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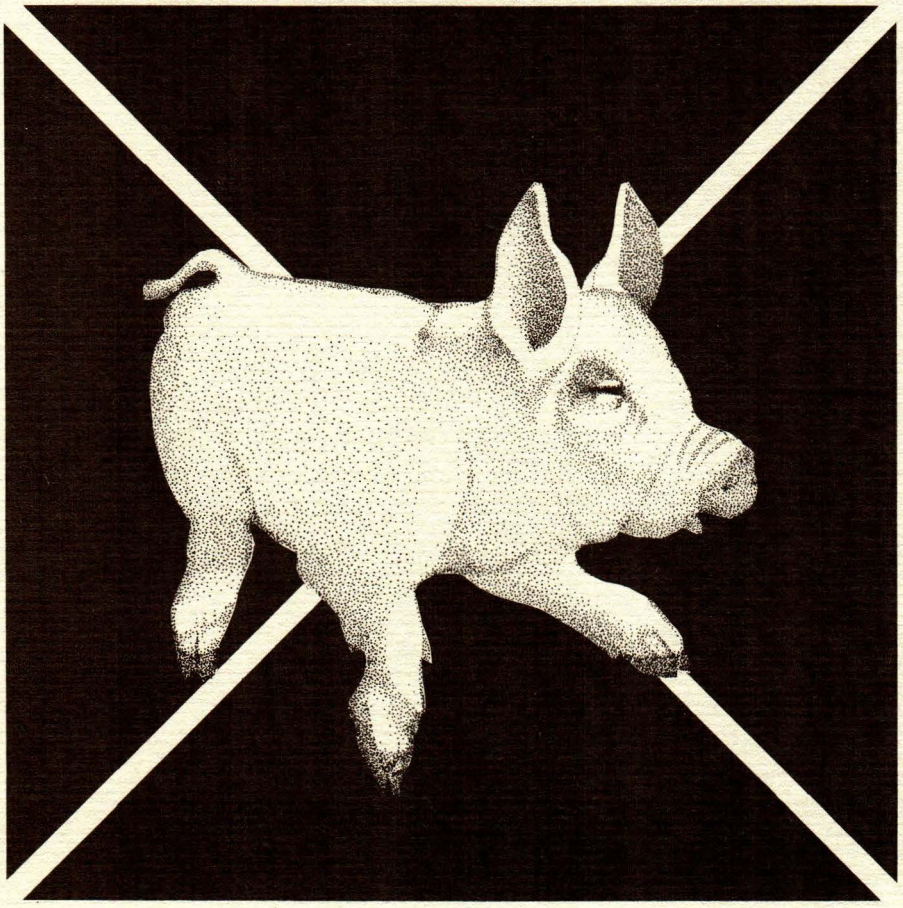

COMPUTING AND BALANCING SWINE RATIONS

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Swine are not roughage-consuming animals in the sense that ruminants (cattle, sheep, and goats) are. They have a simple stomach of relatively small capacity, for example, a 2-gallon capacity in a 200-pound animal. Since the pig is an omnivorous animal, however, 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. Since one type of ration will not serve all purposes, a swine feeding program should be comprised of rations designed for specific 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 weight
4. Finisher	100 pounds to market weight
5. Sow gestation	
6. Sow lactation	

CHARACTERISTICS OF A BALANCED 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, of which twenty-two have been identified. Ten of the twenty-two 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, however, consideration of protein quantity alone is not adequate: the requirements of essential amino acids as well as the total amino acids must be met.

The pig has a specific requirement for each essential amino acid, and 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 also 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 2000 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 of and need for vitamins by the pig may be affected by several factors. High intake of nitrates, for example, increases the need for vitamin A, and 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. And 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, there must be not only an adequate level of each mineral and vitamin D but also suitable ratios among them. The calcium requirements, for instance, are 1¼ to 1½ times the required phosphorus level, and 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, which 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 but 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. Rancid feeds that are not palatable and which result in the destruction of certain vitamins should be avoided in the ration. Feed ingredients with high fat content can result in rancidity, and rice bran, rice polish, dried or pressed copra, and fresh coconut meat are examples of feed ingredients with high fat content.

6. Feed ingredients containing toxic substances should be avoided in the ration. Examples are flourine in raw rock phosphate; selenium in grains grown on certain soils; gossypol in cottonseed meal; minosine 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 polish, 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

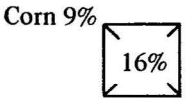
Use of a single energy source plus a commercial protein-mineral-vitamin supplement.

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

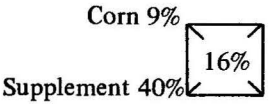
Step 1.
Draw a square.

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

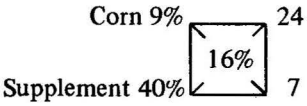
Step 3.
At the upper left-hand corner of the square, write "Corn" and its protein content (9%).



