Ontario

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Comparative Feed Values For Ruminants

Table of Contents

One of the first considerations in selecting or replacing ingredients in a livestock diet is cost. The value of any feed in a ration depends on its usefulness in providing required nutrients. To accurately determine the value of an ingredient, you must know the general feed classification. This helps establish the nutritional profile and allows cost comparisons.

Classification of Commonly Used Alternative Feeds

A general classification of some commodity and alternative feeds for ruminant follow.

1. Energy Suppliers

- Grains (e.g., corn, oats, barley)
- Corn hominy, corn screenings
- Confectionery products
- Bakery wastes
- Cull fruits and vegetables
- Molasses

2. Protein Suppliers

- Oilseed meals (e.g., soybean, canola, cottonseed, flax, peanut, sunflower)
- Corn gluten meal
- Urea

3. Fibre Suppliers

- Oilseed hulls (e.g., soybean, cottonseed)
- Fruit and vegetable pulps (e.g., citrus, beet)
- Grain hulls (e.g., oats, barley)

4. Medium-Protein Feeds

- Wheat middlings, shorts
- Alfalfa meal and pellets
- Brewers and distillers grains

5. Multiple Nutrient Sources

- Cottonseed (fat, fibre & protein)
- Roasted soybeans (bypass protein, fat)

6. Fat Sources

- Tallow
- Specialty bypass fats
- Oils and grease

7. Bypass Protein Sources

- Corn gluten meal
- Blood meal
- Feather meal
- Fish meal
- Meat and bone meal (non-ruminant origin)
- Dried distillers grains

Energy

Feeds providing mainly energy, such as corn and hominy, are called energy suppliers. Waste products of the confectionery and baking industries (bakery, chocolate, or candy wastes) are also high in energy. Some are also high in fat and are more suitably called multiple nutrient sources.

Protein

Meals remaining from the processing of oilseed are predominantly protein suppliers. Some feed ingredients lower in protein than the oil meals (30%-50% crude protein) and equal or lower in energy value than corn (80% total digestible nutrient) are classified as medium-protein feeds.

Fibre

Commodity feeds may have benefits in ruminant nutrition due to their fibre content. These feeds are fibre suppliers and include products such as soybean hulls, oat hulls and beet pulp. An important consideration for fibrous by-products is heat damage resulting in poorer nutritional value. Elevated levels of acid detergent fibre-bound nitrogen (ADF-N), can discern this.

Fat

Fat sources are fed to increase the energy density of the ration, as in the case of high-producing, early-

lactation dairy cows and rapidly growing starter beef cattle. There are well-established limits to the amount and type of fat that can be effectively incorporated into animal rations. Overfeeding fat causes digestive disturbances in ruminants, reducing feed intake and efficiency.

Bypass Protein

Other feed ingredients have special features with respect to protein degradability for use by ruminants. These are classified as bypass or undegradable protein sources, of plant or animal origin, and have a crude protein content greater than 20%, with at least 50% of this protein escaping breakdown in the rumen. Most often, these ingredients have been specially heat treated or dried. They are most suitable for the diet of high-producing, early-lactation dairy cows or rapidly growing starter beef cattle. Bypass protein sources are often highly priced per unit of crude protein. The protein composition (amino acid profile) and levels of degradable, undegradable and soluble protein fractions are particularly important.

Feed Ingredient Evaluation

When considering feeds from a specific class, you can make economic decisions on a cost per kilogram of nutrient. For example, to chose between 48% and 44% soybean meal calculate the cost per unit of crude protein (CP) from each source and choose the one providing protein at the least cost. For example, 48% soybean meal (SBM) costs $380/tonne. The cost per unit of protein is ($380/480) or $0.79/kg. Similarly, if the cost of 44% SBM is $360/tonne, then the cost of protein is (360/440) or $0.82/kg. The same situation holds among the energy feeds based on their Total Digestible Nutrient (TDN) or Net Energy (NE) values.Petersen's equations were developed to compare the value of various feedstuffs with corn and soybean meal, as the sources of protein and energy. The use of these equations provides a fast and easy cost comparison for alternative feeds. In Table 3, *By-product Evaluation Using Petersen's Equations*, Petersen's equations were used to calculate the value of alternative feeds based on their protein and energy contents in comparison to the nutritive value and cost of corn and soybean meal (SBM). Factors used in Petersen's equations can be calculated as follows (input "as fed" values):

