Economic Evaluation of Dairy Feeds

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Feed costs typically represent more than 50% of total costs of producing milk on a dairy farm. Feed cost savings, even a few dollars per ton, add up to significant savings over a year on a large dairy.

For many dairies, a ration-balancing software program that uses linear programming techniques can be used to determine the opportunity cost or price of including a new feed in a ration. However, this requires expertise in using the ration-balancing software, and may not be appropriate when quick decisions need to be made.

The purpose of this guide is to describe alternative methods of pricing various feeds. In particular, four techniques, including the cost/nutrient, index, simultaneous equation, and by-product equation methods are discussed. The manual calculation of these techniques is described herein, but a spreadsheet that uses these methods to determine feed value is available through NMSU's Cooperative Extension Service by contacting Greg Bethard, Extension dairy specialist, at (505) 646-6404.

WHAT INFORMATION IS NECESSARY?

For producers to make proper decisions about purchasing a feed, accurate information is needed about the specific feed. A lab analysis of the feed including dry matter, crude protein (CP), fiber [acid detergent fiber (ADF) or neutral detergent fiber (NDF)], and a prediction of energy is necessary.

It is important to remember that energy [as total digestible nutrients (TDN) or net energy for lactation (NEL)] is not measured in the lab, but is calculated from fiber content. Labs use different equations to predict energy from fiber, particularly for forages. For this reason, if you purchase forages, consider the source of the energy prediction. Also, take caution in using "book" values from published tables such as those in the *1989 Nutrient Requirements of Dairy Cattle*. Often, the actual nutrient content in feeds varies considerably from book values.

For dairy feeds, it is critical that feeds are evaluated on a dry basis rather than an as-fed or as-is basis. As-fed basis includes moisture, and dry basis is without water. Many dairy feeds, particularly silages, contain more than 50% water. The water component contains no nutrients, so high-moisture feeds are less valuable per pound on an as-fed basis.

Lab analysis generally provides a nutrient profile on a dry-matter basis. If nutrient concentrations such as crude protein, TDN, NEL, or minerals are given on an as-fed basis, simply divide the percentage of the component by the percent dry matter to obtain concentrations on a dry basis:

% component on as-fed basis ÷ % dry matter
= % component on dry-matter basis.

For example, suppose a feed is 40% dry matter and contains 8% crude protein on an as-fed basis. The crude protein on a dry matter basis is

8.0 ÷ 0.40 = 20% CP on a dry matter basis.

To convert as-fed pounds to dry-matter pounds, simply multiply the number of as-fed pounds by the percent dry matter:

lb as-fed x % dry matter = lb dry matter.

For example, how many pounds of dry matter are in 1,000 as-fed pounds of corn silage at 35% dry matter?

1,000 x 0.35 = 350 lb of dry matter.

COST/NUTRIENT METHOD

This is a simple, convenient method of calculating cost per unit of protein, energy, fiber, or any other component of a feed. Most feeds are purchased to supply protein or energy, so cost per pound of crude protein and cost per megacalorie (Mcal) of NEL are generally useful. See table 1 for examples of various feeds and the cost per nutrient.

To calculate cost per pound of each nutrient, two items are necessary: cost, and nutrient content. Since cost is normally expressed as dollars per ton, it is simpler to work on a ton basis. If you know the cost for a ton of feed, the cost per pound of any nutrient can be estimated by determining the number of pounds of the nutrient in a ton of feed, thus

(% of component on dry-matter basis ÷ 100)
x [(% dry matter ÷ 100) x 2,000 lb/ton]

= lb of component/ton on as-fed basis.

Using shelled corn as an example (from table 1), pounds of crude protein in a ton can be calculated from protein content (9% on dry matter basis) and dry matter (89%):

(9.0 ÷ 100) x [(89 ÷ 100) x 2,000]
= 160.2 lb CP/ton of as-fed corn.

Thus, a ton of corn contains 160.2 lb of crude protein. If corn costs $150/ton, then cost per pound of protein is

$150/ton ÷ 160.2 lb/ton CP as-fed
= $0.936/lb CP as-fed.

The following is the calculation to determine cost per Mcal NEL for corn, assuming corn contains 0.90 Mcal/lb dry matter and 89% dry matter:

Mcal/lb dry matter x [(% dry matter ÷ 100) x 2,000 lb/ton]
= Mcal/ton as-fed

0.90 x [(89 ÷ 100) x 2,000 lb/ton]
= 1,602 Mcal/ton of as-fed corn

$150/ton ÷ 1,602 Mcal/ton
= $0.0936/Mcal

In table 1, there are three examples of energy sources: corn, barley, and oats. For the prices and nutritive values listed, barley is the least expensive source of energy at $0.090/Mcal NEL, and oats are the least expensive protein source at $0.58/lb crude protein. These feeds would normally be added to a ration to supply energy, and not protein. Thus, cost per pound of protein should not serve as criteria for selecting one of these energy sources.