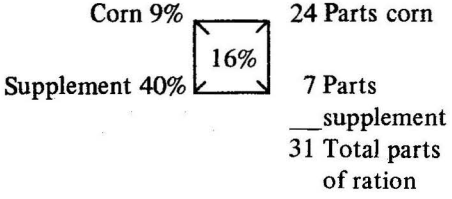
Step 4.
At the lower left-hand corner, write "Supplement" and its protein content (40%).



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

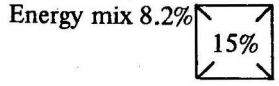
Use of several feed ingredients as energy sources plus a commercial protein-mineral-vitamin supplement.

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.

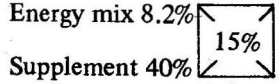
Step 1.
Draw a square.

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

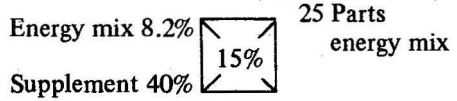
Step 3.
At the upper left-hand corner of the square, write "Energy Mix" and its protein content (8.2%).



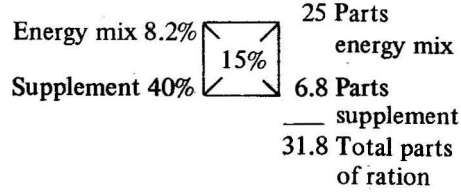
Step 4.
At the lower left-hand corner, write "Supplement" and its protein content (40%).



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 lb
Cassava meal	19.65 lb
Rice bran	19.65 lb
Protein supplement	21.40 lb
Total	100.00 lb

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 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 also we must make sure the adequate levels of minerals (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 to 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.

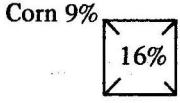
Compute a growing pig ration containing 16 percent protein from corn containing 9 percent protein and soybean oil meal containing 44 percent protein. Since this mixture is comprised of a single energy source and a single protein source of plant origin, additional sources of calcium and phosphorus as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

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.

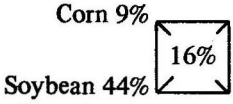
Step 1.
As before, draw a square.

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

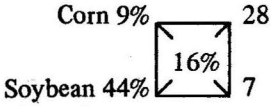
Step 3.
At the upper left-hand corner of the square, write "Corn" and its protein content (9%).



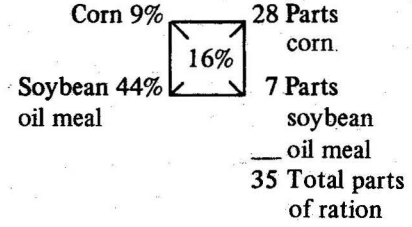
Step 4.
At the lower left-hand corner, write "Soybean Oil Meal" and its protein content (44%).



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. Thus, 28 parts of corn mixed with 7 parts of soybean oil meal gives 35 parts of feed 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 that will be used in the ration.

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

$$\% \text{ Soybean oil meal} = \frac{7}{35} \times 100\% = 20.0\%$$

Thus 80 pounds of corn mixed with 20 pounds of soybean oil meal will 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, trypotophan, and methionine).

Step 8.
To adjust 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 dif-

ferences 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 45 to 80 pounds should contain 0.65% calcium and 0.50% phosphorus. The feed composition table (*see* Appendix, Table 8) shows that yellow corn contains 0.02% calcium and 0.33% phosphorus. Soybean oil meal (49% solvent) 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 0.02% 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 = 0.06 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 (0.016 + 0.06) 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 (0.05 – 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 (lb)	Calculated analysis			
		Protein (lb)	Calcium (lb)	Phosphorus (lb)	Salt (lb)
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 lb) 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 lb needed ÷ 0.19 lb in 1 lb dicalcium phosphate). The requirements for phosphorus are now met. The addition of 0.9 pound of dicalcium phosphate will also contribute 0.24 pound of calcium to the ration (0.9 x 0.27). 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 (0.33) by the amount in 1 pound (0.34) 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 pounds 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 a square.

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

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

Energy mix 7.2%

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

Energy mix 7.2%

Soybean 44%
oil meal

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).

Energy mix 7.2% 34.5

Soybean 44% 2.3
oil meal

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 gives the parts of soybean oil meal (2.3) needed to make a mixture of 9.5% protein. Thus, 34.5 parts of energy mix mixed with 2.3 parts of soybean oil meal gives 36.8 parts of feed with 9.5% protein.

Energy mix 7.2% 34.5 Parts energy mix

Soybean 44% 2.3 Parts soybean oil meal
oil meal

36.8 Total parts of ration

Step 7.
To convert the 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.