A = [(TDN corn x CP of test feed) - (CP of corn x TDN of test feed)] ÷ [(TDN corn x CP of SBM) - (CP of corn x TDN of SBM)]

B = [(CP of test feed) - (CP of SBM x A)] ÷ CP of corn

Petersen's equations are used to calculate the comparative value of a feed as follows:

$ value per tonne of test feed = (A x $ price per T SBM) + (B x $ price per T of corn)

Corn (energy feed) and 48% soybean meal (protein feed) are commonly used as the base feeds in Petersen's equations. However, any other energy or protein feed can be substituted. The value of a test feed is based on its level of TDN and CP in comparison to the costs and nutritive value of the base feeds, in this case, corn and soybean meal.

To use the ratio equations to determine the value of an alternative feed:

- multiply the price of soybean meal by the soy ratio (A)
- multiply the price of corn by the corn ratio (B)
- add or subtract these two results as indicated
- the result is the maximum value of the test feed as a source of energy and protein.

For example, if the price of corn is $120/tonne and the price of soybean meal (48%) is $320/tonne, then the nutrient value of bakery waste is (0.0507 x $320) + (0.9852 x $120) = $134.23. Bakery waste available at a price of less than $134/tonne is a good value when corn costs $120/tonne and soybean meal $320/tonne. A change in the price of either corn or soybean meal will affect the economic value of bakery waste. When feed prices are volatile, update Petersen's equations regularly to determine if an alternative feed source is a better buy. Table 1, Feed Value Comparison based upon Variable Corn and Soybean Meal Prices, shows changes in alternative feed values as the price of corn and soybean meal varies.

Table 1. Feed Value Comparison based upon Variable Corn and Soybean Meal Prices

	Price per Tonne

Corn Grain	$120			$150			$180		
Soybean Meal - 48%	$300	$320	$340	$300	$320	$340	$300	$320	$340
	Value per Tonne								
Bakery Waste	$133	$134	$135	$163	$164	$165	$193	$194	$195
Beet Pulp	$111	$111	$111	$139	$139	$139	$168	$168	$167
Brewers Grain - Wet	$45	$47	$49	$48	$50	$52	$51	$53	$56
Brewers Grain - Dried	$172	$180	$188	$184	$193	$201	$197	$205	$213
Corn Distillers - Wet	$68	$71	$74	$73	$76	$79	$79	$82	$85
Corn Distillers - Dried	$208	$217	$226	$224	$234	$243	$241	$250	$260
Corn Gluten Feed	$86	$90	$93	$93	$97	$101	$101	$105	$108
Corn Gluten Meal - 60%	$364	$390	$417	$356	$382	$408	$348	$374	$400
Corn Hominy	$141	$141	$142	$172	$173	$174	$204	$205	$206
Carrots	$16	$16	$17	$20	$20	$20	$24	$24	$24

While the ratio equations in Table 3 use TDN and CP to compare feeds, these equations can also be used to compare feeds using other nutrients, e.g., Metabolizable Energy (ME), Digestible Energy (DE) or Net Energy (NE) as the energy units. Other protein values may also be used, such as, bypass protein or % lysine. To substitute other nutrients, simply replace the energy and/or protein values for each of the TDN or CP values of corn, soybean meal and the test feed. Provided that the same energy or protein units are used for each of the 3 feeds, the equations to determine the A and B factors for use in Petersen's equation will be appropriate.

Petersen's equations do not accurately evaluate feeds that are mainly suppliers of fibre, by-pass protein or fat. Feeds that contain high amounts of fat have a greater economic value in diets of high-producing cows or rapidly growing starter cattle, where very high energy densities are critical. These types of feeds, such as bakery waste or tallow, must be given special consideration. Feeds that supply multiple nutrients, such as whole cottonseed or roasted soybeans, will actually be worth $25-$60/tonne more than the value expressed in a simple protein/energy value.

