Relative Values of Feedstuffs for Swine - Pork Industry Handbook
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Relative Value of Feedstuffs for Swine

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In the U.S., supplies of competitively priced corn and soybean meal have been readily available through recent decades, so it is reasonable that these feedstuffs are the predominant ingredients used in swine diet formulation. However, a vast amount of swine feeding research and production experience has demonstrated that nutritional requirements of swine can be met with a variety of feed ingredients including alternative grains and oilseeds, grain milling by-products, food and beverage industry by-products, animal processing by-products, and others.

Feed ingredient prices change as markets respond to the forces of supply and demand. The relative value of alternative feeds for swine diet formulation is important because feed costs account for 60% to 70% of production costs and thus have a major impact on profitability. Pork producers willing to effectively compare the value of potential ingredients and appropriately utilize the best alternatives when appropriate can realize increased profit through decreased feed costs. This is particularly true for large scale producers and feed manufacturers with the capacity to procure and store many different ingredients. Moderate and small scale producers and feed mills also can realize benefits from assessing the relative values of ingredients, although the type and quantity of alternative feeds considered for use may be more limited. Least-cost diet formulation programs offer the most common method used to make value comparisons. However, the method described in this fact sheet is simpler and provides an accurate indication of feedstuff value.

When assessing the value of alternative feeds for swine, it is important to recognize that some feeds may have negative properties that limit the quantity that can be effectively included in diet formulations. For example, oats is a feed grain that has greater protein content than corn but the relatively high fiber content of oats reduces energy digestibility. Excessive dietary levels of oats can cause the finished feed to be bulky and physically difficult to handle. PIH-3, *Dietary Energy for Swine,* provides information on maximum inclusion rates for a variety of alternative energy and protein feed sources. Assuming that limitations on inclusion rates for certain ingredients are adhered to, alternative feedstuffs value assessment can be used for cost effective diet formulation.

What Comprises Value in a Swine Feedstuff?

In order of cost contribution to the diet, energy, protein (or essential amino acids), and available phosphorus are the three most costly components in a complete swine feed. If feeds are compared considering their contributions of energy, protein, and phosphorus they will be ranked in a manner similar to a least-cost solution.

Energy must be supplied in the greatest quantity and represents the largest cost contribution to the finished diet. Energy value of ingredients has particular importance because dietary energy levels must be adequate to fuel growth, reproductive function, and milk production. Within limits, swine provided *ad libitum* access to feed can compensate for lower dietary energy levels by voluntarily consuming more feed. Under this circumstance, growth rate may remain stable but feed efficiency will be reduced when feeding a lower energy diet. The energy requirement of pigs and the energy value of feeds typically is expressed as metabolizable energy (ME) which represents total energy minus energy lost in the feces and urine.