Pounds of energy mix = $\frac{34.5}{36.8}$ x 100% x 80 lb = 75 lb

Pounds of soybean oil meal = $\frac{2.3}{36.8}$ x 100% x 80 lb = 5 lb

Thus, of the 80 pounds, 75 pounds will be energy source and 5 pounds will be soy-

bean oil meal. The basic ration will then consist of:

Energy mix	75 lb
Soybean oil meal	5 lb
Coconut oil meal	10 lb
Tuna meal	5 lb
Meat and bone meal	5 lb

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 lb
Corn	18.75 lb
Wheat middlings	18.75 lb
Soybean oil meal	5.0 lb
Coconut oil meal	10.0 lb
Tuna meal	5.0 lb
Meat and bone meal	5.0 lb

Step 8.

To adjust 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, such as chopped dried cassava, other root crops, or tree crops, that may be difficult to use as a complete, uniform mix in the final ration because of their physical consistency.

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-finishing swine fed ad libitum (expressed in percentage or amount per pound of total ration)[1]

Item	Liveweight (lb)				
	10–25	25–45	45–80	80–130	130–220
Expected daily gain, lb	0.7	1.1	1.3	1.6	2.0
Protein and energy:					
Crude protein,[2] %	22	18	16	14	13
Total digestible nutrients,[3] %	80	80	75	75	75
Digestible energy,[3] kcal	1585	1585	1500	1500	1500
Metabolizable energy,[3] kcal	1525	1525	1440	1440	1440
Inorganic nutrients:					
Calcium, %	0.80	0.65	0.65	0.50	0.50
Phosphorus, %	0.60	0.50	0.50	0.40	0.40
Salt (NaCl), %	0.50	0.50	0.50	0.50	0.50
Vitamins:					
B-carotene, mg	2.0	1.6	1.2	1.2	1.2
Vitamin A, I.U.	1000	800	600	600	600
Vitamin D, I.U.	100	90	90	60	60
Vitamin E, mg	5	5	5	5	5
Thiamine, mg	0.6	0.5	0.5	0.5	0.5
Riboflavin, mg	1.4	1.4	1.2	1.0	1.0
Niacin,[4] mg	10.0	8.2	6.3	4.5	4.5
Pantothenic acid, mg	6	5	5	5	5
Vitamin B_6, mg	0.7	0.7	0.5	–	–
Choline, mg	500	408	–	–	–
Vitamin B_{12}, mcg	10	7	5	5	5

[1] Tables 1–4 and 6–7 adapted from National Research Council, Committee on Animal Nutrition, *Nutrient Requirements of Swine*, 7th rev. ed., National Academy of Sciences Publication No. 1599, Washington, D.C., 1973.

[2] Approximate protein levels required to meet the essential amino acid needs. If cereal grains other than corn are used, an increase of 1 or 2 percent protein may be required.

[3] These suggested energy levels are derived from corn-based diets. When barley or medium- or low-energy grains are fed, these energy levels will not be met. Formulations based on barley or similar grains are satisfactory for pigs weighing 50–220 pounds, but feed conversion will normally be reduced with lower energy diets.

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

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

Item	Liveweight (lb)				
	10–25	25–45	45–80	80–130	130–220
Feed intake (air dry), lb	1.3	2.7	3.7	5.5	7.7
Protein and energy:					
Crude protein, [1] lb	0.30	0.50	0.60	0.80	1.0
Total digestible nutrients, [2] lb	1.0	2.2	2.8	4.1	5.8
Digestible energy, [2] kcal	2100	4370	5610	8250	11,550
Metabolizable energy, [2] kcal	2020	4200	5390	7920	11,090
Inorganic nutrients:					
Calcium, g	4.8	8.1	11.0	12.5	17.5
Phosphorus, g	3.6	6.3	8.5	10.0	14.0
Salt (NaCl), g	–	2.9	3.9	–	–
Vitamins:					
B-carotene, [3] mg	2.6	4.4	4.4	6.5	9.1
Vitamin A, I.U.	1300	2200	2200	3250	4550
Vitamin D, I.U.	132	250	340	312	437
Vitamin E, mg	6.6	13.8	18.7	27.5	38.5
Thiamine, mg	0.8	1.4	1.9	2.8	3.9
Riboflavin, mg	1.8	3.8	4.4	5.5	7.7
Niacin, [4] mg	13.2	22.5	24.0	25.0	35.0
Pantothenic acid, mg	7.8	13.8	18.7	27.5	38.5
Vitamin B_6, mg	0.9	1.9	1.9	–	–
Choline, mg	660	1125	–	–	–
Vitamin B_{12}, mcg	13.2	18.8	18.7	27.5	38.5

[1] Approximate protein levels required to meet the essential amino acid needs. If cereal grains other than corn are used, an increase of 1 or 2 percent protein may be required.

[2] These suggested energy levels are derived from corn-based diets. When barley or medium- or low-energy grains are fed, these energy levels will not be met. Formulations based on barley or similar grains are satisfactory for pigs weighing 50–220 pounds, but feed conversion will normally be reduced with lower energy diets.

[3] 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.

