) activate various enzymes & others.

B. At present time, 14 minerals have been shown to perform essential functions (i.e., 14 well-established ones): “Macro” elements include Ca, P, Na, K, Cl, and Mg (& S?), and “Micro/trace” elements include Cu, Fe, Co, I, Mn, Zn, and Se.

C. Others may be required in a minute amount by one or more species - e.g., F, Mo, Ni,, Si, Cr, Tn, Va, and some others.

D. Calcium and phosphorus:
   1) Proper Ca to P ratio is 1:1 (ideal) to 1.3:1.
   2) More important to have adequate levels of Ca & P than the ratio per se.
   3) Levels needed for a maximum growth may be inadequate for maximum bone ash and bone strength! Thus, higher Ca & P concentrations are needed for replacement boars and gilts!

E. Many mineral elements can be “toxic” at a very high concentration!

6. Vitamins

A. Organic compounds that are required in small amounts for “normal” growth, reproduction and health of animals, and they are mostly serving as a component of enzymes!

B. The needs for vitamins may have increased in recent years because (e.g.):
   1) ↑ use of simpler diets (i.e., use of fewer ingredients - e.g., corn-soy-based diets), thus less use of ingredients that are high in vitamin contents.
   2) ↑ use of the confinement system - No pasture, less opportunity for coprophagy, increased stress & disease levels, etc.
   3) ↑ use of antimicrobial agents - Inhibit microbial synthesis of some vitamins.
   4) Selection & crossbreeding for meatier and faster growing pigs - ↑ requirements?

C. Fat-soluble vitamins - Include vitamins A, D, E and K, and typical swine diets are fortified with these vitamins.
D. Water-soluble vitamins:

1) Include thiamin, riboflavin, niacin, pantothenic acid, B₆, choline, biotin, folacin, B₁₂ & vitamin C.

2) Fortification? “Almost always” category includes vitamin B₁₂, riboflavin, niacin, pantothenic acid, and choline, and “May be” category includes biotin, B₆ & folacin.

NUTRIENT AVAILABILITY OF FEED INGREDIENTS

“Availability?” - “Digested, absorbed and utilized” nutrients can be defined as being available!

1. Amino Acids

- Digestibility is the 1° limiting factor in full utilization of proteins!

A. Important to consider digestibility of amino acids when using alternative protein sources or energy sources that contain proteins.

B. Probably, diets will be formulated based on available amino acid contents on a regular basis in the future! (The use of available amino acid values is increasing, even though there are insufficient data on the availability of ingredients at this time!)

C. Apparent ileal digestibility - See a box.

2. Phosphorus

A. “Calcium?” - The Ca content in many ingredients are very low, : their availability may not be that important! Also, limestone is an excellent source of Ca (cheap & highly available)!

B. About ½ or more of P is present as phytin (inositol + P & other minerals) in many grains, and only ≈ 20-30% of phytin P is available to pigs!

C. Availability of phosphorus - See a box.

1) < = 50% of P in plant sources is available to pigs.

2) Inorganic sources are generally highly available (> 80%).
3. **Vitamins**

A. Usually, many vitamins in feed ingredients are ignored because:

1) Contents are usually low.
2) Poor availability because they exist in the bound form.
3) Easily destroyed during the storage, processing, etc.

B. Synthetic and natural forms of vitamins are equally effective, but can be destroyed easily by high temperatures, moisture, certain trace elements, light, etc., thus a proper handling/supplementation is important!

**FEED ADDITIVES**

1. **Common Additives**

A. Antibiotics - Compounds synthesized by living organisms that can inhibit the growth of other microorganisms, and include two types (mostly derived from bacteria and molds):

1) Broad spectrum - e.g., Aureomycin (chlortetracycline) & Terramycin (oxytetracycline).
2) Narrow spectrum - e.g., Tylosin, Penicillin, etc.

B. Chemotherapeutics (or chemobiotics) - Compounds that have bacteriostatic or bactericidal properties, and unlike antibiotics, they are produced chemically (e.g., sulfâ compounds, carbadox, & copper sulfate).

C. Combinations - A combination of antibiotic(s) and chemobiotic(s) such as CSP 250, ASP 250 & Tylan Sulfa-G.

D. Probiotics - Bacteria, yeasts or a combination of those (e.g., live yeast cultures, fermentation by-products, lactobacillus species, sarsaponin, etc.), which may competitively inhibit the development of undesirable microorganisms and(or) favor the development of desirable microorganisms.