Table 1. Composition of selected cereal grains, by-product feeds and protein sources for swine.[1]											
								Suggested percent limit[2] in complete diets for:			
Feedstuff	Acid det. fiber, %	Metabolizable energy, Kcal/lb.	Crude protein, %	Total lysine, %	Apparent digestible lysine, %	Total phosphorus, %	Available phosphorus, %	gestation	lactation	starter >25 lb.	grow-finish
Corn	2.8	1551	8.3	.26	.17	.28	.04	80	80	60	85
Corn, high-oil	–	1590	8.8	.29	–	.28	.04	80	80	60	85
Grain sorghum	8.3	1515	9.2	.22	.14	.29	.06	80	80	60	85
Wheat, soft red winter	–	1499	11.5	.38	.28	.39	.20	80	80	60	85
Wheat, hard red winter	4.0	1456	13.5	.34	–	.37	.19	80	80	60	85
Triticale	3.8	1442	12.5	.39	.30	.33	.15	80	80	20	85
Barley	7.0	1320	10.5	.36	.25	.36	.11	80	80	25	85
Barley, hull-less	2.2	1506	14.9	.44	–	.45	–	80	80	60	85
Oats	13.5	1229	11.5	.40	.28	.31	.07	80	5	0	20
Rye	4.6	1388	11.8	.38	.24	.33	–	20	0	0	25
Dried bakery product	1.3	1678	10.8	.27	.17	.25	–	40	40	20	40
Dried brewers grains	21.9	889	26.5	1.08	.75	.56	.19	40	5	0	10
Beet pulp, dried	24.3	1132	8.6	.52	–	.10	–	10	5	0	0
Corn distillers grain & solubles	16.3	1368	27.7	.62	.29	.77	.59	40	10	5	10
Corn gluten feed	10.7	1182	21.5	.63	.32	.83	.49	90	5	5	25
Corn grits by-product (hominy)	8.1	1456	10.3	.38	–	.43	.06	60	60	0	60
Rice bran	13.9	1293	13.3	.57	.41	1.61	.40	40	5	0	20
Wheat bran	13.0	1032	15.7	.64	.44	1.20	.35	30	5	0	0
Wheat middlings	10.7	1372	15.9	.57	.43	.93	.38	30	5	0	10
Soybean meal, 44% CP	9.4	1442	43.8	2.83	2.41	.65	.20	25	20	35	22
Soybean meal, dehulled	5.4	1553	47.5	3.02	2.57	.69	.16	22	20	30	20
Soybean seeds, heat processed	8.0	1674	35.2	2.22	1.80	.59	–	30	25	40	30
Canola meal, solvent extr.	17.2	1197	35.6	2.08	1.54	1.01	.21	5	5	5	10
Corn gluten meal	4.6	1737	60.2	1.02	.77	.44	.07	5	5	0	5
Cottenseed meal, solv. extr.	19.4	1050	41.4	1.72	1.05	1.06	.01	5	5	0	5
Fish meal (menhaden)	–	1524	62.3	4.81	4.28	3.04	2.86	5	5	5	5
Meat & bone meal	5.6	1009	51.5	2.51	1.86	4.98	4.48	10	5	5	5
Peanut meal, mech. extr.	9.1	1615	43.2	1.48	–	.59	–	5	5	0	5
Poultry by-product meal	–	1297	64.1	3.32	2.59	2.41	–	10	5	0	5
Sunflower meal, dehulled	18.4	1241	42.2	1.20	.89	1.01	–	10	5	0	10

[1]Composition data adapted from NRC (1998) Nutrient Requirements of Swine, tenth revised edition. Values are on an air dry (88-94% DM), as-fed basis.
[2]Suggested limits taken principally from PIH-3, Dietary Energy for Swine (Holden, Shurson and Pettigrew, 1991).

Cereal grains are the primary energy-contributing ingredients for swine diets. Table 1 shows published (NRC 1998) metabolizable energy values for selected grains and grain by-products. Note that on an air-dry, as-fed basis, feeds with higher fiber content generally will contain less ME for swine and thus have lower relative value for diet formulation. For example, barley grain typically has about twice as much fiber as corn and considerably less metabolizable energy than corn.

The second largest contributor to the cost of swine diets is protein, or more specifically, the source of essential amino acids required by swine. For most grain and oilseed meal-based diets, lysine is the most limiting amino acid. For this reason, swine diets typically are formulated to insure that the pig's lysine requirement is met with the knowledge that other amino acids such as tryptophan, threonine, and methionine will be fed at levels slightly above the requirement. Because the total lysine content of feeds is not 100 percent available to pigs, diets can be formulated to more accurately meet lysine requirements when the digestible lysine requirement of the pig is used as the formulation criterion. Reliable data on the apparent digestibility of lysine for swine are available for many, but not all, potential swine feed ingredients (Table 1).

Phosphorus represents the third most significant expense to a swine diet due primarily to the need for inorganic phosphate supplements such as dicalcium phosphate (18.5% available phosphorus), mono-dicalcium phosphate (21% available phosphorus), or defluorinated phosphate (17% available phosphorus). Adding these phosphorus supplements can contribute in the range of $2.00 to $4.00 additional cost per ton of finished feed. Energy and protein sources that also contribute significant quantities of available phosphorus to the final diet add value because less inorganic phosphate supplement is required. Available phosphorus is important because much of the total phosphorus in grains and oilseeds is bound as phytate. Unless the enzyme phytase is supplemented in the diet, most of the phytate-bound phosphorus in feeds is not available to the pig. Unfortunately reliable estimates of phosphorus availability have been determined for only a limited number of typical swine feed ingredients (Table 1); total phosphorus content estimates are available for most feedstuffs that may be used in swine diets.