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

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

Item	Bred gilts and sows	Lactating gilts and sows	Boars–young and adult
Liveweight range, lb	240-350	310-440	240-400
Protein energy:			
Crude protein, %	14	15	14
Total digestible nutrients, %	75	75	75
Digestible energy, kcal	1500	1500	1500
Metabolizable energy, kcal	1440	1440	1440
Inorganic nutrients:			
Calcium, %	0.75	0.75	0.75
Phosphorus, %	0.50	0.50	0.50
Salt (NaCl), %	0.50	0.50	0.50
Vitamins:			
B-carotene, mg	3.7	3.0	3.7
Vitamin A, I.U.	1860	1500	1860
Vitamin D, I.U.	125	100	125
Vitamin E, mg	5	5	5
Thiamine, mg	0.7	0.5	0.7
Riboflavin, mg	1.8	1.6	1.8
Niacin, mg	10	8	10
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, liveweight class (amounts per animal per day)

Item	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	0.62	0.62	1.65	1.82	0.77	0.62
Total digestible nutrients, lb	3.3	3.3	8.2	9.1	4.1	3.3
Digestible energy, kcal	6600	6600	16,500	18,150	8250	6600
Metabolizable energy, kcal	6340	6340	15,840	17,420	7920	6340
Inorganic nutrients:						
Calcium, g	15.0	15.0	37.5	41.2	18.8	15.0
Phosphorus, g	10.0	10.0	25.0	27.5	12.5	10.0
Salt (NaCl), g	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.	8200	8200	16,500	18,150	10,250	8200
Vitamin D, I.U.	550	550	1100	1210	690	550
Vitamin E, mg	22.0	22.0	55.0	60.5	27.5	22.0
Thiamine, mg	3.0	3.0	5.0	5.5	3.8	3.0
Riboflavin, mg	8.0	8.0	17.5	19.3	10.0	8.0
Niacin, mg	44.0	44.0	87.5	96.3	55.0	44.0
Pantothenic acid, mg	33.0	33.0	65.0	71.5	41.3	33.0
Vitamin B_{12}, mcg	28.0	28.0	55.0	60.5	35.0	28.0

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

Amino acid	Growing pigs weighing			Bred sows and gilts	Lactating sows and gilts[2]
	10–25 lb	45–80 lb	130–220 lb		
Arginine	0.28	0.20	0.16	–	0.34
Histidine	0.25	0.18	0.15	0.20[3]	0.26
Isoleucine	0.69	0.50	0.41	0.37	0.67
Leucine	0.83	0.60	0.48	0.66[3]	0.99
Lysine	0.96	0.70	0.57	0.42	0.60
Methionine + cystine[4]	0.69	0.50	0.41	0.28	0.36
Phenylalanine + tyrosine[5]	0.69	0.50	0.41	0.52[3]	1.00
Threonine	0.62	0.45	0.37	0.34	0.51
Tryptophan	0.18	0.13	0.11	0.07	0.13
Valine	0.69	0.50	0.41	0.46	0.68

[1]Adapted from National Research Council, Committee on Animal Nutrition, *Nutrient Requirements of Swine,* 7th rev. ed., National Academy of Sciences Publication No. 1599, Washington, D.C., 1973 and Illinois Coop. Ext. Serv. Circular 866, *Balancing Swine Rations,* 1963.

[2]All suggested requirements for lactation are based on the requirement for maintenance + amino acids produced in milk by sows fed 11–12 pounds of feed per day, from which amino acids are 80 percent available.

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

[4]Methionine can fulfill the total requirement; cystine can meet at least 50 percent of the total requirement.

[5]Phenylalanine can fulfill the total requirement; tyrosine can fulfill 30 percent of the total requirement.

Table 6. Trace minerals for swine

Mineral element	Requirement (mg/lb diet)	Toxic level (mg/lb diet)
Copper	2.7[1]	135-225[3]
Iron	36.3[1]	2270
Iodine	0.1	365
Manganese	9.1	1815
Zinc	23.0[2]	910
Selenium	0.05	2.3-4.5

[1]Baby pig requirement.
[2]Higher levels may be needed if excessive calcium is fed.
[3]In the absence of higher levels of dietary iron and zinc; in a few instances, a dietary level of 113 mg/lb has resulted in symptoms of excess.

