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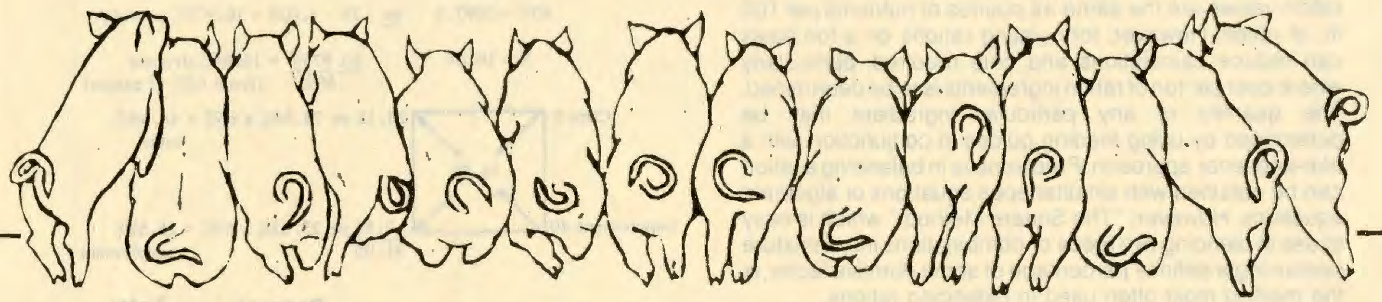
NUTRITION

Pork Industry Handbook



Principles of Balancing a Ration

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A balanced ration contains the necessary nutrients in the correct proportions to nourish the animal properly. The ration nutrients are energy, protein, minerals and vitamins. Fat is also required to supply essential fatty acids but is usually adequate in all practical rations. Water is even more important than energy but normally is provided with free access and is not involved in ration formulation. A palatable and economical energy source can be transformed into a nutritionally balanced ration if the nutrient deficiencies are corrected.

Practical ration formulas must be sufficiently flexible to accommodate price and feedstuffs availability while retaining the necessary nutritive balance and adequacy. When supplements are extremely high priced, it may be most economical to feed slightly less protein than recommended even with a somewhat decreased rate of production. When protein-rich feeds are relatively cheaper than those low in protein, it is sometimes economical to supply a greater amount of protein than normally supplied.

Swine rations are usually formulated around cereal grains because they are high in energy and low in fiber. Corn is the most commonly fed grain, but other grains may be used. All grains are deficient in protein quantity and quality and in minerals and vitamins. Corn is an excellent energy source, and soybean meal is an excellent protein source. Soybean meal can be fed as the only supplemental protein source for swine.

The nutrient content of grains is affected by such factors as type or variety, soil and climatic conditions, stage of maturity at harvest, location where grown and time in storage. Nutrient requirements vary in animals by age, weight, sex and function. Requirements may vary even in animals of the same weight. Therefore, rations are usually over-fortified as insurance against the variation that exists in both feeds and animals.

Usually high-energy, low-fiber rations are used for swine, and energy level is not a particular problem for growing-finishing animals. However, for gilt developer or gestation rations, lower energy and higher fiber levels can be used to control weight.

Logical Steps in Formulating a Ration

1. Identify the animals to be fed.
2. Select nutrient allowances to fit the animal.
3. Select ingredients to meet nutrient allowances.
4. Determine amounts of each ingredient.

Identify animals to be fed by age and function and specific conditions under which they are fed. Penning and feeding in uniform lots allows a producer more accurately to meet the pigs' requirements.

Select a set of nutrient requirements or allowances most appropriate for the animals being fed. An authoritative source of information is "Nutrient Requirements of Swine" published by the National Academy of Sciences. Adaptations from this publication mostly revised upwards are presented in Tables 1 and 2, and are called allowances. Nutrient allowances may differ from requirements and may reflect special area or regional needs, or even opinion. Table 3 gives some conversion factors that are very useful in ration calculations.

Select suitable ingredients to insure that the ration is nutritionally balanced, palatable, safe and economical. Table 4, "Maximum amount of different feeds for various rations," gives some guidelines for utilizing different feeds. Various feeding guides and example rations are helpful in selecting feed ingredients. Average analyses of selected ingredients are presented in Table 5.

