# COMPUTING AND BALANCING SWINE RATIONS

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## CONTENTS


| | Page |
|---|---|
| Characteristics of a Balanced Ration | 3 |
| Protein | 3 |
| Energy (Carbohydrate and Fat) | 4 |
| Vitamins | 4 |
| Minerals | 4 |
| Water | 4 |
| Other Considerations | 5 |
| Ration Formulations | 5 |
| Example I | 5 |
| Example II | 7 |
| Example III | 8 |
| Example IV | 11 |
| Special Considerations | 14 |
| Summary | 14 |
| Appendix | 15 |

# COMPUTING AND BALANCING SWINE RATIONS

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Swine are not roughage-consuming animals in the sense that ruminants (cattle, sheep, goats) are. They have a simple stomach of relatively small capacity (2-gallon capacity in a 200-pound animal). However, since the pig is an omnivorous animal, it is able to eat and utilize feed ingredients of both animal and plant origin.

The nutritional needs of the animal are influenced by size, growth, gestation and lactation. A swine feeding program should therefore be comprised of rations designed for specific purposes. One type of ration will not serve all purposes. Types of rations that should be incorporated into a swine feeding program include:

| | |
|---|---|
| 1. Pre-starter | ) Birth to |
| 2. Starter | ) 40 pounds weight |
| 3. Grower | 40 pounds to 100 pounds |
| 4. Finisher | 100 pounds to market weight |
| 5. Sow gestation | |
| 6. Sow lactation | |

## CHARACTERISTICS OF A DESIRABLE RATION

Balancing swine rations is largely a matter of correcting the nutritional deficiencies of the feed ingredients used as energy sources (grains, cassava, and others), which are normally low in protein (quantity and quality) as well as in certain vitamins and minerals. To formulate rations that are nutritionally adequate and economical, it is necessary to know what the nutrient requirements of swine are (see Appendix, Tables 1–7) and which feed ingredients provide the best sources of the nutrients needed (see Appendix, Table 8).

In general, a swine ration must meet the nutritional requirements of the animal in terms of the nutrients discussed below in order to result in satisfactory performance.

### Protein

Proteins are made up of amino acids. Twenty-two of these have been identified. Ten of these are essential in the ration of the pig since his body cannot produce them sufficiently to meet his needs for maintenance, growth, reproduction, and lactation. In formulating rations, consideration of protein quantity alone is not adequate. The requirement of essential as well as the total amino acids must be met. The pig has a specific requirement for each essential amino acid. The amino acids must be present in the proper amounts and in the correct ratio with each other

to obtain maximum performance. The exact need for each essential amino acid varies not only with age and rate of production, but with the level of total protein. The three amino acids most likely to be deficient or borderline in supply in most swine rations are lysine, tryptophan, and methionine.

**Energy (Carbohydrate and Fat)**

Most of the energy in swine rations is supplied by carbohydrates. Carbohydrates are composed of nitrogen-free extract (N.F.E.), the more digestible part, and crude fiber, the more indigestible portion. Fat is a more concentrated source of energy than carbohydrate. One unit of fat will supply about 2¼ times as much energy as one unit of carbohydrate. Energy values of feed ingredients are expressed in several ways, the most common being total digestible nutrients (T.D.N.) and digestible energy (D.E.). T.D.N. is obtained by adding together the digestible nutrients in the ration (protein, carbohydrate, and fat multiplied by 2.25). Digestible energy refers to the total amount of energy available in a feedstuff minus the nondigested energy that is lost in the feces. One pound of T.D.N. (measured by a digestion trial with the pig) is approximately equivalent to 2,000 kilocalories of D.E.

**Vitamins**

The important vitamins to consider since they may be deficient or barely adequate in swine rations are vitamins A and D, riboflavin, pantothenic acid, niacin, vitamin $B_{12}$, and choline. Some vitamins are stored in the pig's body (vitamins A and D and thiamine). Others are manufactured in the animal's body (vitamins K and C and biotin). The availability and need of vitamins by the pig may be affected by several factors. High intake of nitrates increases the need for vitamin A. The levels of calcium and phosphorus and their ratio influence the need for vitamin D. Most of the niacin in cereal grains is in a bound form and not available to the pig. The amino acids tryptophan and methionine may be used by the pig to produce the vitamins niacin and choline, respectively. Many vitamins, particularly A, E, and D, are unstable and will deteriorate under conditions of high temperature, humidity, long storage, rancidity, or in the presence of certain minerals.

**Minerals**

Of primary importance are the major minerals calcium, phosphorus, and salt (sodium and chlorine), and the trace minerals iron, copper, zinc, iodine, and manganese. There are many interrelationships among minerals that influence the availability of the mineral to the pig. To obtain proper calcium and phosphorus utilization, not only must there be an adequate level of each mineral and vitamin D, but also a suitable ratio between the two. The calcium requirements are 1¼ to 1½ times the required phosphorus level. The level of calcium in the ration will have an effect on how the pig absorbs manganese, zinc, iron, and copper. Interrelationships affecting utilization exist between copper and zinc, copper and iron, cobalt and iodine, iron and cobalt, and iron and manganese. The form of these elements in the feed also may determine their availability to the animal.

**Water**

Depending upon climatic conditions and size of animal, pigs require about 2 to 3 pounds of water for each pound of air-dry feed consumed.

**Other Considerations**

All of the nutrients mentioned above have to be furnished in the correct proportions, levels, and form so as to correctly supply the requirements for the particular phase of production involved. In addition, a good ration has the following characteristics:

1. The ration must be palatable. To obtain its nutritional requirements from the ration, the animal must be willing to consume the ration readily. Fineness of grinding, amount of mineral in the ration, amount of fiber, kind of ingredient, and freshness of mixture all affect palatability.

2. A good ration often includes a variety of feeds. This helps prevent nutritional deficiencies as well as increase palatability. Variety of ingredients within a ration is not essential so long as the nutritional requirements are met. With the premixes of synthetic amino acids, mineral, and vitamin that are available, very simple rations are often successful.

3. A good ration should not contain foreign matter or "filler" materials that serve no particular purpose. Oat hulls, rice hulls, and sugarcane bagasse are examples of "filler" materials. These substances of high fiber content not only fail to supply nutrients, they may also lower the availability of nutrients from other sources.

4. Proper levels of ingredients should be used. Some feed ingredients give good results at low levels but poor results at high levels. Examples are cottonseed meal, tuna meal, and meat and bone meal.

5. Avoid feed ingredients that cause rancidity. Rancid feeds are not palatable and can result in the destruction of certain vitamins. Feed ingredients with high fat content can result in rancidity. Rice bran, rice polish, dried or pressed copra, and fresh coconut meat are examples of feed ingredients with high fat content.

6. Avoid feed ingredients containing toxic substances. Examples are flourine in raw rock phosphate; selenium in grains grown on certain soils; gossypol in cottonseed meal; mimosine in *Leucaena leucocephala* ("koa haole," "ipil-ipil"); prussic acid present in certain varieties of cassava; trypsin inhibitor and methionine and cystine utilization depressant in raw soybeans; and glucoside present in hull and kernel of the seed of the cycad.

7. A ration must be economical in terms of cost per pound of pork produced.

8. A ration should not have an adverse effect on the carcass. Soft pork may result from feeding soybeans, peanuts, rice bran, rice policy, and garbage. Soft pork may or may not be desirable depending upon consumer preference. The use of poor-quality fish meal at high levels may result in fishy flavor in pork.

## RATION FORMULATIONS

The following are examples of ration formulations by the use of the "Pearson Square" or "Dairyman's Square" to determine how much energy and protein ingredients to use to make a feed mixture with a specified protein content.

### EXAMPLE I

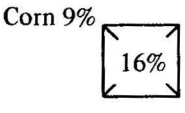
**Use of a single energy source plus a commercial protein-mineral-vitamin supplement.**

Compute a growing pig ration containing 16 percent protein from corn (maize) containing 9 percent protein and a commercial supplement containing 40 percent protein.

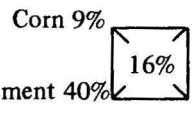
Step 1.
Draw a square.

Step 2.
In the center of the square, put the protein content (16%) desired in the final mixture.

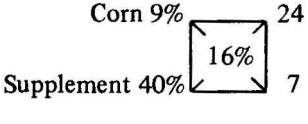

Step 3.
At the upper left-hand corner of the square, write "Corn" and its protein content (9%).