Calculating and Comparing Relative Value of Feedstuffs

One method that has been used to determine the relative value of swine feedstuffs is to solve simultaneous equations to estimate the value of metabolizable energy, lysine, and phosphorus in three reference feeds with known market prices which are typically used in the diet. The value of each component may then be applied to alternative feedstuffs to estimate value of the potential alternative feed relative to the reference feed values. The three reference feeds would include a principle energy source (usually corn), a source of essential amino acids (usually soybean meal), and a supplemental phosphorus source such as dicalcium phosphate. The simultaneous equations for these reference feeds can be written as follows:

Met. Energy, Kcal./lb.		Lysine, %		Phosphorus, %		Market Price
1551X	+	.26Y	+	.28Z	=	corn, $/cwt.
1442X	+	2.83Y	+	.65Z	=	soybean meal (44% CP), $/cwt.
0X	+	0Y	+	18.5Z	=	dicalcium phosphate, $/cwt.

By solving for X (the value coefficient for Met. Energy), Y (the value coefficient for lysine), and Z (the value coefficient for phosphorus), one may calculate the relative total value of an alternative feed by applying the appropriate coefficient to the metabolizable energy, lysine, and phosphorus levels in the alternative feed and then summing the values to estimate the relative value per hundredweight.

The simultaneous equations above would be appropriate if reliable estimates of apparent digestible lysine or available phosphorus were not available. However, if apparent digestible lysine and available phosphorus values for the alternative feed in question were available (Table 1), then a more accurate assessment could be made by substituting digestible lysine and available phosphorus in place of total values. Regardless of whether total, digestible, or available figures are used, it is important that the nutrient values be consistent for the reference feeds and the alternative feed being evaluated.

Table 2. Spreadsheet program for use with personal computers. [1,2]

Column / Row	A	B	C	D	E
1.					
2.	**Ingredient**	**Price/cwt.**	**Energy**	**Lysine**	**Phosphorus**
3.					
4.	Corn	$5.00	1551	.17	.04
5.	Soybean meal (44%)	$10.00	1442	2.41	.20
6.	Dicalcium phosphate	$13.00	0	0	18.5
7.					
8.			(formula 1)	(formula 2)	(formula 3)
9.			(formula 4)	(formula 5)	(formula 6)
10.					
11.	Value of lysine, $/lb			(formula 7)	
12.	Value of phosphorus, $/lb				(formula 8)
13.	Value of energy, $/Kcal/lb		(formula 9)		
14.					
15.	Composition of feed in question:		1499	.28	.20
16.	Relative value of above feed:	(formula 10)			

Formulas for the above locations		**Values**
Formula 1	@SUM(D4..D6)/@SUM(C4..C6)	0.0008620
Formula 2	@SUM(E4..E6)/@SUM(C4..C6)	0.0062612
Formula 3	@SUM(B5..B6)/@SUM(C4..C6)	0.0093551
Formula 4	((C4*D8)-E4)	9.6712395
Formula 5	((C4*D8)-D4)/C9	0.1206649
Formula 6	((C4*@SUM(B4..B6)/@SUM(C4..C6)))-B4)/C9	0.9833130
Formula 7	((C%*E8)-B5-(E9*E5))/<<<C5*C*)-(D9*C5*D8)+(D9*E5))	2.3255334
Formula 8	(B5+(C4*((D11*C8)-E8)-(D11*D4)))/E4-(C4*D8))	0.7027027
Formula 9	(@SUM(B4..B6)/@SUM(C4..C6))-(C8*D11)-(D8*E12)	0.0029507
Formula 10	(C15*C13)+D15*D11)+(E15*E12)	$5.21

[1] After PIH-112, revised 11/87. E.J. Stevermer, C.R. Hamilton, N.T. Moreng, M.J. Parsons, and T.D. Tanksley, Jr., authors.
[2] The example is shown for soft red winter wheat.

Solving these simultaneous equations in computer spreadsheet programs offers a means to rapidly calculate the relative value of alternative feeds, depending on the composition and prices of reference feeds. Computer spreadsheet formulas to solve the simultaneous equations are given in Table 2. The spreadsheet program may be downloaded at no cost from http://www.ansc.purdue.edu/compute/subvalue.htm. It should be noted that neither this method nor linear programming (least-cost) methods assign additional value to high energy feeds based on the potential for improvements in feed efficiency with higher energy diets. Rather this method assigns value to the metabolizable energy content of feeds with the assumption that feed efficiency will be similar for complete diets that contain similar energy levels.