Among the protein sources listed in table 1, there are differences in cost. Cottonseed meal is the least expensive per unit of energy and protein, and would thus be the better buy. However, another consideration is that cottonseed meal may contain gossypol, and feeding large quantities of both cottonseed meal and whole cottonseed increases the risk of gossypol toxicity. Quality of the feed source and possible interactions with other feeds in the ration are not considered in economic evaluation. Other factors in addition to cost need to be considered.

For the rumen undegradable protein (RUP) sources (table 1), blood meal is the least expensive source of crude protein. For RUP protein sources, cost per unit of RUP may also be of interest.

If we assume that 82% of blood meal protein is undegradable, then the cost per unit of RUP is:

% CP x (percent RUP ÷ 100)
= RUP as a % of dry matter

(% RUP of dry matter ÷ 100) x (% dry matter x 2,000 lb/ton)
= lb RUP/ton as-fed

$/ton* ÷ lb RUP/ton as-fed
= $/lb RUP
**From table 3.*

Example:

90% CP x (82 ÷ 100)
= 73.8% RUP of total dry matter

(73.8 ÷ 100) x (0.90 x 2,000)
= 1,328.4 lb RUP/ton of as-fed blood meal

$500 ÷ 1,328.4
= $0.38/lb RUP.

For fish meal, assuming 65% RUP, the calculation is:

$$67 \times (65 \div 100)$$
$$= 43.6\% \text{ RUP of total dry matter}$$

$$(43.6 \div 100) \times (0.92 \times 2{,}000)$$
$$= 802.2 \text{ lb RUP/ton as fed fish meal}$$

$$\$550 \div 802.2$$
$$= \$0.69/\text{lb RUP}.$$

Blood meal is the better buy in terms of cost per pound of crude protein and RUP, but again, quality has not yet been considered. Fish meal has a more desirable amino acid profile than blood meal, which increases its value. This must also be considered before a final purchasing decision is made.

Weaknesses of Cost/Nutrient Method

Although this method is simple and easy to calculate, results should be interpreted with caution. First, feeds should be evaluated based on their most valuable nutrient or what the feed is being purchased for. For example, corn would be purchased to add energy to the ration, so it should be evaluated based on cost per unit of energy. Evaluating corn based on protein would be unwise, as corn contributes little to the total protein in the diet. Likewise, protein sources such as soybean meal and cottonseed meal should be judged mainly on cost per pound of crude protein. Feeds that supply moderate quantities of energy and protein are more difficult to evaluate using this method. For example, distillers' grains typically contain moderate amounts of protein and energy.

A second weakness of the cost/nutrient method is that it does not consider palatability, digestibility, or quality of the feed source. These factors must also be considered when making purchasing decisions. As an extreme example, consider dried cattle manure and soybean meal. Dried cattle manure typically contains 16% crude protein, and is certainly cheaper per pound of crude protein than soybean meal. Obviously, dried cattle manure is unpalatable and a poor feed source, and is not a good buy as a dairy feed no matter how inexpensive it is.

For cost/nutrient analysis to be useful, feeds of similar nature should be compared. Protein sources should be compared with protein sources, and energy sources with energy sources. In addition, protein sources that supply significant quantities of rumen undegradable or bypass protein such as fish meal and blood meal should not be compared to highly rumen-degradable protein sources such as soybean meal.

Table 1. Cost/nutrient for various feedstuffs (dry matter basis).

Feed (%)	DM[1] (%)	CP[2] (Mcal/lb)	NEL[3] ($/ton)	Cost CP	$/lb NEL	$/Mcal
Energy sources						
Shelled corn	89	9.0	0.90	150	0.94	0.094
Barley	88	13.0	0.88	140	0.61	0.090
Oats	89	13.5	0.80	140	0.58	0.098
Protein sources						
Soybean meal	90	55.1	0.91	280	0.28	0.171
Cottonseed meal	93	45.0	0.74	220	0.26	0.160
RUP[4] sources						
Fish meal	92	67.0	0.76	550	0.45	0.393
Blood meal	90	90.0	0.80	500	0.31	0.347

[1]DM: dry matter
[2]CP: crude protein
[3]NEL: net energy for lactation
[4]RUP: rumen undegradable protein

INDEX METHOD

The index method is simply an extension of the cost/nutrient method. It accounts for both protein and energy, with weightings of 30% and 70%, respectively. These weightings correspond to their approximate contribution to total feed cost, excluding vitamins and minerals. Table 2 provides the index rating for the feeds in table 1. The lower the index, the better the buy.