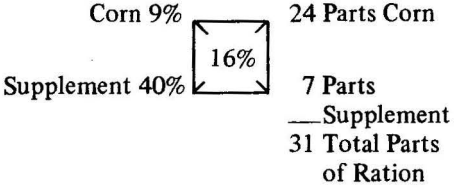

Step 4.
At the lower left-hand corner, write "Supplement" and its protein content (40%).




Step 5.
Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right-hand side (16 - 9 = 7; 40 - 16 = 24).




Step 6.
The number at the upper right-hand corner gives the parts of corn (24), and the number at the lower right-hand corner gives the parts of supplement (7) needed to make a mixture containing 16% protein. Thus 24 parts of corn mixed with 7 parts of supplement gives 31 parts of feed with 16% protein.




Step 7.
To convert the figures above to percentages, divide 31 into 24 and multiply by 100%. The result, 77.4%, indicates the amount of corn that will be used in the ration.

$$\% \text{ Corn} = \frac{24}{31} \times 100\% = 77.4\%$$

$$\% \text{ Supplement} = \frac{7}{31} \times 100\% = 22.6\%$$

The supplement portion would represent 22.6% (divide 31 into 7 and multiply by 100% or 100 - 77.4 = 22.6). Thus in a 100-pound 16% protein mix, there would be 77.4 pounds of corn and 22.6 pounds of supplement.

The above example is the simplest way to compute and balance a ration, using a single energy source combined with a commercial protein-mineral-vitamin supplement. A reliable commercial supplement contains sufficient levels of protein, minerals, and vitamins so that when mixed with the energy source (in

this case, corn) according to recommendations, a complete ration will be obtained to adequately meet the animal's nutrient requirements. For a ration using several sources of energy together with a commercial supplement, the procedure becomes a little more involved. However, the basic principles of the "Square Method" is used.

**EXAMPLE II**

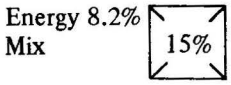
**Use of several feed ingredients as energy sources plus a commercial protein-mineral-vitamin supplement.**

Compute a feed mixture for gestating sows containing 15 percent crude protein from a mixture of corn (9% crude protein), dried cassava meal (1.4% crude protein), and rice bran (13.5% crude protein) and a commercial protein-mineral-vitamin supplement containing 40 percent crude protein. It will be assumed that the energy mixture to be used will be comprised of 50 percent corn, 25 percent cassava meal, and 25 percent rice bran. Before we can apply the "Square Method" it is necessary to establish the protein content of the energy mixture. This calculates to be approximately 8.2 percent crude protein [(50 x 9%) + (25 x 1.4%) + (25 x 13.5%)]. We can now proceed as before.

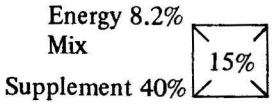
Step 1.
Draw a square.

Step 2.
In the center of the square, put the protein content (15%) desired in the final mixture.

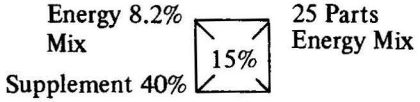

Step 3.
At the upper left-hand corner of the square, write "Energy Mix" and its protein content (8.2%).



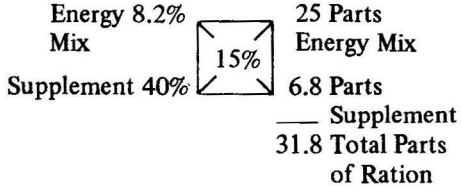

Step 4.
At the lower left-hand corner, write "Supplement" and its protein content (40%).




Step 5.
Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right-hand side (15 - 8.2 = 6.8; 40 - 15 = 25).




Step 6.
The number at the upper right-hand corner gives the parts of energy mix (25), and the number at the lower right-hand corner gives the parts of supplement (6.8) needed to make a final mixture containing 15% protein. Thus, 25 parts of energy mix combined with 6.8 parts of supplement gives 31.8 parts of feed with 15% protein.



Step 7.
To convert the figures above to percentages, divide 31.8 into 25 and multiply by 100%. The result, 78.6%, indicates the amount of energy mix that will be used in the ration.

$$\% \text{ Energy Mix} = \frac{25}{31.8} \times 100\% = 78.6\%$$

The supplement portion would represent 21.4% (divide 31.8 into 6.8 and multiply by 100% or 100 - 78.6 = 21.4). Thus in a 100-pound 15% protein mix, there would be 78.6 pounds of energy mix and 21.4 pounds of supplement. Corn would represent 50% of 78.5 pounds or 39.3 pounds, cassava meal would be 25% of 78.5 pounds or 19.65 pounds, and rice bran would constitute 25% of 78.5 pounds or 19.65 pounds. Thus the complete ration to provide a 15% protein ration will be:

| | |
|---|---|
| Corn | 39.30 lbs. |
| Cassava meal | 19.65 lbs. |
| Rice bran | 19.65 lbs. |
| Protein supplement | 21.40 lbs. |
| Total | 100.00 lbs. |

In the case where a commercial protein-mineral-vitamin supplement is not available and the ration must be computed using basic feed ingredients, or where several sources of protein and/or energy are desired, the procedure becomes a little more complex. However, the same "square" principle can be used. In this situation, not only must we be concerned about the correct protein level, but we must also make sure that adequate levels of mineral (calcium, phosphorus, and salt, primarily) and vitamins are present in the final mixture. Certain guidelines can be used to determine approximate levels of feed ingredients to use. Table 9 in the Appendix can be used as a guide in establishing maximum levels of feed ingredients to add depending upon the phase of production concerned. Most complete swine rations require a standard addition of 0.5 percent salt (trace mineralized salt preferred). Where only protein from plants is used, then normally 1 or 2 percent dicalcium phosphate or steamed bone meal (calcium and phosphorus source) will need to be added. If vitamin premixes are available, then normally 0.25 to 0.50 percent will be added to the complete ration to ensure adequate vitamin levels.

**EXAMPLE III**

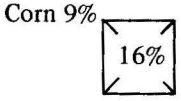
**Use of a single energy source plus a single protein source.**

Compute a growing pig ration containing 16 percent protein from corn containing 9 percent protein and soybean oil meal containing 44 percent protein. Since this mixture is comprised of a single energy source and a single protein source of plant origin, additional sources of calcium and phosphorus as well as salt are needed. A vitamin premix should be added if available.

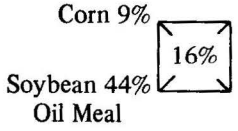
Step 1.
The first step in balancing the ration is to determine what combination of the two main ingredients is needed to establish the correct protein level. As before, draw a square.

Step 2.
In the center of the square, put the desired protein content (16%) of the final mix.

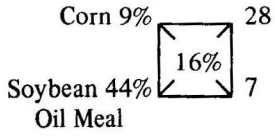

Step 3.
At the upper left-hand corner of the square, write "Corn" and its protein content (9%).



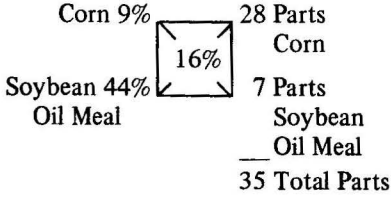

Step 4.
At the lower left-hand corner write "Soybean Oil Meal" and its protein content (44%).




Step 5.
Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right-hand side (16 - 9 = 7; 44 - 16 = 28).




Step 6.
The number at the upper right-hand corner gives the parts of corn (28) and the number at the lower right-hand corner gives the parts of soybean oil meal (7) needed to make a mixture with 16% protein.




Step 7.
To convert the figures above to percentages, divide 35 into 28 and multiply by 100%. The result, 80%, indicates the amount of corn in the ration. Thus 80 pounds of corn mixed with 20 pounds of soybean oil meal will

$$\% \text{ Corn} = \frac{28}{35} \times 100\% = 80.0\%$$

$$\% \text{ Soybean Oil Meal} = \frac{7}{35} \times 100\% = 20.0\%$$

provide a 16% protein mix. This then meets the protein requirements and assumes that the amino acid requirements are also met. However, when untested combinations of ingredients are used, the total amino acid level should be checked against the pig's requirement, especially the three amino acids that are commonly deficient (lysine, tryptophan, and methionine).