Table 3 illustrates relative value estimates for selected feed grains and Table 4 show relative values for selected grain by-products when corn, 54% protein soybean meal, and dicalcium phosphate are used as the reference price feeds. In these tables, values are given for situations in which corn is priced from $4.00 to $8.00 per hundredweight ($2.24 to $4.48/bu.), soybean meal is priced at $200 or $250 per ton, and dicalcium phosphate is priced at $260 per ton. All values generated for the table are expressed on an equal weight basis ($/cwt.). This is important because bushel weights vary substantially among feed grains and thus would not allow for accurate price comparisons for different grains. Once relative values per cwt. are determined, appropriate standard bushel weights for feed grains can be used to calculate relative value based on price per bushel.

Table 3. Estimated value of feed grains for swine using corn, soybean meal (44% CP), and dicalcium phosphate as reference price feedstuffs.[1]

Corn $/cwt	High-oil corn $/cwt	Grain sorghum $/cwt	Soft Red Winter Wheat $/cwt	Hard Red Winter Wheat $/cwt	Triticale $/cwt	Barley $/cwt	Hull-less Barley $/cwt	Oats $/cwt	Rye $/cwt
Soybean Meal (44% CP) at $200/ton, dicalcium phosphate at $260/ton									
4.00	4.16	3.85	4.30	4.09	4.19	3.75	4.44	3.59	3.87
5.00	5.17	4.84	5.21	4.99	5.06	4.55	5.35	4.33	4.73
6.00	6.19	5.83	6.13	5.90	5.93	5.36	6.25	5.06	5.59
7.00	7.21	6.81	7.05	6.80	6.80	6.17	7.16	5.79	6.45
8.00	8.22	7.80	7.97	7.71	7.67	6.98	8.06	6.52	7.30
Soybean Meal (44% CP) at $250/ton, dicalcium phosphate at $260/ton									
4.00	4.18	3.82	4.42	4.18	4.34	3.86	4.63	3.76	3.97
5.00	5.20	4.81	5.34	5.09	5.22	4.67	5.53	4.49	4.83
6.00	6.21	5.80	6.26	5.99	6.09	5.48	6.43	5.22	5.68
7.00	7.23	6.78	7.18	6.90	6.96	6.29	7.34	5.95	6.54
8.00	8.25	7.77	8.10	7.80	7.83	7.09	8.24	6.69	7.40

[1]Relative values are based on solving for value coefficients X (metabolizable energy), Y (lysine or digestible lysine), and Z (phosphorus or available phosphorus) using simultaneous equations with the reference feeds, then applying the value of X, Y, and Z coefficients to the composition of the feed in question.

Table 4. Estimated value of by-product feeds for swine using corn, soybean meal (44% CP), and dicalcium phosphate as reference price feedstuffs.[1]

Corn $/cwt	Dried bakery product $/cwt	Dried brewers grain $/cwt	Beet pulp, dried $/cwt	Corn distillers grain+ solubles $/cwt	Corn gluten feed $/cwt	Corn grits by-product (hominy) $/cwt	Rice bran $/cwt	Wheat bran $/cwt	Wheat middlings $/cwt
Soybean Meal (44% CP) at $200/ton, dicalcium phosphate at $260/ton									
4.00	4.25	4.20	3.61	4.30	3.89	4.09	4.33	3.78	4.55
5.00	5.34	4.50	4.22	5.13	4.58	4.98	5.05	4.31	5.32
6.00	6.43	4.80	4.84	5.95	5.26	5.87	5.77	4.84	6.08
7.00	7.52	5.11	5.45	6.77	5.94	6.76	6.50	5.38	6.85
8.00	8.60	5.41	6.06	7.60	6.63	7.65	7.22	5.91	7.62
Soybean Meal (44% CP) at $250/ton, dicalcium phosphate at $260/ton									
4.00	4.24	4.92	3.93	4.46	4.10	4.23	4.62	4.15	4.86
5.00	5.33	5.23	4.54	5.28	4.79	5.12	5.35	4.68	5.63
6.00	6.41	5.53	5.15	6.11	5.47	6.01	6.07	5.21	6.39
7.00	7.50	5.83	5.77	6.93	6.15	6.90	6.79	5.74	7.16
8.00	8.59	6.14	6.38	7.75	6.84	7.79	7.52	6.27	7.93

[1]Relative values are based on solving for value coefficients X (metabolizable energy), Y (lysine or digestible lysine), and Z (phosphorus or available phosphorus) using simultaneous equations with the reference feeds, then applying the value of X, Y, and Z coefficients to the composition of the feed in question.