Evaluating Bypass Protein or Bypass Protein Evaluation

Feeds providing significant bypass protein must also be given special consideration, as the cost of this form of protein is 25%-30% higher than crude protein. Since bypass protein is more expensive than crude protein and may be the only limiting nutrient in a specific diet, a comparison of alternative bypass protein sources may be desired. These feeds may be compared based on cost per unit of bypass protein. The comparative values of bypass protein in various feeds listed in Table 2, *Bypass Protein Evaluation*, are obtained using the following formula:

$/kg bypass protein = $/unit feed ÷ kg/unit of feed x % CP x % UIP

% CP = crude protein of feed on an as-fed basis

% UIP = undegradable intake protein content of feed as % of CP

For example, the cost per kg of bypass protein when 48% soybean meal containing 35% UIP costs $370/tonne is:

$370/tonne ÷ (1000 kg/tonne) x 0.48 x 0.35 = $2.20/kg bypass protein

This method can also be used when comparing the values of other feeds that supply only one nutrient, such as tallow and oils.

Table 2. Bypass Protein Evaluation

Feed	Price/T $	CP % as fed	UIP % of CP	Cost/kg UIP
Soybean Meal	372	48.0	35	$2.21
Dried Corn Distillers	234	27.1	62	$1.39
Corn Gluten Meal	550	61.2	55	$1.63
Fish Meal	850	60.3	72	$1.96
Blood Meal	900	79.1	82	$1.39

Note that with the values used in Table 2, blood meal and dry corn distillers are the cheapest sources of bypass protein.

Least Cost Formulation

Petersen's equations and single nutrient evaluations are simple and easy to use. However, the small number of nutrients that they consider in evaluating a feedstuff limits them. More advanced methods have developed for determining the dollar value of by-product feeds. For many years, the feed industry and large livestock producers have used least-cost computer formulation methods to formulate diets and minimize feed costs. These programs use matrix algebra or linear programming to match the feeds available to the nutrient requirements of the animal. Many nutrients can be evaluated simultaneously.

Linear programming can also determine maximum dollar values and replacement values for any feed not used in a particular ration formulation. This allows a user to estimate when an ingredient might be an economical alternative particularly when feed prices are changing rapidly. Linear programs provide the most accurate estimate of an ingredient's worth. Linear programs can also adjust for predetermined dietary inclusion limits for ingredients based upon palatability or nutritional considerations.

Other Considerations

Cost of alternative feeds should not be the only consideration when thinking about replacing nutrients in a diet. Other considerations include trucking costs, special storage, handling and processing facilities and increased labour requirements for handling and processing. Spoilage must be considered, as some of these products are high in moisture and have a short storage life. Contaminants, such as plastic, can be a problem and additional costs are incurred to the producer for sorting and disposal of the contaminants. Quality of the ingredient including nutritional composition and palatability must also be considered, as the feeds listed in the tables can only substitute for a portion of the more traditional ration ingredients.

Relevant OMAFRA Factsheets

Comparative Feed Values for Swine, Order No. 03-003

Livestock Feed Terms Defined, Order No. 08-039

Nutrient Testing, Order No. 03-007

Table 3. By-product Evaluation Using Petersen's Equations

Feed	% DM	% TDN	% CP	% TDN	% CP	A-SOYRatio	B-CORNRatio	FeedValue
		DM basis		As-fed basis				
Corn Grain	85.0	89.0	9.6	75.7	8.2	0.0000	1.0000	$140.00
Soybean Meal 48%	89.0	84.0	53.9	74.8	48.0	1.0000	0.0000	$320.00
Milling and Processing Products								
Apple Pomace	20.0	70.0	5.0	14.0	1.0	- 0.0128	0.1977	$23.59
Bakery Waste	88.0	89.0	11.9	78.3	10.5	0.0507	0.9852	$154.15
Beet Pulp	91.0	78.0	8.0	71.0	7.3	- 0.0094	0.9476	$129.64
Wet Brewers Grain	24.0	67.0	25.0	16.1	6.0	0.1069	0.1069	$49.17