Step 8.
Adjusting the mineral. The next step is to calculate how much calcium and phosphorus the corn and soybean oil meal contribute, then to make up the

differences between these amounts and the recommended levels of these nutrients. The nutrient requirements table (see Appendix, Table 1) indicates that a 16% protein ration for growing animals weighing 44 to 77 pounds should contain 0.65% calcium and 0.50% phosphorus. The feed composition table (see Appendix, Table 8) shows that corn contains 0.02% calcium and 0.33% phosphorus. Soybean oil meal contains 0.32% calcium and 0.67% phosphorus. To calculate the amount of calcium and phosphorus contributed by each ingredient, a worksheet similar to that shown in Figure 1 can be used for the necessary calculations. Thus, to calculate the amount of calcium and phosphorus supplied by the corn:

(a) Multiply .02% calcium in corn x 80 pounds = 0.016 lb.
(b) Multiply 0.33% phosphorus in corn x 80 pounds = 0.26 lb.

To calculate the amount of calcium and phosphorus in soybean oil meal:

(a) Multiply 0.32% calcium in soybean oil meal x 20 pounds = .06 lb.
(b) Multiply 0.67% phosphorus in soybean oil meal x 20 pounds = 0.13 lb.

The total amount of calcium and phosphorus supplied in the ration then is 0.076 pound calcium (.016 + .06) and 0.39 pound phosphorus (0.26 + 0.13). Since the calcium and phosphorus requirements are 0.65 and 0.50 pound, respectively, this means that 0.57 pound calcium (0.65 - 0.08) and 0.11 pound phosphorus (0.50 - 0.39) must be added to the ration.

Table 10 in the Appendix indicates some common supplemental sources of calcium, phosphorus, and trace minerals.

| Ingredient | Amount (Lbs.) | Calculated Analysis Protein (Lbs.) | Calcium (Lbs.) | Phosphorus (Lbs.) | Salt (Lbs.) |
|---|---|---|---|---|---|
| Corn | 80 | 7.20 | .016 | .26 | - |
| Soybean oil meal | 20 | 8.80 | .060 | .13 | - |
| Sub-Total | 100 | 16.00 | .076 | .39 | 0 |
| Dicalcium phosphate | 0.9 | - | .27 | .19 | |
| Limestone | 1.0 | - | .34 | - | |
| Salt (trace mineralized) | 0.5 | | | | .50 |
| Grand Total | 102.4 | 16.0 | .69 | .58 | .50 |
| Nutritive requirement | | 16.0 | .65 | .50 | .50 |

*Figure 1. Worksheet of a sample ration formulation using a single energy source plus a single protein source*

The supplemented phosphorus need can be determined by dividing the amount of phosphorus needed (0.11 lbs ) by the amount of phosphorus in 1 pound of the phosphorus supplement. If dicalcium phosphate is used, then 0.9 pound will need to be added to the ration (0.11 lbs needed ÷ 0.19 lbs in 1 lb. dicalcium phosphate). The requirements for phosphorus are now met. The addition of 0.9 pound of dicalcium phosphate will also contribute .24 pound of calcium to the ration (0.9 x .27). This brings the total amount of calcium in the ration up to 0.32 pound. The ration is still short 0.33 pound of calcium to meet the requirements. If limestone is used, then the amount of limestone needed to supply this is calculated by dividing the need (.33) by the amount in 1 pound (.34) which equals 1 pound. Thus the addition of 1 pound of limestone will contribute 0.34 pound calcium. Now the calcium requirements are met.

The salt requirement is ½ of 1 percent of the ration. This can be met by adding ½ pound of trace mineralized salt. The use of trace mineralized salt will also satisfy the trace mineral requirements.

Similar procedures as outlined above can be used to establish levels of vitamins and other nutrients in the ration to compare with the requirements. To satisfy the vitamin requirements, the simplest procedure is to add 0.25 to 0.50 percent vitamin premix (or manufacturer's recommendation) to the ration.

With the addition of the mineral, salt, and vitamin mix to the ration, the total amount of the ration exceeds 100. This will have the effect of slightly reducing the percentage of protein. To maintain the 16-percent protein level, it will be necessary to adjust the total amount of corn and soybean oil meal. By making the slight adjustment of increasing the soybean oil meal by 1 pound to 21 pounds and reducing the corn by a corresponding 1 pound to 79 pounds, the total ration of 102.4 pound will analyse to 16 percent protein.

**EXAMPLE IV**

**Use of several feed ingredients as sources for energy and for protein.**

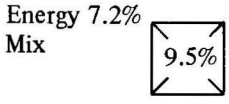
Formulate a sow gestation ration containing 15 percent protein. The feed ingredients to be used in the energy mix will be comprised of cassava meal, corn, and wheat middlings in the proportion of 50, 25, and 25 percent, respectively. It will be assumed that a standard amount of 10 percent coconut oil meal (copra meal), 5 percent tuna meal, and 5 percent meat and bone meal will be added to the ration as protein sources. Soybean oil meal is available to balance the ration for protein. Using the feed composition table (see Appendix, Table 8), it is noted that coconut oil meal (solvent) is comprised of 21.4 percent crude protein; tuna meal, 55 percent crude protein; and meat and bone meal, 51 percent crude protein. Consequently, 10 pounds of coconut oil meal will contribute 2.14 pounds of protein (10 x 21.4%) to the ration. Five pounds of tuna meal will contribute 2.75 pounds of protein (5 x 55%), and 5 pounds of meat and bone meal will contribute 2.55 pounds of protein (5 x 51%). The addition of these three protein sources will then contribute a total of 7.4 pounds of protein to the ration. Therefore, we need only 7.6 percent additional protein (15 - 7.4) from the energy and soybean oil meal portions of the ration. However, the energy sources and the soybean oil meal will now only comprise 80 percent of the ration. Thus, to obtain the desired protein level, we divide 80 into 7.6 to obtain 9.5 percent. Before we can apply the "Square

Method" it is necessary to establish the protein content of the energy mixture. This calculates to be approximately 7.2 percent crude protein [(50 x 1.4%) + (25 x 9%) + (25 x 17%)]. We can now proceed as before.

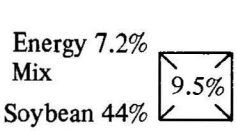
Step 1.
Draw the square.

Step 2.
In the center of the square, put the protein content (9.5%) desired.

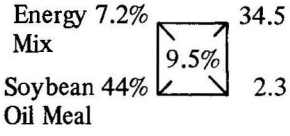

Step 3.
At the upper left-hand corner of the square write "Energy Mix" and its protein content (7.2%).



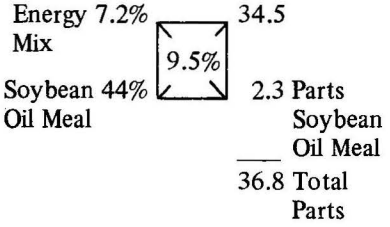

Step 4.
At the lower left-hand corner, write "Soybean Oil Meal" and its protein content (44%).




Step 5.
Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right-hand side (9.5 - 7.2 = 2.3; 44 - 9.5 = 34.5).




Step 6.
The number at the upper right-hand corner gives the parts of energy source (34.5) and the number at the lower right-hand corner (2.3) gives the parts of soybean oil meal needed to make a mixture of 9.5% protein.




Step 7.
To convert these figures above to percentages, divide 36.8 into 34.5 and multiply by 100% and divide 36.8 into 2.3 and multiply by 100%. This results in 93.7% and 6.3%, respectively. Thus, of the 80 pounds, 75 pounds will by energy source and 5 pounds will be soybean oil

$$\text{Pounds of Energy Mix} = \frac{34.5}{36.8} \times 100\% \times 80\# = 75\#$$

$$\text{Pounds of Soybean Oil Meal} = \frac{2.3}{36.8} \times 100\% \times 80\# = 5\#$$

meal. The basic ration will then consist of:

| | |
|---|---|
| Energy mix | 75 lbs. |
| Soybean oil meal | 5 lbs. |
| Coconut oil meal | 10 lbs. |
| Tuna meal | 5 lbs. |
| Meat and bone meal | 5 lbs. |

Cassava meal would represent 50% of 75 pounds or 37.5 pounds; corn would represent 25% of 75 pounds or 18.75 pounds; and wheat middlings would be 25% of 75 pounds or 18.75 pounds. Thus, the complete mix to provide a 15% protein ration would consist of:

| | |
|---|---|
| Cassava meal | 37.5 lbs. |
| Corn | 18.75 lbs. |
| Wheat middlings | 18.75 lbs. |
| Soybean oil meal | 5.0 lbs. |
| Coconut oil meal | 10.0 lbs. |
| Tuna meal | 5.0 lbs. |
| Meat and bone meal | 5.0 lbs. |

Step 8.