Feed grains that contain similar or higher metabolizable energy levels, higher digestible lysine, and higher available phosphorus levels than corn will be valued somewhat higher than corn on an equal weight basis. For example, soft red winter wheat has slightly less metabolizable energy than corn but higher digestible lysine and available phosphorus than corn. When soybean meal is priced at $200 per ton and corn is priced at $5.00 per cwt. ($2.80/bu.) then soft red winter wheat is valued at $5.21 per cwt. ($3.12/bu.) (Table 3). Under this scenario, if soft red winter wheat can be purchased for less than $5.21 per cwt., it is more cost effective to include more wheat and less corn in the diet formulation. These relative value estimates hold true assuming that diets are formulated properly and the maximum inclusion rate limits indicated in Table 1 are not exceeded.

This method is equally valid for determining relative value estimates for high protein feedstuffs. In this case the producer or feed formulator is more interested in the relative value of the alternative feed as compared to a standard protein source such as soybean meal. Table 5 illustrates the relative values of selected protein sources when 44% protein soybean meal, corn, and dicalcium phosphate are used as reference price feeds. In this table 44% protein soybean meal is priced over a range of $9.00 to $13.00 per cwt. ($180 to $260 per ton), corn is priced at $4.50 or $6.50 per cwt. ($2.52 or $3.64/bu.), and dicalcium phosphate is priced at $260 per ton. As indicated a protein source such as dehulled soybean meal (48% CP) which is higher in energy and digestible lysine than standard soybean meal (44%LP) will have higher relative value per cwt. than 44%LP soybean meal. Conversely, a protein source with less energy and digestible lysine such as canola meal will have less value when compared to soybean meal.

Related Publications

PIH-3 Dietary Energy for Swine
PIH-5 Protein and Amino Acids for Swine
PIH-7 Principles of Balancing a Swine Ration
PIH-23 Swine Diets
PIH-52 Minerals for Swine
PIH-108 By-products in Swine Diets

Table 5. Estimated value of protein feed sources for swine using soybean meal (44% CP), corn, and dicalcium phosphate as reference price feedstuffs.[1]

Soybean meal, 44% CP $/cwt	Soybean meal, dehulled $/cwt	Soybean seeds, heat processed $/cwt	Canola meal, solvent extr. $/cwt	Corn gluten meal $/cwt	Cottonseed meal solv.extr. $/cwt	Fish meal, menhaden $/cwt	Meat& bone meal $/cwt	Poultry by-product meal $/cwt	Sunflower meal, dehulled $/cwt
Corn at $4.50/cwt ($2.52/bu), dicalcium phosphate at $260/ton									
9.00	9.60	8.32	6.54	6.27	4.99	14.99	9.71	10.23	5.67
10.00	10.67	9.04	7.17	6.52	5.40	16.82	10.49	11.32	6.01
11.00	11.73	9.76	7.79	6.78	5.82	18.64	11.26	12.40	6.34
12.00	12.80	10.47	8.42	7.04	6.23	20.47	12.04	13.49	6.68
13.00	13.86	11.19	9.04	7.30	6.65	22.30	12.82	14.58	7.01
Corn at $6.50/cwt ($3.64/bu), dicalcium phosphate at $260/ton									
9.00	9.62	9.14	6.92	8.03	5.57	13.56	9.57	9.88	6.65
10.00	10.69	9.86	7.55	8.29	5.98	15.39	10.34	10.97	6.99
11.00	11.75	10.58	8.17	8.54	6.40	17.21	11.12	12.05	7.32
12.00	12.82	11.30	8.80	8.80	6.81	19.04	11.90	13.14	7.66
13.00	13.88	12.01	9.42	9.06	7.23	20.87	12.67	14.23	7.99

[1]Relative values are based on solving for value coefficients X (metabolizable energy), Y (lysine or digestible lysine), and Z (phosphorus or available phosphorus) using simultaneous equations with the reference feeds, then applying the value of X, Y, and Z coefficients to the composition of the feed in question.

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