E. Anthelmintics/dewormers.

2. **Antibiotics**

A. Responses:

1) Age: (Summary of 937 experiments with 20,472 pigs; Peo, 1986. Proc. NE Whole Hog Days)

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Antibiotics</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter (15-57 lb):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, lb</td>
<td>0.86</td>
<td>1.01</td>
<td>16</td>
</tr>
<tr>
<td>Feed:gain</td>
<td>2.32</td>
<td>2.16</td>
<td>7</td>
</tr>
<tr>
<td>Grower (37-108 lb):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, lb</td>
<td>1.30</td>
<td>1.45</td>
<td>11</td>
</tr>
<tr>
<td>Feed:gain</td>
<td>2.91</td>
<td>2.78</td>
<td>5</td>
</tr>
<tr>
<td>Grower-finisher (44-189):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, lb</td>
<td>1.50</td>
<td>1.56</td>
<td>4</td>
</tr>
<tr>
<td>Feed:gain</td>
<td>3.37</td>
<td>3.30</td>
<td>2</td>
</tr>
</tbody>
</table>
2) Experiment station vs. commercial production unit: (Data based on 12,000 pigs; Peo, 1986. Proc. NE Whole Hog Days)

<table>
<thead>
<tr>
<th>Item</th>
<th>Exp. Station</th>
<th>Commercial Prod. Unit</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG (g/d)</td>
<td>16.9</td>
<td>28.4</td>
<td>19.2</td>
</tr>
<tr>
<td>F:G (%)</td>
<td>7.0</td>
<td>14.5</td>
<td>8.5</td>
</tr>
</tbody>
</table>

3) Antibiotics & reproductive performance: (Cromwell, 1986. Univ. of Kentucky)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Conception rate, %</td>
<td>91.4</td>
<td>82.6</td>
</tr>
<tr>
<td>No. pig born</td>
<td>10.8</td>
<td>10.2</td>
</tr>
<tr>
<td>No. pigs weaned</td>
<td>8.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Survival rate, %</td>
<td>89.7</td>
<td>80.9</td>
</tr>
<tr>
<td>Incidence of MMA, %</td>
<td>&lt; 10</td>
<td>66</td>
</tr>
</tbody>
</table>

B. Mode of action (growth promoting activity):

1) “Metabolic effect:”
   a) Directly affect the rate or pattern of metabolic processes.
   b) Bacteriostatic or bactericidal effects. (“Metabolism” is likely to be affected by systemic infections.)

2) “Nutrient-sparing effect” - May stimulate the growth of desirable microorganisms that synthesize vitamins and(or) amino acids.

3) “Disease-control effect” - Can suppress organisms that cause clinical or subclinical manifestation of diseases.

C. Drug resistance:

1) Resistance?
   a) For every 10-mil bacteria, usually one is resistant to a particular antibiotic.
   b) With continuous use of the same antibiotic, the majority of bacteria will be inhibited or killed, but the “resistant” bacteria will multiply rapidly.
      "Equally applicable to domestic species, humans, etc."

2) Two types of resistance:
   a) “Mutational” - Being passed on to daughter cells only.
   b) “Transferable” - Has a R factor or resistance factor, which can be transferred to other bacteria of the same or different types.

3) Questions/problems?
   a) Are antibiotics still effective in animals? - Similar responses to antibiotics, \( \therefore \) still effective (See a box)!
b) Can R factors from normal bacteria be transferred to pathogenic bacteria such as salmonella? - Can be, but very rarely, and disease-causing capability is considerably when they are transferred!
c) Can the resistant pathogen be passed on to humans (. . . If so, antibiotics are no longer effective in treating humans, and drugs of the greatest concern are penicillin and tetracycline!) - Resistant bacteria are unable to establish themselves in the GI tract of human volunteers.


☎️ The Bottom Line?

a) Antibiotics are still effective!
b) Not likely to transfer the resistance from animals to humans! (But, theoretically possible! . . continues to be a subject of concern!)
c) Discontinuing their use may have little impact on antibacterial resistance!

3. Additives and Residues

☎️ Many feed additives must be withdrawn from feeds to ensure residue-free carcasses, and withdrawal periods before slaughter vary among additives.
☎️ The main concern is “sulfa residues!”

A. Reasons for concern (sulfa):

1) Some people are hypersensitive to sulfa - Can develop allergic reactions, and some people show reactions to undetectable levels (. . . fortunately, very small percentage of population!)
2) Sulfamethazine may cause cancer in the thyroid of rodents, which was reported by a group of researchers in 1988 . . but:

a) Their findings have been refuted by many toxicologists during the FDA hearing.
b) The amount of sulfonylurea consumed through meat/pork is unlikely to cause problem - e.g., a total from consumption of one pork chop containing 0.1 ppm/day for 80 years equals one daily dose of human sulfonylurea medication that has no adverse effect on human thyroid!