Adjusting the mineral. The next step is to calculate how much calcium and phosphorus are contributed by the ingredients in the ration. Using the feed composition tables (see Appendix, Table 8) and the worksheet (Figure 2), it is found that sufficient calcium and phosphorus is supplied by these ingredients to meet the requirements. This is brought about primarily by the addition of tuna meal and meat meal. Thus, it is not necessary to add a supplemental source of calcium and phosphorus. One-half percent of trace mineralized salt should be added to meet the salt and trace mineral requirements. If available, a vitamin premix can be added at levels recommended by the manufacturer to ensure that vitamin requirements are satisfied.

| Ingredient | Amount (Lbs.) | Calculated analysis Protein (Lbs.) | Calcium (Lbs.) | Phosphorus (Lbs.) | Salt (Lbs.) |
|---|---|---|---|---|---|
| Cassava meal | 37.5 | .52 | .05 | .06 | |
| Corn | 18.75 | 1.69 | .00 | .06 | |
| Wheat middlings | 18.75 | 3.19 | .02 | .10 | |
| Soybean oil meal | 5.0 | 2.20 | .01 | .03 | |
| Coconut oil meal | 10.0 | 2.14 | .02 | .06 | |
| Tuna meal | 5.0 | 2.75 | .25 | .15 | |
| Meat meal | 5.0 | 2.55 | .53 | .25 | |
| Sub-Total | 100.0 | 15.04 | .88 | .71 | |
| Salt (trace mineralized) | .5 | | | | .50 |
| Grand Total | 100.5 | 15.04 | .88 | .71 | .50 |
| Nutritive requirements | | 15.0 | .75 | .50 | .50 |

*Figure 2. Worksheet of a sample ration formulation using several feed ingredients as sources of energy and of protein*

**Special Considerations**

Certain feeding practices may call for the use of protein-mineral-vitamin supplements rather than the use of complete feeds. Situations that would lend itself to the use of supplements include:

1. Garbage feeding.
2. Feeding the energy source *ad libitum* and separately from the protein source.
3. Feeding energy ingredients that may be difficult to use as a complete, uniform mix in the final ration because of their physical consistency. Examples of these ingredients would be chopped dried cassava, other root crops, tree crops.

Protein supplements can be mixed with the energy source to make a complete ration or they can be hand-fed in measured amounts each day in addition to the energy source, which can be fed *ad libitum.*

## SUMMARY

All of the examples above show how to formulate complete rations. These complete rations will meet the animal's nutritional requirements when this is the only ration fed, assuming that adequate amounts of the ration are consumed by the animal. Complete rations should not be diluted with any other feed ingredients after the initial formulation; otherwise, the nutrient requirements may not be met.

It is difficult to formulate a single supplement to meet the protein, mineral, and vitamin requirements for all ages of pigs. Most protein supplements formulated will approximate 35 to 40 percent protein. When fed with grains, depending upon the desired protein level of the final mix, the ratio of supplement to grain may vary from 1:3 up to 1:8 or 1:9. It is particularly important that the levels of minerals and vitamins be sufficiently high in the supplement so that the animal's requirements will be met in the final mix. Thus, if the supplement to be used is to be mixed with an energy source in the ratio of 1:4, the level of vitamins and minerals in the supplement should be four times the level of that of the final complete mix. Table 9 in the Appendix can be used as a guide in establishing levels of protein ingredients to incorporate into the supplement.

# APPENDIX

**Table 1. Nutrient requirements of growing and finishing swine (expressed in percentage or amount per pound of total ration)[1]**

| | Full-fed on cereal grains | | | Full-fed on corn | | Full-fed on wheat, barley, oats | |
|---|---|---|---|---|---|---|---|
| Liveweight, lb. | 11–22 | 22–44 | 44–77 | 77–132 | 132–220 | 77–132 | 132–220 |
| Expected daily gain, lb. | 0.7 | 1.1 | 1.3 | 1.6 | 2.0 | 1.5 | 1.8 |
| Protein and energy: | | | | | | | |
| Crude protein, % | 22 | 18 | 16 | 14 | 13 | 15 | 14 |
| Total digest. nutrients, % | 80 | 80 | 75 | 75 | 75 | 70 | 70 |
| Digestible energy, kcal. | 1,587 | 1,587 | 1,496 | 1,496 | 1,496 | 1,406 | 1,406 |
| Inorganic nutrients: | | | | | | | |
| Calcium, % | 0.80 | 0.65 | 0.65 | 0.50 | 0.50 | 0.50 | 0.50 |
| Phosphorus, % | 0.60 | 0.50 | 0.50 | 0.40 | 0.40 | 0.40 | 0.40 |
| Salt (NaCl), % | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Vitamins: | | | | | | | |
| B-carotene, mg. | 2.0 | 1.6 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Vitamin A, I.U. | 1,000.0 | 800.0 | 600.0 | 600.0 | 600.0 | 600.0 | 600.0 |
| Vitamin D, I.U. | 100.0 | 90.0 | 90.0 | 60.0 | 60.0 | 60.0 | 60.0 |
| Thiamine, mg. | .6 | .5 | .5 | .5 | .5 | .5 | .5 |
| Riboflavin, mg. | 1.4 | 1.4 | 1.2 | 1.0 | 1.0 | 1.0 | 1.0 |
| Niacin,[2] mg. | 10.0 | 8.2 | 6.3 | 4.5 | 4.5 | 4.5 | 4.5 |
| Pantothenic acid, mg. | 6.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Vitamin $B_6$, mg. | .7 | .7 | .5 | — | — | — | — |
| Choline, mg. | 500.0 | 408.0 | — | — | — | — | — |
| Vitamin $B_{12}$, mcg. | 10.0 | 7.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |

[1] From National Academy of Sciences Publication 1599 (1968), *Nutrient Requirements of Swine.*

[2] It is assumed that all the niacin in the cereal grains and their by-products is in a bound form and thus is largely unavailable.

**Table 2. Nutrient requirements of growing and finishing swine (amounts per animal per day)**

| | Full-fed on cereal grains | | | Full-fed on corn | | Full-fed on wheat, barley, oats | |
|---|---|---|---|---|---|---|---|
| Liveweight, lb. | 11–22 | 22–44 | 44–77 | 77–132 | 132–220 | 77–132 | 132–220 |
| Expected daily gain, lb. | 0.7 | 1.1 | 1.3 | 1.6 | 2.0 | 1.5 | 1.8 |
| Total air dry feed requirements, lb. | 1.3 | 2.7 | 3.7 | 5.5 | 7.7 | 5.5 | 7.3 |
| Protein and energy: | | | | | | | |
| Crude protein, lb. | .29 | .49 | .60 | .77 | 1.0 | .83 | 1.0 |
| Total digest. nutrients, lb. | 1.0 | 2.2 | 2.8 | 4.1 | 5.8 | 3.9 | 5.1 |
| Digestible energy, kcal.[1] | 2,100 | 4,370 | 5,610 | 8,250 | 11,550 | 7,750 | 10,320 |
| Inorganic nutrients: | | | | | | | |
| Calcium, gm. | 4.8 | 8.1 | 10.2 | 12.5 | 17.5 | 12.5 | 16.5 |
| Phosphorus, gm. | 3.6 | 6.3 | 8.5 | 10.0 | 14.0 | 10.0 | 13.2 |
| Salt (NaCl), gm. | 2.9 | 6.1 | 8.4 | 12.5 | 17.5 | 12.5 | 16.6 |
| Vitamins: | | | | | | | |
| B-carotene, mg.[2] | 2.6 | 4.4 | 4.4 | 6.5 | 9.1 | 6.5 | 8.6 |
| Vitamin A, I.U. | 1,300 | 2,200 | 2,200 | 3,250 | 4,550 | 3,250 | 4,300 |
| Vitamin D, I.U. | 132 | 250 | 340 | 312 | 437 | 312 | 412 |
| Thiamine, mg. | 0.8 | 1.4 | 1.9 | 2.8 | 3.9 | 2.8 | 3.6 |
| Riboflavin, mg. | 1.8 | 3.8 | 4.4 | 5.5 | 7.7 | 5.5 | 7.3 |
| Niacin, mg.[3] | 13.2 | 22.5 | 23.8 | 25.0 | 35.0 | 25.0 | 33.0 |
| Pantothenic acid, mg. | 7.8 | 13.8 | 18.7 | 27.5 | 38.5 | 27.5 | 36.3 |
| Vitamin $B_6$, mg. | 0.9 | 1.9 | 1.9 | — | — | — | — |
| Choline, mg. | 660 | 1,125 | — | — | — | — | — |
| Vitamin $B_{12}$, mcg. | 13.2 | 18.8 | 18.7 | 27.5 | 38.5 | 27.5 | 36.3 |

[1] Requirements are based on the assumption that 1 pound of T.D.N. has 2,000 kcal. of digestible energy.