Determine the necessary fixed amounts of certain ingredients (minerals and vitamins) and then mix grain(s)

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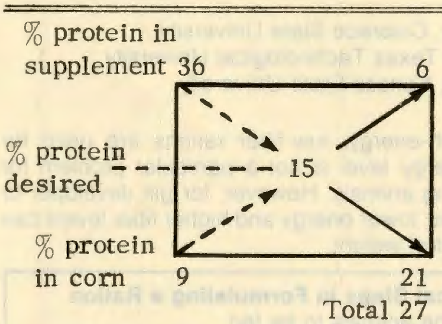
relative to protein supplement to provide the desired protein level. Rations can be formulated on either a 100 lb. basis or on a ton basis, depending on personal preference. The advantage of using 100 lb. basis is that percent of ration values are the same as pounds of nutrients per 100 lb. of ration. However, formulating rations on a ton basis can reduce calculations and time required, particularly where cost per ton of ration ingredients is to be determined. The quantity of any particular ingredient may be determined by using feeding guides in conjunction with a trial-and-error approach. Preciseness in balancing a ration can be obtained with simultaneous equations or algebraic equations. However, "The Square Method," which is easy to use in blending two feeds or combinations into a mixture containing a definite percentage of some nutritive factor, is the method most often used in balancing rations.

Computer formulation is available in some areas at a reasonable cost. This method often suggests additional alternatives of feed substitution and reduces time and chances of error in hand calculation.

Balancing rations for grain and protein supplementation

Example: Combine a 36% supplement and 9% corn to make a 15% ration.



Cwt. or % basis		Ton basis
6/27 x 100 = 22.2%	x	20 = 444 lb. supplement
21/27 x 100 = 77.8%	x	20 = 1556 lb. corn
100.0%		2000 lb.

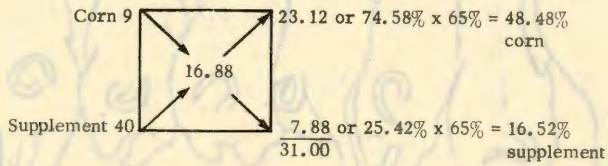
Subtract on the diagonal the smaller number from the larger to obtain relative amounts of corn (36 - 15 = 21) and supplement (15 - 9 = 6). Six parts of 36% supplement to 21 parts of 9% corn would give a 15% ration. To put on a percentage basis, divide 21 by 27 and multiply by 100 to get 77.8% corn, and divide 6 by 27 and multiply by 100 to get 22.2% supplement. Each of these percentage figures can be multiplied by 20 to put on a ton basis. The protein contents of other grains, supplements or mixtures, can be substituted in the above formula to mix a ration of a desired protein content.

Example: A 15% protein ration is needed. It is to contain 35% barley and an appropriate amount of corn and 40% supplement. Protein content of barley is 11.5% and corn is 9.0%. Since 35% of the ration is 11.5% protein, 65% of the ration must be considerably higher to give a 15% protein ration.

(35 x 11.5) + 65X = 100 x 15 | 35 x .115 = 4.025% protein (from barley)

65X = 1097.5 | or 15 - 4.025 = 10.975% protein

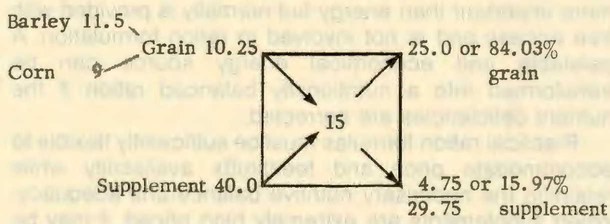
X = 16.88 | $\frac{10.975\%}{.65\%}$ = 16.88% protein (from 65% of ration)



Ingredients	Pounds	Percent protein	Total protein
Barley	35.0	11.5	4.025
Corn	48.5	9.0	4.365
Supplement	16.5	40.0	6.6
	100.0		*14.99 or 15%*

The above method may be used for any predetermined amount of any ingredient such as 5% fish meal, 10% alfalfa meal, 5% whey, etc.

Example: a 15% protein ration is to contain equal parts of corn and barley balanced with 40% protein supplement. The protein content of corn is 9.0% and barley is 11.5%, which gives a 10.25% average for the two grains.