Dry Brewers Grain	92.0	67.0	25.0	61.6	23.0	0.4097	0.4099	$188.50
Corn Cobs	90.0	47.0	2.8	42.3	2.5	- 0.0512	0.6097	$68.98
Wet Corn Distillers	30.0	84.0	29.5	25.2	8.9	0.1537	0.1813	$74.55
Dry Corn Distillers	92.0	83.7	29.5	77.0	27.1	0.4710	0.5524	$228.05
Corn Gluten Feed	40.0	82.0	27.5	32.8	11.0	0.1870	0.2488	$94.67
40% Gluten Meal	91.0	86.0	43.9	78.3	39.9	0.7895	0.2543	$288.24
60% Gluten Meal	91.0	86.0	67.2	78.3	61.2	1.3208	- 0.2708	$384.76
Citrus Pulp	18.3	82.5	6.6	15.1	1.2	- 0.0105	0.2100	$26.02
Hominy - Corn	91.0	92.0	11.8	83.7	10.7	0.0428	1.0644	$162.71
Oat Hulls	93.0	35.0	3.8	32.6	3.5	0.0006	0.4297	$60.34
Oats - Mixed Feed	90.0	60.0	14.0	54.0	12.6	0.1698	0.5460	$130.77
Roasted Soybeans	92.0	93.5	41.3	86.0	38.0	0.7198	0.4255	$289.90
Rye Distillers - Wet	30.0	84.0	29.0	25.2	8.7	0.1499	0.1850	$73.86
Whey	7.0	78.0	14.0	5.5	1.0	0.0098	0.0625	$11.88
Wheat Bran	89.0	70.0	18.0	62.3	16.0	0.2330	0.5932	$157.63
Rice middlings	88.0	66.9	15.6	58.9	13.7	0.1849	0.5955	$142.53
Rendering By-products								
Fat - Animal	95.0	200.0		190.0	0.0	- 0.5136	3.0191	$258.33
Feather Meal	93.0	67.7	91.4	63.0	85.0	1.9597	- 1.1038	$472.56
Blood Meal	92.0	65.0	86.0	59.8	79.1	1.8210	- 1.0091	$441.44
Fish Meal	90.0	70.0	67.0	63.0	60.3	1.3407	- 0.4922	$360.13
Meat and Bone Meal (Non-Ruminant Origin)	93.0	73.1	53.8	68.0	50.0	1.0691	- 0.1577	$320.04
Fruits and Vegetables								
Apples	17.0	70.0	2.8	11.9	0.5	- 0.0202	0.1773	$18.35
Bananas	24.3	84.1	4.5	20.4	1.1	- 0.0278	0.2977	$32.76
Beets	13.0	80.3	12.6	10.4	1.6	0.0128	0.1253	$21.65
Bread	63.0	89.0	13.3	56.1	8.4	0.0584	0.6835	$114.37
Broccoli	11.0	70.0	33.0	7.7	3.6	0.0701	0.0325	$26.99
Cabbage	9.5	85.3	25.3	8.1	2.4	0.0383	0.0692	$21.96
Carrots	12.0	84.0	9.9	10.1	1.2	0.0025	0.1308	$19.11
Celery	6.0	62.0	15.3	3.7	0.9	0.0129	0.0364	$9.24
Lettuce	5.0	51.0	22.0	2.6	1.1	0.0207	0.0133	$8.47
Onions	9.0	57.6	12.6	5.2	1.1	0.0144	0.0543	$12.21
Potatoes	23.0	81.0	9.5	18.6	2.2	0.0044	0.2419	$35.28
Tomatoes	6.0	69.0	16.4	4.1	1.0	0.0135	0.0414	$10.11

e.g. to determine the value of wet distillers grain when corn is $140 per tonne and soybean meal is $320

per tonne:

(0.1537 x $320) + (0.1813 x $140) = $74.56

Related Links

- An Interactive Version of Petersen's Equations

---

ag.info.omafra@ontario.ca