Table 7. Recommended antibiotic levels for swine

Variable	Pig weight (lb)	Antibiotic level (g)
		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[1]—Continued

Feed ingredient	Dry matter (%)	Energy		Protein		Amino acids				Carbohydrates		Fat (%)	Ash (%)	Minerals		Vitamins			
		T.D.N. (%)	D.E. kcal/lb	Crude (%)	Dig. (%)	Lysine (%)	Meth. (%)	Cystine (%)	Tryp. (%)	Fiber (%)	N.F.E. (%)			Ca (%)	P (%)	Rib. (mg/lb)	P.A. (mg/lb)	Niacin (mg/lb)	Choline (mg/lb)
Energy feeds																			
Bakery waste, dried	91	100	–	10.9	10.0	–	–	–	–	0.7	64.7	13.7	1.6	–	–	–	–	–	–
Barley	89	72	1400	11.6	8.2	0.53	0.18	0.18	0.18	5.0	68.2	1.9	2.4	0.08	0.42	0.9	2.9	26.1	468
Cassava meal	86	63	–	1.4	1.0	–	–	–	–	3.1	78.6	0.6	2.0	0.13	0.15	–	–	–	–
Cassava root	33	26	–	1.1	0	–	–	–	–	1.4	28.8	0.3	1.0	0.05	0.06	–	–	–	–
Coconut meat, fresh	54	73	–	4.4	3.3	–	–	–	–	5.5	6.5	36.0	1.0	–	–	–	–	–	–
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	0.15	0.45	–	–	–	–
Corn and Cob Meal	87	70	1410	8.1	5.8	0.16	0.08	0.08	0.08	8.0	66.1	3.2	1.6	0.04	0.27	0.4	1.8	7.2	160
Corn, yellow, no. 2 Dent	89	82	1640	9.0	7.1	0.18	0.09	0.09	0.09	2.0	73.1	3.9	1.1	0.02	0.33	0.6	1.1	12.0	244
Fats, oils, and tallows	100	199	3990	0	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	–	–	–	–	0.7	3.0	5.7	1.5	0.10	0.06	–	–	–	–
Irish potato root	22	20	392	2.2	1.6	–	–	–	–	0.7	18.3	0.1	1.1	0.01	0.05	0.1	2.9	5.0	–
Millet grain	90	66	1317	12.0	8.8	–	–	–	–	8.0	62.9	4.8	3.2	0.05	0.28	0.7	3.4	23.9	359
Milo (sorghum)	89	78	1570	11.0	7.8	0.27	0.09	0.18	0.09	2.0	71.6	2.8	1.7	0.04	0.29	0.5	5.2	19.4	308
Molasses, cane	75	56	1120	3.2	0	–	–	–	–	0	63.6	0.1	8.1	0.89	0.08	1.5	17.4	15.6	398
Oats	89	65	1300	11.8	9.9	0.36	0.18	0.18	0.18	11.0	58.5	4.5	3.2	0.10	0.35	0.7	5.9	7.2	488
Pineapple bran	86	65	–	3.8	0.6	–	–	–	–	20.0	58.5	1.7	2.6	0.16	0.15	–	–	–	–
Rice bran	91	74	1480	13.5	10.2	0.50	0.24	0.10	0.10	11.0	40.5	15.1	10.9	0.06	1.82	1.2	10.7	138.0	570
Rice polishings	90	89	1780	11.8	10.3	0.50	0.20	0.10	0.10	3.0	54.0	13.2	8.0	0.04	1.42	0.8	26.5	242.0	594
Rice, rough	89	57	1140	7.3	5.5	0.27	0.15	0.10	0.12	9.0	66.4	1.9	4.5	0.04	0.26	0.5	4.0	13.8	450
Rice, white, polished	89	86	1720	7.3	6.2	0.27	0.27	0.09	0.09	0.4	80.4	0.4	0.5	0.03	0.12	0.3	1.5	6.4	412
Rye	89	75	1500	11.9	9.6	0.45	0.18	0.18	0.09	2.0	71.8	1.6	1.7	0.06	0.34	0.7	3.1	0.5	–
Sugar, crude	99	96	1816	0.8	0	0	0	0	0	0	0	–	–	0.20	0.03	–	–	–	–
Sweet potato meal	88	63	–	7.9	6.0	–	–	–	–	4.0	69.5	1.1	3.5	0.09	0.15	–	–	–	–
Sweet potato root	32	26	–	1.6	0.2	–	–	–	–	1.9	26.7	0.4	1.2	0.03	0.04	–	–	–	–