B. Tolerance level: (FDA)

1) “0.1 ppm” in muscle, liver or kidney - Established based on a long-term toxicology study, and it provides at least a 2,000-fold safety margin for humans!
2) Incidence of violations in pork liver - See a box.

C. Prevention check list:

1) Always read and follow directions, i.e., use proper dosage and follow withdrawal times & keep records! Don't rely on “memory!”

2) Use part of other ingredients as a carrier for uniform mixing, and mix diets in proper sequence & flush the mixer - e.g., medicated feed – non-medicated feed for non-marketable animals – withdrawal feed, etc.

3) Use only a granulated form, never use a powdered form!

4) Restrict its use to starter diets.

5) Clean everything regularly - mixing equipment/rooms, transporting equipment (feed and pigs), holding bins, etc.

6) Avoid the use of feeders for both medicated and non-medicated feed. (Just one mouthful can result in a tissue concentration that can violate!)

7) Do not mix pigs receiving diets with sulfa with market hogs.

8) After sulfa withdrawal, move pigs to clean pens, and clean pens thoroughly 3 to 4 consecutive days.

### ON-FARM MIXING OF FEED

1. Terminology

   A. Supplements - Contain protein, minerals and vitamins, and mix with grain(s) to produce complete diets.

   B. Base mixes - Contain minerals and vitamins, and mix with grain(s) and protein supplement(s) to produce complete diets.

   C. Premixes - Mineral or vitamin mix, and mix with grain(s), protein supplement(s) and mineral and(or) vitamin premix to produce complete diets.

2. Basic Systems of Mixing Diets

   A. Portable grinder-mixer:

      1) Break-even volume? - 200 to 400 tons/yr (30 to 60 sows).
      2) Advantages? - Provides a flexibility (location, delivery, etc.), and can grind hay.
      3) Disadvantages? - Highest labor & operating costs, and requires a tractor.

   B. Mill with portable mixer:

      1) Break-even volume? - 200 to 400 tons/yr (30 to 60 sows).
      2) Advantages? - Can pre-grind grain, flexibility.
      3) Disadvantages? - High labor & operating costs, and requires a tractor or truck.

   C. Stationary mill with stationary mixer:

      1) Break-even volume? - 200 to 400 tons/yr (30 to 60 sows).

---

### Incidence of violations in pork liver:

(Cromwell, 1986. Univ. of Kentucky)

<table>
<thead>
<tr>
<th>Year</th>
<th>% viol.</th>
<th>Year</th>
<th>% viol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970's</td>
<td>&gt;15</td>
<td>1981</td>
<td>6.0</td>
</tr>
<tr>
<td>1977</td>
<td>13.2</td>
<td>1982</td>
<td>4.3</td>
</tr>
<tr>
<td>1978</td>
<td>9.7</td>
<td>1983</td>
<td>8.0</td>
</tr>
<tr>
<td>1979</td>
<td>6.3</td>
<td>1984</td>
<td>5.9</td>
</tr>
<tr>
<td>1980</td>
<td>4.5</td>
<td>1985</td>
<td>5.4</td>
</tr>
</tbody>
</table>

& More recent data on "Sulfa-on-Site (SOS)" surveillance of market pigs:


<table>
<thead>
<tr>
<th>Year</th>
<th>% viol.</th>
<th>Year</th>
<th>% viol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>0.28%</td>
<td>1991</td>
<td>0.20%</td>
</tr>
<tr>
<td>1989</td>
<td>0.44%</td>
<td>1992</td>
<td>0.21%</td>
</tr>
<tr>
<td>1990</td>
<td>0.26%</td>
<td>1993</td>
<td>0.10%</td>
</tr>
</tbody>
</table>
2) Advantages? - Can have more control in diet composition, can pre-grind grain, can include automatic delivery system.
3) Disadvantages? - High labor costs, components must be matched, i.e., may or may not be able to use some existing facilities.

D. Automatic electric mill:

1) Break-even volume? - 200 to 400 ton/yr (30 to 60 sows).
2) Advantages? - Lowest labor & operating costs, can include automatic delivery system.
3) Disadvantages? - Must be routinely calibrated, does not handle hay, may or may not be able to use some existing facilities.

E. Package feed center with automatic mill:

1) Break-even volume? - 800 to 1,200 tons/yr (100 to 180 sows).
2) Advantages? - Pre-engineered for reliability, use of bucket-elevator (e.g.) for handling grains & feed, can include automatic delivery system.
3) Disadvantages? - High costs due to overhead bins, few options in size of the unit.

F. Batching plant - Highly mechanized:

1) Break-even volume? - 2,000 to 4,000 tons/yr (300 to 600 sows).
2) Advantages? - Precise diet control, does not require calibration.
3) Disadvantages? - High initial costs, must be a custom-built.