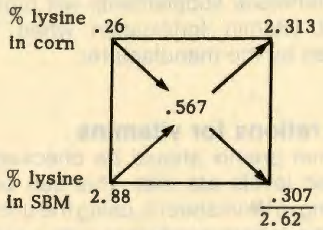


Ingredients	Pounds	Percent protein	Total protein
Barley	42.0	11.5	4.83
Corn	42.0	9.0	3.78
Supplement	16.0	40.0	6.4
	100.0		15.01 or 15%

Balancing rations for amino acids

Rations can be balanced on an amino acid basis rather than on a crude protein basis. This can provide a more precise indication of ration protein adequacy. Lysine is the amino acid recognized as most critical in protein supplementation of all-plant swine rations.

Example: A corn-soybean meal ration furnishing 0.55% lysine is needed for finishing hogs. Assume that 3% of the ration formula will be needed to furnish minerals, vitamins and additives. Corn contains about 0.26% lysine, and soybean meal contains about 2.88% lysine. Since only 97% of the ration contains lysine, that portion must contain 0.567% lysine (0.55 ÷ .97 = 0.567).



Cwt. or % — Ton basis

$$\frac{2.313}{2.62} \times 100 = 88.28 \times .97 = 85.63 \times 20 = 1713 \text{ lb. corn}$$

$$\frac{.307}{2.62} \times 100 = 11.72 \times .97 = 11.37 \times 20 = 227 \text{ lb. SBM}$$

$$3.0 \times 20 = 60 \text{ lb. added}$$

$$100.00 \qquad 2000 \text{ lb. total}$$

A mixture of 1713 lb. corn, 227 lb. soybean meal and 60 lb. of minerals, vitamins, and additives result in 1 ton of ration with a lysine level of 0.55%. If complete mixture totaled less than 2000 lb., corn can be used to make up the difference.

Balancing rations for minerals

The following procedure is suggested for supplementing a corn-soy ration with minerals.

1. Use iodized salt and trace mineral mix or swine trace mineral salt in all rations to meet sodium, chlorine and trace mineral needs.

2. Supply calcium and phosphorus to meet allowance levels shown in Table 1.

Example: Meet the requirements for a 50-lb. pig of 0.65% calcium and 0.50% phosphorus using an 80% corn and 20% soybean meal mixture.

Step 1. Using the analyses in Table 5, calculate the calcium and phosphorus available from your corn and soybean meal. Eighty lb. of corn and 20 lb. of soybean meal provides 0.058 lb. of calcium and 0.32 lb. of phosphorus.

Ingredient	Lb.	Ca %	Ca lb.	P %	P lb.
Corn	80	.01	.008	.25	.20
SBM	20	.25	.05	.60	.12
			.058		.32

Step 2. Subtract calcium and phosphorus supplied in corn and soybean meal from the requirement. Calcium is still short by 0.592% or 0.592 lb., and phosphorus is short by 0.18% or 0.18 lb.

	Ca %	P %
Requirement	.650	.500
Corn & SBM	.058	.32
Shortage	.592	.180

Steps 3 & 4. Meet the phosphorus requirement first since most phosphorus sources also contain some calcium (phosphorus sources are also more expensive than calcium sources). In this example, using 1.0 lb. or 1.0% of dicalcium phosphate would provide an additional 0.22 lb. of calcium and 0.18 lb. of phosphorus. This would meet the phosphorus requirement and leave the calcium short 0.372 lb.

(Dicalcium phosphate 22% Ca - 18% P)

Lb.	Ca %	Ca lb.	P %	P lb.
1.0	22	.22	18	.18

Calcium - short 0.372 (.592 - .22)

Phosphorus - need is met

Step 5. Provide limestone in adequate amount to meet the calcium shortage. Do not add excess limestone just because it is low in cost. In this example, 1.0 lb. or 1.0% limestone would provide 0.38 lb. calcium and would satisfy the requirement.