Table 8. Analysis of feedstuffs commonly used in swine rations[1]—Continued

Feed ingredient	Dry matter (%)	Energy		Protein		Amino acids				Carbohydrates		Fat (%)	Ash (%)	Minerals		Vitamins			
		T.D.N. (%)	D.E. (kcal/lb)	Crude (%)	Dig. (%)	Lysine (%)	Meth. (%)	Cystine (%)	Tryp. (%)	Fiber (%)	N.F.E. (%)			Ca (%)	P (%)	Rib. (mg/lb)	P.A. (mg/lb)	Niacin (mg/lb)	Choline (mg/lb)
Taro root	28	18	–	1.5	1.0	–	–	–	–	0.6	24.2	0.1	1.2	0.02	0.07	–	–	–	–
Wheat	89	80	1600	12.7	11.7	0.45	0.18	0.18	0.18	3.0	70.0	1.7	1.6	0.05	0.36	0.5	5.5	25.7	377
Wheat bran	89	57	1142	16.0	12.2	0.60	0.10	0.30	0.30	10.0	52.8	4.1	6.1	0.14	1.17	1.4	13.2	95.0	499
Wheat middlings (wheat, flour byproduct)	89	73	1460	17.0	15.0	0.60	0.10	0.20	0.20	2.0	63.0	3.6	2.5	0.08	0.52	0.7	6.2	23.9	490
Wheat mill run (wheat mixed feed)	90	72	1440	15.3	12.2	0.50	0.40	0.20	0.20	8.0	57.5	4.0	5.2	0.09	1.02	1.1	6.0	51.0	466
Protein feeds																			
Alfalfa meal, dehydrated	93	32	652	17.9	8.3	0.80	0.20	0.40	0.40	24.3	38.9	3.0	9.0	1.33	0.24	5.6	13.6	20.8	690
Blood meal	91	61	1220	80.0	62.0	6.90	0.90	1.40	1.10	1.0	2.8	1.6	5.6	0.28	0.22	0.7	0.5	14.3	344
Buttermilk, dried	93	77	1540	32.0	29.8	2.40	0.70	–	0.50	0	45.2	5.8	9.6	1.30	0.90	14.1	13.7	3.9	822
Buttermilk, liquid	9	9.1	–	3.5	3.3	–	–	–	–	0	4.5	0.6	0.8	0.14	0.08	0.7	2.1	0.6	–
Coconut oil meal (expeller)	93	76	1529	20.4	14.9	0.50	0.30	0.20	0.20	12.0	47.2	6.6	6.9	0.20	0.60	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	0.17	0.60	6.0	–	–	–
Cottonseed meal, 41% (expeller)	94	67	1337	41.0	35.0	1.70	0.60	0.80	0.60	12.0	30.4	4.3	6.2	0.16	1.20	2.3	6.4	18.3	1264
Cottonseed meal, 41% (solvent)	92	61	1224	41.0	35.0	1.70	0.60	0.80	0.60	12.0	31.9	1.4	6.2	0.16	1.20	2.3	6.4	17.9	1300
Meat and bone meal	94	65	1300	51.0	45.0	3.50	0.70	0.60	0.20	2.2	2.6	9.5	29.1	10.60	5.10	2.0	1.7	21.7	995
Peanut oil meal (expeller)	92	86	1714	46.0	43.0	1.30	0.60	0.70	0.50	11.0	23.6	5.9	5.7	0.17	0.57	2.4	21.9	76.8	765
Peanut oil meal (solvent)	92	77	1549	47.4	44.5	2.30	0.40	–	0.50	13.0	25.9	1.2	4.5	0.20	0.65	5.0	24.1	77.3	909
Shark meal	91	71	1422	72.0	66.2	–	0.80	–	–	0.5	–	2.5	13.5	3.50	1.90	3.1	4.1	28.8	1660
Skim milk, dried	94	86	1720	33.5	32.8	2.80	0.80	0.50	0.40	0.2	51.8	0.9	7.6	1.30	1.00	9.1	15.3	5.2	648
Skim milk, liquid	9.5	8.7	–	3.6	3.4	–	–	–	–	0	5.1	0.1	0.7	0.13	0.10	0.9	1.6	0.5	–

Table 8. Analysis of feedstuffs commonly used in swine rations[1]—Continued

Feed ingredient	Dry matter (%)	Energy		Protein		Amino acids				Carbohydrates		Minerals		Vitamins			
		T.D.N. (%)	D.E. (kcal/lb)	Crude (%)	Dig. (%)	Lysine (%)	Meth. (%)	Cystine (%)	Tryp. (%)	Fiber (%)	N.F.E. (%)	Fat (%)	Ash (%)	Ca (%)	P (%)	Rib. (mg/lb)	P.A. (mg/lb)	Niacin (mg/lb)	Choline (mg/lb)
Soybean oil meal, dehulled (solvent)	90	77	1548	50.9	46.3	3.20	0.70	0.70	0.80	2.8	29.7	0.8	5.6	0.26	0.62	1.4	6.6	9.8	1255
Soybean oil meal, 44% (expeller)	90	79	1580	44.0	39.5	2.70	0.80	0.60	0.60	6.0	29.8	4.7	5.7	0.27	0.63	1.4	6.4	13.8	1215
Soybean oil meal, 44% (solvent)	89	75	1500	45.8	41.7	2.90	0.60	0.60	0.60	6.0	30.5	0.9	5.8	0.32	0.67	1.5	6.6	12.2	1247
Sunflower oil meal (expeller)	93	71	1416	41.0	33.7	2.00	1.60	–	–	13.0	24.6	7.6	6.8	0.43	1.00	–	–	–	–
Tuna meal	87	69	1377	57.3	52.7	6.20	1.70	1.00	0.90	1.0	0.9	8.9	19.0	5.30	3.10	3.6	3.6	27.0	1300
Whey, liquid	6.7	6.0	–	0.9	0.8	–	–	–	–	0	5.0	0.1	0.7	0.10	0.10	0.1	2.4	0.4	–