3. Physical Forms and Processing of Feed

A. Fineness of grind:

1) All feedstuffs should be ground (or rolled) for swine.
2) Optimum fineness depends on age of pigs, method of processing, type of grain, feed wastage, etc.
3) “Finely ground” (< ½ to 3/16-in screen) - Can be utilized better by young pigs, but can increase wind loss, increase dusty conditions in the confinement, may increase incidence of gastric ulcers, and may reduce acceptability/palatability (e.g., wheat).
4) “Medium ground” (¼ to ½-in screen) - Perhaps, gives the best overall results!
5) “Coarsely ground” (> ½-in screen) - Generally, utilized less efficiently, but acceptable for high moisture grains.

B. Pelleting:

1) Used extensively by commercial feed companies.
2) Can expect improvement in feed efficiency by 5 to 8%. (For oats and barley-based diet, can expect 7 to 10% improvement.)
3) In general, can be justified for expensive diets (e.g., starter diets).

C. “Wet” feeders:

1) Feeders that allow pigs to wet feed with water before consumption.
2) Slightly better feed efficiency in some instances.
3) May require more intensive management vs. dry feeders. (A proper adjustment is must! Otherwise, ↓ feed intake/↑ wastage of feed.)

4. Improving “On-Farm” Mixed Diet

A. Should the producer be concerned about quality of feeds? - See one data set in a box!

Both an excess or deficiency can be costly, i.e., costs of supplements & costs of reduced performance!

B. Possible causes of “poor” feed quality:

1) Errors in the diet formulation:

a) Using supplements - Less problem, except when using alternative grains.
b) Using premixes - More susceptible to formulation errors.
c) May want to have the formula double-checked by a nutritionist.

2) Not adhering to formula:

a) Some ingredients may be inadvertently excluded.
b) Thus, may want to use a checklist - e.g.:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
<th>00/00/00</th>
<th>Date 00/00/00</th>
<th>Date 00/00/00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1596</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean meal</td>
<td>310</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dical</td>
<td>22</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>. . ., etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) Not weighing ingredients properly:

a) Weighing is more accurate than measuring by volume because “bulk density” changes according to moisture content, fiber content, etc. (If measured by the volume, calibrate equipment frequently!)
b) Weighing also allows producers to keep more accurate feed records.

4) Insufficient mixing time:

a) Double ribbon “horizontal” mixers (require less time.) - Satisfactory mix in 5 min after addition of the last ingredient?
b) Single screw “vertical” mixers (require more time) - 15 min may be sufficient?

5) The amount of feed and size of mixer - Both over- & under-filling can result in inadequate mixing, follow manufacture's suggested levels!

6) Improper sequence of adding ingredients:

a) The order of adding ingredients can affect the uniformity of diets, and also the time required to achieve adequate mixing.
b) Suggested sequence? - About 1/2 of grain (or all protein supplement) → premixes and other micro ingredients → protein source(s) → balance of grain.

7) Premixing - Difficult to mix drugs, vitamin & mineral premixes properly because of the amount to be incorporated:
   a) Recommendations? - Never add < 2 to 2½ percent when using vertical mixer, whereas a minimum to add should be 1 percent when using a horizontal mixer.
   b) If including less than those levels, use a carrier (e.g., finely ground corn) before adding small amounts into the mixer.

8) Segregation:
   a) Major contributing factors are particle size, shape & density.
   b) Can ↓ segregation by processing grains to ↓ particle-size variations among ingredients.

9) Variations in composition of ingredients:
   a) Soybean meal - The CP content is guaranteed, but sometimes it does not meet the specification.
   b) Corn - May need to analyze for CP periodically.

C. Laboratory feed analyses:

1) Samples - Must obtain representative samples to be meaningful:
   a) A probe is a valuable tool in sampling feeds and ingredients.
   b) It is best to collect numerous samples, mix them thoroughly and subsample.

2) Suggested analyses:
   a) Complete diets - Moisture & CP if using grain & supplement, and moisture, CP, Ca, P & one trace mineral if using grain, soybean meal & premixes.
   b) Individual ingredients - Moisture & CP for grains, and moisture, CP & Ca for soybean meal.

<table>
<thead>
<tr>
<th>Range of CP, %</th>
<th>% of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0 - 6.9</td>
<td>3</td>
</tr>
<tr>
<td>7.0 - 7.9</td>
<td>51</td>
</tr>
<tr>
<td>8.0 - 8.9</td>
<td>36</td>
</tr>
<tr>
<td>9.0 - 9.9</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 10.0</td>
<td>6</td>
</tr>
</tbody>
</table>

Average = 7.88%