(Limestone 38% Ca)

Lb.	Ca %	Ca lb.
1.0	38	.38

To calculate this on a ton basis, multiply the answer by 20. This same system can be used with additional feed ingredients. Calcium and phosphorus levels in each ingredient can be obtained from Table 5. This procedure is fairly accurate, but results in more than a 100-lb. mix, and protein levels will be slightly less than those calculated using 100 lb. after minerals are added, unless allowance is made for minerals and premixes as in the earlier example with lysine.

Example: Calculate the mineral adequacy of a ration, using a commercial protein-mineral-vitamin supplement and grain. Assume that the supplement contains 36% protein, 3.5% calcium, and 1.6% phosphorus according to the label. It is being fed in a combination of 1700 lb. corn and 300 lb. of 36% supplement. Assume a desired level of

0.60% calcium and 0.50% phosphorus in the ration. Calculate the expected levels of calcium and phosphorus:

	Ca %	P %	Ca/1 ton	P/1 ton
1,700 lb. ground corn	.01	0.25	0.17 lb.	4.25 lb.
300 lb. supplement	3.5	1.6	10.5	4.8
Totals:			10.67 lb.	9.05 lb.
Desired levels in 1 ton:			12.0 lb.	10.0 lb.
Minus amounts provided:			-10.67	- 9.05
Shortage/ton, if any:			1.33 lb.	0.95 lb.

Calculations suggest the above combination of feedstuffs is slightly lower than desired in both calcium and phosphorus. The ration is short 1.33 lb. calcium per ton and 0.95 lb. phosphorus per ton. Select a mineral supplement that will provide phosphorus and calcium in the amounts needed. Dicalcium phosphate contains 22% calcium and 18% phosphorus, and its Ca/P ratio closely approximates what is needed. By dividing the amount of phosphorus needed by phosphorus level of dicalcium phosphate, the amount needed per ton is determined:

$$\frac{0.95}{18\% \text{ or } .180} = 5.28 \text{ lb. dicalcium phosphate}$$

Adding 6 lb. dicalcium phosphate per ton to the ration of 1700 lb. corn and 300 lb. supplement will raise the ration phosphorus level to very near 0.50% (9.05 plus 6 x .180 = 10.13). Six lb. of dicalcium phosphate addition also raises the calcium level by 1.32 lb. (6 x .22 = 1.32), which now meets the 0.60% calcium level sought (10.67 + 1.32 = 11.99).

Most commercial supplements will provide adequate mineral and vitamin fortification when fed at levels recommended by the manufacturer.

Balancing rations for vitamins

The vitamin premix should be checked to see if the recommended levels are met. This can be done rather simply by filling in Worksheet 1, using the units per pound of premix and the recommended pounds per ton of ration.

Summary

Most rations are formulated in one of three ways:

1. Combining corn and/or other grains with a complete protein supplement. Table 6 gives varying protein levels using corn and supplement.
2. Combining corn and/or other grains with soybean meal and a complete vitamin-mineral premix. Table 7 shows some example rations using this method.
3. Combining corn and/or other grains with soybean meal, a vitamin-premix, trace minerals, salt and sources of calcium and phosphorus. This would involve a further extension of Table 7.

Worksheet 1. Calculating vitamin requirement using given premix.

Vitamin	Units per lb. premix	Pounds premix per ton	Total units per ton	Units required per ton
Vitamin A, IU				
Vitamin D, IU				
Vitamin E, IU				
Vitamin K, mg.				
Riboflavin, mg.				
Niacin, mg.				
Pantothenic, mg.				
Choline, mg.				
Vitamin B_{12}, mcg.				

Table 1. Nutrient allowances of starting, growing and finishing swine, percentage or amount per pound of diet.

Liveweight class, lb.	to 35	35-75	75-125	125-mkt.
Metabolizable energy, kcal.	1,400	1,400	1,400	1,400
Protein, %	18	16	14	13
Lysine, %	.90	.77	.60	.55
Methionine + cystine, %	.56	.40	.30	.25
Tryptophan, %	.15	.12	.09	.08
Calcium, %	.80	.65	.60	.60
Phosphorus, %	.60	.50	.50	.50
Salt, %	.50	.50	.50	.50
Iron, mg.	36	36	36	36
Copper, mg.	2.7	2.7	2.7	2.7
Manganese, mg.	14	14	14	14
Zinc, mg.	30	30	30	30
Iodine, mg.	0.1	0.1	0.1	0.1
Selenium, mg.	0.045	0.045	0.045	0.045
Vitamin A, IU	3,000	1,500	1,500	1,500
Vitamin D, IU	300	150	150	150
Vitamin E, IU	10	10	10	10
Vitamin K, mg.	1	1	1	1
Riboflavin, mg.	2	1.4	1.4	1.2
Niacin, mg.	12	8	8	8
Pantothenic acid, mg.	8	6	6	6
Choline, mg.	600	400	400	300
Vitamin B_{12}, mcg.	10	6	6	6