[2] Carotene and vitamin A values are based on 1 mg. of B-carotene equaling 500 I.U. of biologically active vitamin A. Vitamin A requirements can be met by carotene or vitamin A or both.

[3] It is assumed that all the niacin in the cereal grains and their by-products is in a bound form and thus is largely unavailable.

**Table 3. Nutrient requirements of breeding swine (expressed in percentage of amount per pound of total ration)**

| | Bred gilts and sows | Lactating gilts and sows | Boars–young and adult |
|---|---|---|---|
| Liveweight range, lb. | 240–350 | 310–440 | 240–400 |
| Protein and energy: | | | |
| Crude protein, % | 14 | 15 | 14 |
| Total digestible nutrients, % | 75 | 75 | 75 |
| Digestible energy, kcal. | 1,500 | 1,500 | 1,500 |
| Inorganic nutrients: | | | |
| Calcium, % | 0.75 | 0.60 | 0.75 |
| Phosphorus, % | 0.50 | 0.40 | 0.50 |
| Salt (NaCl), % | 0.50 | 0.50 | 0.50 |
| Vitamins: | | | |
| B-carotene, mg. | 3.7 | 3.0 | 3.7 |
| Vitamin A, I.U. | 1,860 | 1,500 | 1,860 |
| Vitamin D, I.U. | 125 | 100 | 125 |
| Thiamine, mg. | 0.6 | 0.5 | 0.6 |
| Riboflavin, mg. | 1.9 | 1.5 | 1.9 |
| Niacin, mg. | 10.0 | 8.0 | 10.0 |
| Pantothenic acid, mg. | 7.5 | 6.0 | 7.5 |
| Vitamin $B_{12}$, mcg. | 6.3 | 5.0 | 6.3 |

**Table 4. Nutrient requirements of breeding swine (amounts per animal per day)**

| | Breeding swine, liveweight class | | | | | |
|---|---|---|---|---|---|---|
| | Bred gilts | Bred sows | Lactating gilts | Lactating sows | Young boars | Adult boars |
| Liveweight, lb. | 240–350 | 350–550 | 310–440 | 440–550 | 240–400 | 400–550 |
| Expected daily gain, lb. | 0.8-1.0 | 0.3-0.7 | – | – | 0.6-1.0 | – |
| Total air dry feed requirements, lb. | 4.4 | 4.4 | 11.0 | 12.0 | 5.5 | 4.4 |
| Protein and energy: | | | | | | |
| Crude protein, lb. | .62 | .62 | 1.65 | 1.82 | .77 | .62 |
| Total digestible nutrients, lb. | 3.3 | 3.3 | 8.2 | 9.1 | 4.1 | 3.3 |
| Digestible energy, kcal. | 6,600 | 6,600 | 16,500 | 18,150 | 8,250 | 6,600 |
| Inorganic nutrients: | | | | | | |
| Calcium, gm. | 15.0 | 15.0 | 30.0 | 33.0 | 18.8 | 15.0 |
| Phosphorus, gm. | 10.0 | 10.0 | 20.0 | 22.0 | 12.5 | 10.0 |
| Salt (NaCl), gm. | 10.0 | 10.0 | 25.0 | 27.5 | 12.5 | 10.0 |
| Vitamins: | | | | | | |
| B-carotene, mg. | 16.4 | 16.4 | 33.0 | 36.3 | 20.5 | 16.4 |
| Vitamin A, I.U. | 8,200 | 8,200 | 16,500 | 18,150 | 10,250 | 8,200 |
| Vitamin D, I.U. | 550 | 550 | 1,100 | 1,210 | 690 | 550 |
| Thiamine, mg. | 2.8 | 2.8 | 5.5 | 6.0 | 3.5 | 2.8 |
| Riboflavin, mg. | 8.2 | 8.2 | 16.5 | 18.2 | 10.3 | 8.2 |
| Niacin, mg. | 44.0 | 44.0 | 88.0 | 96.8 | 55.0 | 44.0 |
| Pantothenic acid, mg. | 33.0 | 33.0 | 66.0 | 72.6 | 41.3 | 33.0 |
| Vitamin $B_{12}$, mcg. | 27.6 | 27.6 | 55.0 | 60.5 | 34.5 | 27.6 |

**Table 5. Essential amino acid requirements of swine (expressed as percentage of the diet)[1]**

| Amino Acids | Growing pigs weighing 11–22 lbs. | Growing pigs weighing 44–77 lbs. | Finishing pigs | Bred sows and gilts |
|---|---|---|---|---|
| Arginine[2] | 0.37 | 0.20 | 0.15 | – |
| Histidine | 0.27 | 0.18 | 0.14 | 0.20[2] |
| Isoleucine | 0.76 | 0.50 | 0.35 | 0.43 |
| Leucine | 0.90 | 0.60 | 0.40 | 0.66[2] |
| Methionine[3] | 0.80 | 0.50 | 0.32 | 0.35 |
| Phenylalanine[4] | 0.79 | 0.50 | 0.32 | 0.52[2] |
| Threonine | 0.70 | 0.45 | 0.27 | 0.42 |
| Tryptophan | 0.18 | 0.13 | 0.09[2] | 0.08[2] |
| Valine | 0.65 | 0.50 | 0.28 | 0.46 |
| Lysine | 1.20 | 0.70 | 0.50 | 0.49 |

[1] From National Academy of Sciences Publication 1599 (1968), *Nutrient Requirements of Swine,* and University of Illinois Circular 866, *Balancing Swine Rations.*

[2] This level is adequate; the minimum requirement has not been established.

[3] Cystine can satisfy 40 percent of the need for methionine.

[4] Tyrosine can satisfy 30 percent of the need for phenylalanine.

**Table 6. Trace minerals for swine**

| Mineral element | Requirement (mg./lb. diet) | Toxic level (mg./lb. diet) |
|---|---|---|
| Copper | 2.7[1] | 113[2] |
| Iron | 36.3[1] | 2,270 |
| Iodine | 0.1 | – |
| Magnesium | 181[1] | – |
| Manganese | 9.1 | 1,814 |
| Zinc | 23[3] | 907 |
| Selenium | 0.5 | 2.3 |

[1] Baby pig requirement.
[2] Toxic symptoms have been obtained on a few occasions.
[3] Higher levels may be needed if excess calcium is fed.

**Table 7. Recommended antibiotic levels**

| | Pig weight lb. | Antibiotic level gm. |
|---|---|---|
| | | Per ton of complete feed |
| Baby pigs | 10 | 40 |
| | 25 | 40 |
| Growing pigs | 50 | 10–20 |
| Finishing pigs | 100–200 | 10 |
| Therapeutic level | | 100–200[1] |
| | | Per ton of supplement |
| Supplement to be fed free choice with grain | | 50–100 |

[1] If pigs are in very poor condition and will not eat, antibiotic can be given in drinking water.