Using the index method, barley and oats are the best buys among the energy sources, cottonseed meal is the best buy among protein sources, and blood meal is the best buy among RUP sources.

Weaknesses for the cost/nutrient and index methods are similar. Specifically, there is no consideration of palatability, digestibility, or quality. Like the cost/nutrient method, only similar feeds should be evaluated using the index method. That is, compare protein sources to protein sources, and so forth. The index method may be most useful for comparing intermediate feeds, such as distillers' grains and brewers' grains, that are not typical protein or energy sources.

Table 2. Economic evaluation of feeds using the index method.

Feed	Net energy Cost/Mcal		Net energy Weighting		Crude protein Cost/lb		Crude protein Weighting		Index
Energy sources									
Shelled corn	0.094	x	0.70	+	0.94	x	0.30	=	0.348
Barley	0.090	x	0.70	+	0.61	x	0.30	=	0.246
Oats	0.098	x	0.70	+	0.58	x	0.30	=	0.243
Protein sources									
Soybean meal	0.171	x	0.70	+	0.28	x	0.30	=	0.204
Cottonseed meal	0.160	x	0.70	+	0.26	x	0.30	=	0.190
RUP sources									
Fish meal	0.393	x	0.70	+	0.45	x	0.30	=	0.410
Blood meal	0.347	x	0.70	+	0.31	x	0.30	=	0.336

RELATIVE VALUE COMPARED TO CORN AND SOYBEAN MEAL USING SIMULTANEOUS EQUATIONS

This method involves solving simultaneous equations to equate the energy and protein value of a feed to the energy and protein in corn and soybean meal. Corn and soybean meal make good comparisons because they are readily available, commonly used dairy concentrates that are widely traded on the open market. By determining a value for a particular feed using this method, a producer can determine a current market value for the product. If the calculated value is less than the current market price, then the feed would not be a good buy. If the value is higher than the current price, then the feed is a good buy. This is an ideal method for valuing forages. However, this method is tedious and prone to error due to the many calculations. The spreadsheet FEEDVAL determines a value for any feed using this method. This spreadsheet is available from NMSU's Cooperative Extension Service by contacting Greg Bethard, Extension dairy specialist, at (505) 646-6404.

The steps to determine value per ton using simultaneous equations follow. For this example, we will assume the following nutrient profile for corn and soybean meal, on an as-fed basis:

	Crude protein (%)	NEL (Mcal/lb)	Cost/lb
Soybean meal	48.0	0.82	0.14
Corn	8.1	0.80	0.075

Step 1. Simultaneous equations are set up to determine the values of protein (x) and energy (y).

	Protein		NEL		Cost/lb
Eq. 1 (soybean meal)	0.48x	+	0.82y	=	0.14
Eq. 2 (corn)	0.081x	+	0.80y	=	0.075

Step 2. Solve for the value of protein (x) by dividing Equation 1 by 0.82, and Equation 2 by 0.80.

Eq. 1(a) $\frac{0.48x}{0.82} + \frac{0.82y}{0.82} = \frac{0.14}{0.82}$

equals: (b) $0.585x + y = 0.171$

Eq. 2 (a) $\frac{0.08lx}{0.80} + \frac{0.80y}{0.80} = \frac{0.075}{0.80}$

equals: (b) $0.101x + y = 0.094$

Step 3. From Step 2, subtract Equation 2b from Equation 1b. Then solve for x.

Eq. 1 (b)	0.585x	+	y	=	0.171
Eq. 2 (b)	- 0.101x	+	- y	=	-0.094
	0.484x	+	0	=	0.077
			x	=	$0.159/ lb of protein

Step 4. Substitute 0.159 for x in either equation in Step 3, and solve for y (value of energy).

Eq. 1(b)	.585(0.159) +	y	=	0.171
		y	=	$0.078/ Mcal of energy

Therefore, the values of protein (x) and energy (y) are $0.159/lb and $0.078/Mcal, respectively.