Table 2. Nutrient allowances of breeding swine, percentage or amount per pound of diet.

Animal class	Gestating	Lactating	Boars
Metabolizable energy, kcal.	1,400	1,400	1,400
Protein, %	15	15	15
Lysine, %	.50	.60	.60
Methionine + cystine, %	.32	.32	.32
Tryptophan, %	.08	.10	.08
Calcium, %	.90	.75	.90
Phosphorus, %	.70	.60	.70
Salt, %	.50	.50	.50
Iron, mg.	36	36	36
Copper, mg.	2.7	2.7	2.7
Manganese, mg.	14	14	14
Zinc, mg.	30	30	30
Iodine, mg.	0.1	0.1	0.1
Selenium, mg.	0.045	0.045	0.045
Vitamin A, IU	3,000	3,000	3,000
Vitamin D, IU	300	300	300
Vitamin E, IU	10	10	10
Vitamin K, mg.	1	1	1
Riboflavin, mg.	2	2	2
Niacin, mg.	12	12	12
Pantothenic acid, mg.	10	10	10
Choline, mg.	400	400	400
Vitamin B_{12}, mcg.	10	10	10
Feed required, lb.	4.0	12.0	5.0

Table 3. Metric system—mass conversions.

Equivalents

1 pound (lb) = 454 grams (g)
1 kilogram (kg) = 2.2 lb = 1000 g
1 g = 1000 milligrams (mg)
1 mg = 1000 micrograms (mcg)
1 mg/kg = 1 part/million (ppm)
1 mcg/lb = 2 mg/ton
1 mg/lb = 2 g/ton
1 mg/lb = 2.2 ppm
1 mcg/g = 1 ppm

To convert

mg/g to mg/lb — multiply by 454
mcg/g to mg/g — divide by 1000
mcg/lb to mg/lb — divide by 1000
mg/lb to mcg/g — divide by 0.454
mg/lb to ppm — multiply by 2.2
g/lb to % — divide by 4.54
% to g/lb — multiply by 4.54

Conversion table

%	ppm	g/ton	mg/lb
0.0001	1.0	0.9	0.45
0.00011	1.1	1.0	0.5
0.001	10.0	9.1	4.55
0.0011	11.0	10.0	5.0
0.01	100.0	90.8	45.4
0.011	110.0	100.0	50.0
0.1	1000.0	908.0	454.0
0.11	1100.0	1000.0	500.0

Table 4. Maximum amount of different feeds for various rations.

	% complete ration				
	Gestation	**Lactation**	**Starter**	**Grower**	**Finisher**
Alfalfa meal	90	10	0	5	5
Barley	80	80	25	80	90
Blood meal	3	3	0	3	3
Corn	85	85	70	80	90
Corn and cobmeal	70	10	0	0	0
Cottonseed meal	5	5	0	5	5
Dist. dried sol. corn	5	5	5	5	5
Fish meal	10	10	5	10	5
Linseed meal	5	5	5	5	5
Meat and bone meal	10	10	5	5	5
Grain sorghum	85	85	60	80	90
Molasses	5	5	5	5	5
Oats	70	15	0	20	20
Skim milk, dried	0	0	40	0	0
Soybean meal	20	20	30	25	20
Tankage	10	5	0	5	5
Wheat	85	85	60	80	90
Whey	5	5	20	5*	5*

*Recent research indicates higher levels may be fed without reducing performance.

Table 5. Average analysis of ingredients used in swine rations.