## Table 8. Analysis of Feedstuffs Commonly Used in Swine Rations*

| Feed Ingredient | Dry Matter % | Energy T.D.N. % | Energy Dig. E. Kcal/lb. | Protein Crude % | Protein Dig. % | Amino Acids Lysine % | Amino Acids Meth. Cystine % | Amino Acids Tryp. % | Carbohydrate Fiber % | Carbohydrate N.F.E. % | Fat % | Mineral Ash % | Mineral Ca. % | Mineral P. % | Vitamins Rib. mg./lb. | Vitamins P.A. mg./lb. | Vitamins Niacin mg./lb. | Vitamins Choline mg./lb. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barley | 89 | 72 | 1400 | 11.6 | 8.2 | .53 | .18 | .18 | 5.0 | 68.2 | 1.9 | 2.4 | .08 | .42 | .9 | 2.9 | 26.1 | 468 |
| Corn Yellow, #2 Dent | 89 | 82 | 1640 | 9.0 | 7.1 | .18 | .09 | .09 | 2.0 | 73.1 | 3.9 | 1.1 | .02 | .33 | .6 | 1.1 | 12.0 | 244 |
| Corn and Cob Meal | 87 | 70 | 1410 | 8.1 | 5.8 | .16 | .08 | .08 | 8.0 | 66.1 | 3.2 | 1.6 | .04 | .27 | .4 | 1.8 | 7.2 | 160 |
| Millet Grain | 90 | 66 | 1317 | 12.0 | 8.8 | – | – | – | 8.0 | 62.9 | 4.8 | 3.2 | .05 | .28 | .7 | 3.4 | 23.9 | 359 |
| Milo (Sorghum) | 89 | 78 | 1570 | 11.0 | 7.8 | .27 | .09 | .18 | 2.0 | 71.6 | 2.8 | 1.7 | .04 | .29 | .5 | 5.2 | 19.4 | 308 |
| Oats | 89 | 65 | 1300 | 11.8 | 9.9 | .36 | .18 | .18 | 11.0 | 58.5 | 4.5 | 3.2 | .10 | .35 | .7 | 5.9 | 7.2 | 488 |
| Rice-Rough | 89 | 57 | 1140 | 7.3 | 5.5 | .27 | .15 | .10 | 9.0 | 66.4 | 1.9 | 4.5 | .04 | .26 | .5 | 4.0 | 13.8 | 450 |
| Rice-White, Polished | 89 | 86 | 1720 | 7.3 | 6.2 | .27 | .27 | .09 | .4 | 80.4 | .4 | .5 | .03 | .12 | .3 | 1.5 | 6.4 | 412 |
| Rye | 89 | 75 | 1500 | 11.9 | 9.6 | .45 | .18 | .18 | 2.0 | 71.8 | 1.6 | 1.7 | .06 | .34 | .7 | 3.1 | .5 | – |
| Wheat | 89 | 80 | 1600 | 12.7 | 11.7 | .45 | .18 | .18 | 3.0 | 70.0 | 1.7 | 1.6 | .05 | .36 | .5 | 5.5 | 25.7 | 377 |
| Rice Bran | 91 | 74 | 1480 | 13.5 | 10.2 | .50 | .24 | .10 | 11.0 | 40.5 | 15.1 | 10.9 | .06 | 1.82 | 1.2 | 10.7 | 138.0 | 570 |
| Rice Polishings | 90 | 89 | 1780 | 11.8 | 10.3 | .50 | .20 | .10 | 3.0 | 54.0 | 13.2 | 8.0 | .04 | 1.42 | .8 | 26.5 | 242.0 | 594 |
| Wheat Bran | 89 | 57 | 1142 | 16.0 | 12.2 | .60 | .10 | .30 | 10.0 | 52.8 | 4.1 | 6.1 | .14 | 1.17 | 1.4 | 13.2 | 95.0 | 499 |
| Wheat Middlings (Wheat, Flour By-product) | 89 | 73 | 1460 | 17.0 | 15.0 | .60 | .10 | .20 | 2.0 | 63.0 | 3.6 | 2.5 | .08 | 0.52 | .7 | 6.2 | 23.9 | 490 |
| Wheat Mill Run (Wh. Mixed Feed) | 90 | 72 | 1440 | 15.3 | 12.2 | .50 | .40 | .20 | 8.0 | 57.5 | 4.0 | 5.2 | .09 | 1.02 | 1.1 | 6.0 | 51.0 | 446 |
| Bakery Waste-Dried | 91 | 100 | – | 10.9 | 10.0 | – | – | – | .7 | 64.7 | 13.7 | 1.6 | – | – | – | – | – | – |
| Cassava Meal | 86 | 63 | – | 1.4 | 1.0 | – | – | – | 3.1 | 78.6 | .6 | 2.0 | .13 | .15 | – | – | – | – |
| Copra-Dried | 90 | 123 | – | 7.2 | 5.4 | – | – | – | 4.7 | 14.8 | 61.3 | 2.1 | | | | | | |
| Copra-Pressed | 89 | 98 | – | 14.0 | 10.5 | – | – | – | 8.1 | 29.6 | 34.6 | 3.6 | .15 | .45 | – | – | – | – |
| Fats, Oils, Tallows | 100 | 199 | 3990 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Garbage (Wet) | 15 | 17 | 295 | 3.0 | 2.4 | – | – | – | .7 | 3.0 | 5.7 | 1.5 | .10 | .06 | – | – | – | – |
| Molasses-Cane | 75 | 56 | 1120 | 3.2 | 0 | – | – | – | 0 | 63.6 | .1 | 8.1 | .89 | .08 | 1.5 | 17.4 | 15.6 | 398 |
| Pineapple Bran | 86 | 65 | – | 3.8 | .6 | – | – | – | 20.0 | 58.5 | 1.7 | 2.6 | .16 | .15 | – | – | – | – |
| Sweet Potato Meal | 88 | 63 | – | 7.9 | 6.0 | – | – | – | 4.0 | 69.5 | 1.1 | 3.5 | .09 | .15 | – | – | – | – |
| Sugar–Crude | 99 | 96 | 1816 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | – | – | .20 | .03 | – | – | – | – |
| Cassava Root | 33 | 26 | – | 1.1 | 0 | – | – | – | 1.4 | 28.8 | .3 | 1.0 | .05 | .06 | – | – | – | – |
| Irish Potato Root | 22 | 20 | 392 | 2.2 | 1.6 | – | – | – | .7 | 18.3 | .1 | 1.1 | .01 | .05 | .1 | 2.9 | 5.0 | – |
| Sweet Potato Root | 32 | 26 | – | 1.6 | .2 | – | – | – | 1.9 | 26.7 | .4 | 1.2 | .03 | .04 | – | – | – | – |