Values per ton for various feeds are calculated in table 3. For the first item, corn silage, value per ton was calculated as follows, assuming corn silage is 35% dry matter, and contains 8% crude protein and 0.70 Mcal/lb on a dry matter basis:

Dry matter lb/ton	= 2,000 lb/ton x (% dry matter ÷ 100)
Crude protein lb/ton	= (% CP ÷ 100) x dry matter lb/ton
Mcal NEL/ton	= Mcal/lb x dry matter lb/ton
Value/ton	= CP lb/ton x cost/lb CP
Dry matter lb/ton	= 2,000 lb/ton x (35 ÷ 100) = 700 lb/ton
Crude protein lb/ton	= (8 ÷ 100) x 700 = 56 lb/ton
Mcal NEL/ton	= 0.70 x 700 = 490 Mcal/ton
Value/ton	= [56 lb/ton CP x $0.159/lb CP] + [490 Mcal/ton x $0.078/Mcal] = $8.90 + $38.22 = $47.12/ton

For the feeds listed in table 3, all are a good buy, with the exception of blood meal and fish meal. A "good buy" implies that the value per ton is greater than the cost. This illustrates some problems with this method. Like the cost/nutrient and index methods, this method does not consider palatability, quality, or digestibility. In addition, RUP is not considered, hence high RUP prices are not fairly evaluated. This method is most useful for valuing by-product feeds and forages. It is important to note that this method may slightly over-value wet forages. High-moisture forages, such as corn silage and alfalfa haylage, are generally not as marketable as dry feeds due to transportation costs of hauling large quantities of water in the feed.

RELATIVE VALUE COMPARED TO CORN AND SOYBEAN MEAL USING SPECIFIC BY-PRODUCT EQUATIONS

Specific equations have been developed to determine value per ton for specific feeds relative to corn and soybean meal. Table 4 lists these equations, which can be solved simply with the cost per ton of corn and soybean meal. These equations yield similar results as the simultaneous equations method above.

Table 3. Value per ton for various feeds relative to corn ($150/ton) and soybean meal ($280/ton).

Feed	DM[1] (%)	CP[2] (%)	NEL[3] (Mcal/lb)	lb CP/ ton	Mcal/ ton	Value/ ton	Cost/ ton
Forages							
Corn silage	35	8.0	0.70	56	490	$ 47.12	$ 40.00
Alfalfa hay	85	22.0	0.65	374	1105	$ 145.66	$ 130.00
Energy sources							
Barley	88	13.0	0.88	229	1549	$ 157.19	$ 140.00
Oats	89	13.5	0.80	240	1424	$ 149.28	$ 140.00
Protein sources							
Cottonseed meal	93	45.0	0.74	837	1376	$ 240.44	$ 220.00
RUP[4] sources							
Fish meal	92	67.0	0.76	1233	1398	$ 305.09	$ 550.00
Blood meal	90	90.0	0.80	1620	1440	$ 369.90	$ 500.00

[1]DM: dry matter
[2] CP: crude protein
[3] NEL: net energy for lactation
[4] RUP: rumen undegradable protein

Table 4. Specific equations to value feeds based on soybean meal and corn price.

Barley	=	(0.908	x	corn $/ton)	+	(0.093	x	soybean mcal $/ton)
Wheat	=	(0.875	x	corn $/ton)	+	(0.125	x	soybean meal $/ton)
Hominy feed	=	(1.043	x	corn $/ton)	+	(0.012	x	soybean meal $/ton)
Soybean hulls	=	(0.081	x	corn $/ton)	+	(0.175	x	soybean meal $/ton)
Alfalfa pellets	=	(0.325	x	corn $/ton)	+	(0.241	x	soybean meal $/ton)
Wheat middlings	=	(0.683	x	corn $/ton)	+	(0.258	x	soybean meal $/ton)
Whole cottonseed	=	(0.656	x	corn $/ton)	+	(0.303	x	soybean meal $/ton)
Dry brewers grains	=	(0.374	x	corn $/ton)	+	(0.464	x	soybean meal $/ton)
Wet brewers grains	=	(0.121	x	corn $/ton)	+	(0.081	x	soybean meal $/ton)
Dry corn distillers	=	(0.701	x	corn $/ton)	+	(0.350	x	soybean meal $/ton)
Cottonseed meal	=	(0.025	x	corn $/ton)	+	(0.770	x	soybean meal $/ton)
Peanut meal	=	(0.087	x	corn $/ton)	+	(0.996	x	soybean meal $/ton)

From *Feeds and Feeding*, F.B. Morrison, Ithaca, NY.

CONCLUSION

There are a number of methods to economically evaluate feeds. Each method has advantages and disadvantages, but provides objective information to aid in making purchasing decisions. It is important to remember that none of the methods described here consider palatability, digestibility, or quality. Considering these criteria in addition to economic analysis should provide ample information to make sound feed purchasing decisions.

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