Ingredient (air dry)	Metabolizable energy Kcal/lb.	Protein	Calcium	Phosphorus	Fat	Fiber	Lysine	Methionine	Cystine	Tryptophan
		percent								
Alfalfa meal (dehydrated)	543	17	1.30	0.23	2.5	27.0	0.80	0.29	0.29	0.36
Barley	1,275	11.5	0.06	0.36	1.8	7.0	0.36	0.18	0.19	0.16
Blood meal	1,200	80	0.28	0.22	1.0	1.0	5.37	1.04	1.40	1.02
Corn (yellow)	1,500	8.8	0.01	0.25	3.8	2.5	0.26	0.19	0.20	0.09
Corn and cob meal (yellow)	1,200	7.5	0.04	0.20	3.0	10.0	0.16	0.15	0.13	0.06
Cottonseed meal (solvent)	1,100	41	0.15	1.00	1.5	13.0	1.55	0.49	0.65	0.48
Distillers dried solubles, corn	1,500	27	0.12	0.68	7.5	9.0	0.77	0.50	0.36	0.18
Fish meal (menhaden)	1,200	60	4.90	2.80	9.4	1.0	4.60	1.88	0.62	0.71
Linseed meal (solvent)	900	33	0.35	0.75	0.5	9.5	1.20	0.48	0.66	0.48
Meat and bone meal	1,100	50	8.10	4.10	8.6	2.8	2.50	0.65	0.62	0.29
Milo, grain sorghum	1,425	9	0.02	0.27	2.5	2.7	0.22	0.17	0.14	0.09
Molasses, cane	1,060	3	0.50	0.05	----	----	----	----	----	----
Oats	1,200	12	0.10	0.33	4.0	12.0	0.34	0.18	0.15	0.13
Skim milk, dried	1,545	33	1.25	1.00	0.5	----	2.70	0.80	0.40	0.45
Soybean meal (solvent, hulled)	1,520	48.5	0.20	0.65	0.5	3.0	3.14	0.73	0.82	0.63
Soybean meal (solvent)	1,475	44	0.25	0.60	0.5	7.0	2.88	0.56	0.66	0.55
Soybeans (whole, cooked)	1,600	38	0.25	0.58	18.0	5.0	2.40	0.51	0.54	0.55
Tankage	980	60	4.60	2.50	6.4	2.0	3.89	0.75	0.52	0.58
Wheat (hard)	1,500	12.2	0.05	0.35	1.5	2.4	0.38	0.20	0.16	0.15
Wheat (soft winter)	1,500	10.0	0.05	0.30	1.7	2.8	0.30	0.14	0.20	0.12
Whey (dried)	1,445	12	0.90	0.80	0.5	----	0.80	0.16	0.24	0.13

Table 6. Varying protein per ton of feed using corn and supplement.*

Ingredients	18% protein	16% protein	15% protein	14% protein	13% protein	12% protein
Ground corn	1455	1576	1636	1697	1758	1818
42% supplement	545	424	364	303	242	182
Ground corn	1419	1548	1613	1678	1740	1806
40% supplement	581	452	387	322	260	194
Ground corn	1379	1517	1586	1655	1724	1793
38% supplement	621	483	414	345	276	207
Ground corn	1333	1481	1556	1630	1704	1778
36% supplement	667	519	444	370	296	222
Ground corn	1276	1436	1517	1598	1678	1759
34% supplement	724	564	483	402	322	241
Ground corn	1218	1391	1478	1565	1652	1740
32% supplement	782	609	522	435	348	260
Ground corn	1142	1333	1428	1524	1620	1714
30% supplement	858	667	572	476	380	286

*Corn figured at 9.0% protein.

Table 7. Rations using mineral-vitamin premix.

	Gestation	Lactation	to 35	35-75	75-125	125-mkt.
Ground corn (9%), lb.	1600	1555	1390	1515	1650	1705
Soybean meal (44%), lb.	315	370	535	425	295	240
Mineral-vitamin premix*	85	75	75	60	55	55
Total, lb.	2000	2000	2000	2000	2000	2000
Protein, %	14	15	18	16	14	13
Calcium, %	.90	.75	.80	.65	.60	.60
Phosphorus, %	.70	.60	.60	.50	.50	.50

*In preparing premixes, actual weights can vary with ingredient sources and carriers.