[1]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—Continued

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Corn (maize)	60	80	90	80	80	–	1. High energy and low fiber contents; highly palatable. 2. Yellow corn is not a dependable source of vitamin A; white corn has no vitamin value. 3. Deficient in most essential amino acids, particularly in lysine and tryptophan. 4. High lysine corn (Opaque-2) is higher in protein, lysine, and tryptophan. 5. Low in calcium.
Wheat	35	80	90	90	90	–	1. Higher in protein content (11–13%) than corn. 2. Ground wheat has replacement value of 95–110% corn. 3. Should be ground coarsely or rolled for hogs as has a tendency to be less palatable if finely ground.
Wheat bran, wheat mixed feed (millrun)	0	5	5	30	15	–	1. Crude protein content of 14–16%. 2. High fiber content (8–10%), bulky. 3. Bran has a mild laxative effect. 4. Bran is palatable. 5. Should not replace more than 10% corn in ration for growing pigs.
Wheat middlings, wheat pollard, wheat shorts	5	30	30	20	20	–	1. Crude protein content of 15–16%. 2. When limited to 20% of ration, feeding value surpasses corn. 3. Slightly lower in fiber content than wheat bran and millrun.
Barley	25	80	90	80	80	–	1. Higher in crude protein (10–11%) than corn. 2. Higher in fiber content (6%), lower in energy than corn. 3. Ground barley has replacement value of 85%–95% corn. 4. Should be ground or rolled for swine.

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

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Oats	0	20	20	40	20	–	1. Higher in crude protein (11–12%) than corn. 2. High in fiber (12%), lower in energy. 3. Ground whole oats has replacement value of 80–85% corn when limited to 25% of the ration. 4. Hulled or rolled oats has replacement value of 105–110% corn.
Milo (sorghum)	35	70	80	70	70	–	1. Crude protein content of 10–11%. 2. Ground milo has replacement value of 90–95% corn. 3. Some sorghums because of higher tannin content are less palatable.
Rice	30	40	45	55	55	–	1. Rough rice fairly high in fiber content (9%). 2. When finely ground, rough rice has 75–85% feeding value of corn.
Rice bran	0	20	20	55	20	–	1. Crude protein content of 12%. 2. High in fat content (11–12%), which is often rancid. 3. Produces soft pork unless solvent is extracted. 4. Worth 85% value of corn when restricted to 30% of the ration. 5. May cause scouring in young pigs.
Rice polish	0	30	50	50	50	–	1. Crude protein content of 12%. 2. When limited to 30% of corn in the ration, has feeding value of 120% corn. 3. Soft pork is produced if rice polish makes up more than 50% of the ration. 4. May cause scouring in young pigs.
Rye	0	50	70	0	0	–	1. Crude protein content of 11–12%. 2. Lacks palatability.

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

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Rye (Cont.)							3. Ground rye has replacement value of 90% corn when limited to 20% of corn in the ration. 4. Possible contamination with ergot which may cause abortions.
Pineapple bran	0	5	10	30	15	–	1. High in fiber content (18–20%), lower in energy content. 2. Reduces gain in growing pigs if fed at high levels.
Molasses (cane)	10	50	55	50	20	–	1. High level of molasses requires fibrous material in the ration to prevent scouring. 2. Exact level of molasses dependent upon price relationship with grains since growth rate will be less and feed per unit of grain will be greater than on standard rations. 3. Handling of high molasses ration is more difficult. 4. Primary value is as energy source with virtually no protein value.
Garbage	0	Ad libitum feeding plus ½ to 1 lb daily of a protein supplement.			0	–	1. Variable in composition. 2. Best not to feed pigs less than 75 lb on a high garbage diet. 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 contents. 2. Can replace up to 50% grain for swine. 3. Dried bakery waste may have to be moistened at feeding time.

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

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Root crops: Irish potato, sweet potato, taro, 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% total ration. If root crops are fed ad libitum, 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 energy; and deficient in vitamins A and D. 2. Generally, root crops should not be fed at higher rate than 3–4 lb roots to 1 lb grain. When fed at this rate, cooked starchy root crops are worth about 25% of the value of corn. 3. Dry matter contains mostly carbohydrate (starch). 4. Starchy root crops should be cooked. a. Irish potatoes — add salt (2 lb per 100 lb potatoes) to increase palatability, but drain off water before feeding. b. Cassava—cooking eliminates prussic acid problem.
Fruits: coconut, banana, breadfruit, papaya, 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. 2. a. Coconut and breadfruit relatively high in dry matter (40-50%). b. Avocado and banana relatively low in dry matter (20–25%). c. Papaya low in dry matter (10%). 3. Coconut and avocado high in fat (36% and 16%). a. Avocado produces soft pork. b. Coconut produces hard pork. 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. Suggested maximum levels of ingredients to use in swine rations—Continued