## Table 8. Analysis of Feedstuffs Commonly Used in Swine Rations*

| Feed Ingredient | Dry Matter % | Energy T.D.N. % | Energy Dig. E. Kcal/lb. | Protein Crude % | Protein Dig. % | Amino Acids Lysine % | Amino Acids Meth. Cystine % | Amino Acids Tryp. % | Carbohydrate Fiber % | Carbohydrate N.F.E. % | Mineral Ash % | Mineral Ca. % | Mineral Ca. % | Mineral P. % | Vitamins Rib. mg./lb. | Vitamins P.A. mg./lb. | Vitamins Niacin mg./lb. | Vitamins Choline mg./lb. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taro Root | 28 | 18 | – | 1.5 | 1.0 | – | – | – | .6 | 24.2 | .1 | 1.2 | .02 | .07 | – | – | – | – |
| Coconut Meat-Fresh | 54 | 73 | – | 4.4 | 3.3 | – | – | – | 5.5 | 6.5 | 36.0 | 1.0 | – | – | – | – | – | – |
| Blood Meal | 91 | 61 | 1220 | 80 | 62 | 6.9 | .9 | 1.4 | 1.0 | 2.8 | 1.6 | 5.6 | .28 | .22 | .7 | .5 | 14.3 | 344 |
| Meat and Bone Meal | 94 | 65 | 1300 | 51 | 45 | 3.5 | .7 | .6 | 2.2 | 2.6 | 9.5 | 29.1 | 10.6 | 5.1 | 2.0 | 1.7 | 21.7 | 995 |
| Shark Meal | 91 | 71 | 1422 | 72 | 66.2 | – | .8 | – | .5 | – | 2.5 | 13.5 | 3.5 | 1.9 | 3.1 | 4.1 | 28.8 | 1660 |
| Tuna Meal | 87 | 69 | 1377 | 57.3 | 52.7 | 6.2 | 1.7 | 1.0 | 1.0 | .9 | 8.9 | 19.0 | 5.3 | 3.1 | 3.6 | 3.6 | 27.0 | 1300 |
| Skim Milk–Dried | 94 | 86 | 1720 | 33.5 | 32.8 | 2.8 | .8 | .5 | .2 | 51.8 | .9 | 7.6 | 1.3 | 1.0 | 9.1 | 15.3 | 5.2 | 648 |
| Buttermilk–Dried | 93 | 77 | 1540 | 32 | 29.8 | 2.4 | .7 | – | .5 | 0 | 45.2 | 5.8 | 9.6 | 1.3 | .9 | 14.1 | 13.7 | 3.9 | 822 |
| Coconut Oil Meal (Expeller) | 93 | 76 | 1529 | 20.4 | 14.9 | .5 | .3 | .2 | .2 | 12.0 | 47.2 | 6.6 | 6.9 | .2 | .6 | 1.4 | 3.0 | 11.3 | 418 |
| Coconut Oil Meal (Solvent) | 92 | 71 | 1420 | 21.4 | 15.5 | – | – | – | – | 15.0 | 48.3 | 1.8 | 5.6 | .17 | .6 | 6.0 | – | – | – |
| Cottonseed Meal-41% (Expeller) | 94 | 67 | 1337 | 41 | 35 | 1.7 | .6 | .8 | .6 | 12.0 | 30.4 | 4.3 | 6.2 | .16 | 1.2 | 2.3 | 6.4 | 18.0 | 1264 |
| Cottonseed Meal-41% (Solvent) | 92 | 61 | 1224 | 41 | 35 | 1.7 | .6 | .8 | .6 | 12.0 | 31.9 | 1.4 | 6.2 | .16 | 1.2 | 2.3 | 6.4 | 17.9 | 1300 |
| Peanut Oil Meal (Expeller) | 92 | 86 | 1714 | 46 | 43 | 1.3 | .6 | .7 | .5 | 11.0 | 23.6 | 5.9 | 5.7 | .17 | .57 | 2.4 | 21.9 | 76.8 | 765 |
| Peanut Oil Meal (Solvent) | 92 | 77 | 1549 | 47.4 | 44.5 | 2.3 | .4 | – | .5 | 13.0 | 25.9 | 1.2 | 4.5 | .2 | .65 | 5.0 | 24.1 | 77.3 | 909 |
| Soybean Oil Meal 44% (Expeller) | 90 | 79 | 1580 | 44 | 39.5 | 2.7 | .8 | .6 | .6 | 6.0 | 29.8 | 4.7 | 5.7 | .27 | .63 | 1.4 | 6.4 | 13.8 | 1215 |
| Soybean Oil Meal 44% (Solvent) | 89 | 75 | 1500 | 45.8 | 41.7 | 2.9 | .6 | .6 | .6 | 6.0 | 30.5 | .9 | 5.8 | .32 | .67 | 1.5 | 6.6 | 12.2 | 1247 |
| Soybean Oil Meal Dehulled (Solvent) | 90 | 77 | 1548 | 50.9 | 46.3 | 3.2 | .7 | .7 | .8 | 2.8 | 29.7 | .8 | 5.6 | .26 | .62 | 1.4 | 6.6 | 9.8 | 1255 |
| Sunflower Oil Meal (Expeller) | 93 | 71 | 1416 | 41 | 33.7 | 2.0 | 1.6 | – | – | 13.0 | 24.6 | 7.6 | 6.8 | .43 | 1.0 | – | – | – | – |
| Alfalfa Meal–Dehydrated | 93 | 32 | 652 | 17.9 | 8.3 | .8 | .2 | .4 | .4 | 24.3 | 38.9 | 3.0 | 9.0 | 1.33 | .24 | 5.6 | 13.6 | 20.8 | 690 |
| Buttermilk–Liquid | 9 | 9.1 | – | 3.5 | 3.3 | – | – | – | – | 0 | 4.5 | .6 | .8 | .14 | .08 | .7 | 2.1 | .6 | – |
| Skim Milk–Liquid | 9.5 | 8.7 | – | 3.6 | 3.4 | – | – | – | – | 0 | 5.1 | .1 | .7 | .13 | .10 | .9 | 1.6 | .5 | – |
| Whey–Liquid | 6.7 | 6.0 | – | .9 | .8 | – | – | – | – | 0 | 5.0 | .1 | .7 | .10 | .10 | .1 | 2.4 | .4 | – |

*From United States-Canadian Tables of Feed Composition, National Academy of Sciences Pub. 1684; *Feeds and Feeding*, 22nd. ed., F. B. Morrison; Univ. of Hawaii feed composition data.

**Table 9. Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Corn (Maize) | 60 | 80 | 90 | 80 | 80 | – | 1. High energy, low fiber, highly palatable.<br>2. Yellow corn is not a dependable source of vitamin A. White corn has no vitamin value.<br>3. Deficient in most essential amino acids particularly lysine and tryptophan.<br>4. High lysine corn (Opaque-2) is higher in protein and in lysine and tryptophan.<br>5. Low in calcium. |
| Wheat | 35 | 80 | 90 | 90 | 90 | – | 1. Higher in protein content than corn (11-13%)<br>2. Ground wheat has replacement value of 95-110% of corn.<br>3. Should be ground coarsely or rolled for hogs as has a tendency to be less palatable if finely ground. |
| Barley | 25 | 80 | 90 | 80 | 80 | – | 1. Higher in crude protein than corn (10-11%).<br>2. Higher fiber content (6%), lower in energy than corn.<br>3. Ground barley has replacement value of 85-95% or corn.<br>4. Should be ground or rolled for swine. |
| Oats | 0 | 20 | 20 | 40 | 20 | – | 1. Higher in crude protein (11-12%) than corn.<br>2. High in fiber (12%), low in energy.<br>3. Ground whole oats has replacement value of 80-85% of corn when limited to 25% of the ration.<br>4. Hulled or rolled oats has replacement value of 105-110% of corn. |
| Milo (Sorghum) | 35 | 70 | 80 | 70 | 70 | – | 1. Crude protein content of 10-11%.<br>2. Ground milo has replacement value of 90-95% of corn.<br>3. Some sorghums because of higher tannin content are less palatable. |

**Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Rice | 30 | 40 | 45 | 55 | 55 | – | 1. Rough rice fairly high in fiber (9%).<br>2. When finely ground, rough rice has 75--85% feeding value of corn. |
| Rye | 0 | 50 | 70 | 0 | 0 | – | 1. Crude protein content of 11-12%.<br>2. Lacks palatability.<br>3. Ground rye has replacement value of 90% of corn when limited to 20% of corn.<br>4. Possible contamination with ergot which may cause abortion. |
| Rice Bran | 0 | 20 | 20 | 55 | 20 | – | 1. Crude protein of 12%.<br>2. High in fat (11-12%) which is often rancid.<br>3. Produces soft pork unless solvent extracted.<br>4. Worth 85% value of corn when restricted to 30% of the ration.<br>5. May cause scouring in young pigs. |
| Rice Polish | 0 | 30 | 50 | 50 | 50 | | 1. Crude protein of 12%.<br>2. When limited to 30% of corn has feeding value of 120% of corn.<br>3. Soft pork produced if it makes up more than 50% of ration.<br>4. May cause scouring in young pigs. |
| Wheat Bran<br>Wheat Mixed Feed<br>(Millrun) | 0 | 5 | 5 | 30 | 15 | – | 1. Crude protein content of 14-16%.<br>2. High fiber (8-10%) bulky.<br>3. Bran has a mild laxative effect.<br>4. Bran is palatable.<br>5. Should not replace more than 10% of corn in ration for growing pigs. |
| Wheat Middlings<br>Wheat Pollard<br>Wheat Shorts | 5 | 30 | 30 | 20 | 20 | – | 1. Crude protein content of 15-16%.<br>2. When limited to 20% of ration, feeding value surpasses corn.<br>3. Slightly lower in fiber than wheat bran and millrun. |

**Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Pineapple Bran | 0 | 5 | 10 | 30 | 15 | – | 1. High in fiber (18-20%), lower in energy.<br>2. Reduces gain in growing pigs if fed at high levels. |
| Molasses (cane) | 10 | 50 | 55 | 50 | 20 | – | 1. High levels of molasses requires fibrous material in the ration to prevent scouring.<br>2. Exact levels of molasses dependent upon price relationship with grains since growth rate will be less and feed per unit of gain will be greater.<br>3. Handling of high molasses ration is more difficult.<br>4. Primary value is as energy source with virtually no protein value. |
| Garbage | 0 | Ad libitum feeding plus ½ to 1 pound daily of a protein supplement. | | | 0 | – | 1. Variable in composition.<br>2. Best not to feed pigs less than 75 pounds on a high garbage diet.<br>3. Garbage should be cooked (disease precaution) and should not be diluted with water. |
| Bakery Waste– stale bread, cake, pastries, bakery crumbs. | 30 | 40 | 45 | 40 | 40 | – | 1. Generally considered similar in nutritional value to corn but dependent upon dry matter and fat content.<br>2. Can replace up to 50% of grain for swine.<br>3. Dried bakery waste may have to be moistened at feeding time. |
| Root Crops<br>–Irish potato<br>–Sweet potato<br>–Taro<br>–Cassava (manioc) | 0 | For best results proportion of cooked starchy root crops to grain mix should not be greater than 3-4 parts for each part of grain mix and should not exceed 50% of total ration.<br><br>If root crops are fed ad libitum (free choice), then depending upon size of pig, 1-2 lb of a 36-40% protein supplement should be fed daily per pig. | | | During lactation, use of root crops should be restricted since they are low in dry matter and energy. | – | 1. High in moisture (70-80%), low in protein and energy and deficient in vitamins A and D. |

**Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Continuation of Root Crops<br>–Irish potato<br>–Sweet potato<br>–Taro<br>–Cassava (manioc) | | | | | | | 2. Generally, root crops should not be fed at higher rate than 3-4 lb of roots to 1 lb of grain. When fed at this rate, cooked starchy root crops are worth about 25% value of corn.<br>3. Dry matter contains mostly carbohydrate (starch).<br>4. Starchy root crops should be cooked.<br>–Irish potatoes – add salt (2 lb per 100 lb potatoes) to increase palatability, but drain off water before cooking.<br>–Cassava – cooking eliminates prussic acid problem. |
| Fruits<br>–Coconut<br>–Banana<br>–Breadfruit<br>–Papaya (paw-paw)<br>–Avocado | 0 | Feeding recommendations similar to that for root crops. | | | During lactation use of fresh fruits should be restricted since they are low in dry matter and energy. | | 1. Most fruits low in dry matter, energy and protein.<br>2. –Coconut & breadfruit relatively high in dry matter (40-50%).<br>–Avocado & banana relatively low in dry matter (20-25%).<br>Papaya low in dry matter (10%).<br>3. Coconut & avocado high in fat (36% and 16%).<br>–Avocado produces soft pork.<br>–Coconut produces hard pork.<br>4. In Hawaii trials, where papaya, banana and avocado have comprised 25-30% of total ration, value was 25-45% of grain-mix ration. |

**Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Dehydrated or dried roots<br>–Cassava meal<br>–Sweet potato meal<br>–Irish potato meal | | 45 | 50 | 50 | 45 | – | 1. Primarily used as an energy source.<br>2. Low in protein.<br>3. When limited to about one-third of total ration, have feeding value comparable to grain. |
| Coconut Oil Meal (Copra) | 10 | 30 | 30 | 25 | 25 | 50 | 1. Crude protein content of about 20%.<br>2. Medium quality protein.<br>3. Lacking in palatability<br>4. If cheaper in price then grain may be used as substitute for part of grain up to about 40% of grain portion. |
| Cottonseed Meal | 0 | 5 | 9 | 9 | 9 | 25 | 1. Normally available as 41% or 44% crude protein.<br>2. **Gossypol toxicity** problem–**C.S.M.** should not exceed 9% of complete ration and level of gossypol in the total ration should not exceed 0.01% free gossypol.<br>3. Low in lysine and marginal in isoleucine, threonine and tryptophan.<br>4. Low in calcium. |
| Peanut Oil Meal (groundnut Meal) | 5 | 15 | 15 | 15 | 15 | 25 | 1. Generally contains 45-50% protein.<br>2. Low in lysine. |
| Alfalfa Meal<br>Lucerne Meal | 0 | 5 | 5 | 10 | 10 | 15 | 1. Good source of carotene (vit. A).<br>2. High fiber (25%).<br>3. Low palatability.<br>4. Normally cannot justify as protein or vitamin source because of cost and gain depression. |
| Blood Meal | 2 | 3 | 3 | 3 | 3 | 15 | 1. Protein content about 80%.<br>2. Liable to excessive heating or other damage during processing thus affecting available levels of amino acids, digestability and palatability. |

**Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations**

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Tuna Meal | 5 | 5 | 5 | 10 | 10 | 25 | 1. Normally 50-60% crude protein.<br>2. Variable quality. |
| Meat Meal<br>Meat and Bone Meal<br>Tankage | 5 | 5 | 5 | 10 | 10 | 25 | 1. Crude protein content of 45-60%.<br>2. Variable quality—dependent upon amount of bone and connective tissue and processing method used.<br>3. Low in tryptophan particularly, as well as in methionine and isoleucine.<br>4. High in calcium and phosphorus.<br>5. Good source of lysine, but improper processing may destroy or reduce availability. |
| Skim Milk—Dried | 20 | 0 | 0 | 0 | 0 | 20 | 1. Crude protein content of 33%.<br>2. Excellent protein quality.<br>3. Good source of B vitamins, calcium and phosphorus.<br>4. Cost limitation. |
| Soybean Oil Meal | 20 | 20 | 15 | 20 | 20 | 80 | 1. Crude protein content of 41-50%.<br>2. Best vegetable protein source for pigs.<br>3. Marginal in methionine.<br>4. When used as only source of protein, must be supplemented with minerals and vitamins. |
| Liquid Skim Milk<br>Liquid Buttermilk | 0 | 2 pounds of grain-vitamin-mineral mix plus one-half gallon<br>Ratio of grain to milk approximately 1:2-3 | 4-5 pounds of grain-vitamin-mineral mix plus ¾-1 gallon or 2 pounds of grain mix plus *ad libitum* (3½ gal.) | 2 pounds of grain mix plus milk at rate of 1 gallon per 1 1/5 pounds of grain mix | 4 pounds of grain mix plus milk at rate of 1 gallon per 1 1/5 pounds of grain mix | – | 1. Liquid skim milk and buttermilk are similar in feeding value.<br>2. For younger pigs particularly, milk should be consistently fresh, sour or preserved otherwise digestive upsets may occur. To preserve add ¾-1½ pints of formalin (40% solution of formaldhyde in water) to each 100 gallons of separated milk. |

Table 9 (Continued). Suggested maximum levels of ingredients to use in swine rations

| Ingredients | % of total ration | | | | | % of Supplement | Remarks |
|---|---|---|---|---|---|---|---|
| | Starter | Grower | Finisher | Gestation | Lactation | | |
| Continuation of<br>Liquid Skim Milk<br>Liquid Buttermilk | | | | | | | 3. For maximum performance results, it is best not to feed to appetite.<br>4. Exact levels of feeding dependent upon price relationship with grains.<br>5. One gallon contains about one pound of dry matter.<br>6. 100 pounds is equal in value to about 28 pounds of corn. |
| Liquid Whole Whey | 0 | 2½ pounds of grain mix plus *ad libitum* ( ½–2 gals ) | 2½ pounds of grain mix plus *ad libitum* ( 2–5 gals ) | | | – | 1. Lower protein than skim milk or buttermilk. More suitable for pigs weighing over 100 pounds.<br>2. Feeding value about one-half that of skim milk.<br>3. Similar feeding value to corn when making up 25-30% of the ration. |

**Table 10. Sources of minerals**

| | | Ca % | P % |
|---|---|---|---|
| Calcium and Phosphorous Supplement | | | |
| Bone black | | 27 | 12.7 |
| Bone meal (steamed) | | 29 | 13.6 |
| Defluorinated phosphate rock | | 29 | 13.3 |
| Dicalcium phosphate | | 27 | 19.1 |
| Calcium Supplement | | | |
| Limestone | | 33.8 | |
| Oyster shell | | 38.0 | |
| Coral rock | | 38.0 | |
| Phosphorous Supplement | | | |
| Diammonium phosphate | | | 22.3 |
| Sodium tripolyphosphate | | | 25.3 |
| Magnesium | | | |
| Magnesium sulfate | 9.9% Mg. | | |
| Manganese | | | |
| Manganese oxide | 72.0% Mn. | | |
| Manganese carbonate | 48.0% Mn. | | |
| Manganese sulfate | 32.0% Mn. | | |
| Iron | | | |
| Iron oxide | 70.0% Fe. | | |
| Iron sulfate (ferrous) | 20.0% Fe. | | |
| Iodine | | | |
| Calcium iodate | 60.0% I. | | |
| Potassium iodide | 76.0% I. | | |
| Cobalt | | | |
| Cobalt carbonate | 50.0% Co. | | |
| Cobalt sulfate | 25.0% Co. | | |
| Cobalt oxide | 73.0% Co. | | |
| Copper | | | |
| Copper oxide | 80.0% Cu. | | |
| Copper sulfate | 25.0% Cu. | | |
| Copper carbonate | 53.0% Cu. | | |
| Zinc | | | |
| Zinc oxide | 80.0% Zn. | | |
| Zinc sulfate | 23.0% Zn. | | |
| Zinc carbonate | 52.0% Zn. | | |

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