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Dehydrated or dried roots: cassava meal, sweet potato meal, Irish potato meal	–	45	50	50	45	–	1. Primarily used as an energy source. 2. Low in protein content. 3. When limited to about one-third of the total ration, dried roots have feeding value comparable to grain.
Coconut oil meal (copra)	10	30	30	25	25	50	1. Crude protein content of about 20%, but of medium quality. 2. Lacking in palatability. 3. If cheaper in price, then 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. 2. Gossypol toxicity problem Cottonseed meal should not exceed 9% of complete ration, and level of gossypol in the total ration should not exceed 0.01% free gossypol. 3. Low in lysine and marginal in isoleusine, threonine, and tryptophan contents. 4. Low in calcium content.
Peanut oil meal (groundnut meal)	5	15	15	15	15	25	1. Generally contains 45–50% protein. 2. Low in lysine content.
Alfalfa meal, lucerne meal	0	5	5	10	10	15	1. Good source of carotene (Vit. A). 2. High fiber content (25%). 3. Low palatability. 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%. 2. Liable to excessive heating or other damage during processing thus affecting available levels of amino acids, digestability, and palatability.

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

Ingredient	% 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. 2. Variable quality.
Meat meal, meat and bone meal, tankage	5	5	5	10	10	25	1. Crude protein content of 45–60%. 2. Variable quality—dependent upon amount of bone and connective tissue and processing method used. 3. Low in tryptophan particularly; somewhat low in methionine and isoleucine contents. 4. High in calcium and phosphorus contents. 5. Good source of lysine, but improper processing may destroy or reduce availability.
Soybean oil meal	20	20	15	20	20	80	1. Crude protein content of 41–50%. 2. Best vegetable protein source for pigs. 3. Marginal in methionine content. 4. When used as only source of protein, must be supplemented with minerals and vitamins.
Skim milk, dried	20	0	0	0	0	20	1. Crude protein content of 33%, which is of excellent quality. 2. Good source of the B vitamins, calcium, and phosphorus. 3. Cost limitation.
Liquid skim milk, liquid buttermilk	0	2 lb grain-vitamin-mineral mix *plus* ½ gal milk (Ration of grain to milk approximately 1:2-3)	4–5 lb grain-vitamin-mineral mix *plus* ¾–1 gal milk *or* 2 lb grain mix *plus* 3½ gal ad libitum	2 lb grain mix *plus* milk at rate of 1 gal per 1-1/5 lb grain mix	4 lb grain mix *plus* milk at rate of 1 gal per 1-1/5 lb grain mix	–	1. Liquid skim milk and buttermilk are similar in feeding value. 2. For younger pigs, particularly, milk should be consistently fresh, sour, or preserved, otherwise digestive upsets may occur. To preserve, add ¾–1½ pints formalin (40% solution of formaldehyde in water) to each 100 gal separated milk.

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

Ingredient	% of total ration					% of supplement	Remarks
	Starter	Grower	Finisher	Gestation	Lactation		
Liquid skim milk (Cont.)							3. For maximum performance results, it is best not to feed to appetite. 4. Exact levels of feeding dependent upon price relationship with grains. 5. One gal contains about 1 lb dry matter. 6. 100 lb is equal in value to about 28 lb corn.
Liquid whole whey	0	2½ lb grain mix *plus* ½–2 gal ad libitum	2½ lb grain mix *plus* 2–5 gal ad libitum	–	–	–	1. Lower protein content than in skim milk or buttermilk. More suitable for pigs weighing over 100 lb. 2. Feeding value about one-half that of skim milk. 3. Similar feeding value to corn when making up 25–30% of the ration.

Table 10. Percentage of minerals present in various supplement sources

Source	Mineral		
	Calcium	Phosphorus	Other
Calcium and phosphorous supplement			
Bone black	27.0	12.7	
Bone meal (steamed)	29.0	13.6	
Defluorinated phosphate rock	29.0	13.3	
Dicalcium phosphate	27.0	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 supplement			
Magnesium sulfate			9.9% Mg
Maganese supplement			
Maganese oxide			72.0% Mn
Maganese carbonate			48.0% Mn
Maganese sulfate			32.0% Mn
Iron supplement			
Iron oxide			70.0% Fe
Iron sulfate (ferrous)			20.0% Fe
Iodine supplement			
Calcium iodate			60.0% I
Potassium iodide			76.0% I
Cobalt supplement			
Cobalt carbonate			50.0% Co
Cobalt sulfate			25.0% Co
Cobalt oxide			73.0% Co
Copper supplement			
Copper oxide			80.0% Cu
Copper sulfate			25.0% Cu
Copper carbonate			53.0% Cu
Zinc supplement			
Zinc oxide			80.0% Zn
Zinc sulfate			23.0% Zn
Zinc carbonate			52.0% Zn

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