

Understanding and Using a Feed Analysis Report

This NebGuide provides tips on how to interpret and use a feed analysis report.

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Why Test Feeds?

Livestock are most productive when fed a ration balanced according to their nutrient needs. Unfortunately, many rations are balanced using average values for each feedstuff. These so-called “book values” often result in over- or under-feeding certain nutrients. More economical and better-balanced rations can be formulated using nutrient concentrations determined from feed analysis.

This NebGuide will focus on explaining and applying the results from a commercial feed analysis. *Table I* lists common nutrients and the units in which they are reported.

Methods of Feed Testing

Once a feed sample has been collected properly, it can be analyzed for nutrients. Most commercial laboratories offer standard feed tests for forages, grains, or total mixed rations. Analyzing feeds for moisture, protein, and energy is recommended when designing diets for beef cattle. Furthermore, you may wish to identify key minerals or minor nutrients of interest. Typically, results are reported on an as-is and dry matter basis (see sample analysis). Nutrients should always be balanced in a diet on a dry-matter basis because nutrient requirements for beef and dairy cattle are reported on a dry-matter basis. After formulation on a dry-matter basis, values convert to an as-is basis, using the feed’s moisture content, to determine the actual amount of feed (as-is) that should be fed or delivered.

<i>Nutrient</i>	<i>Common Units</i>
Moisture	%
Crude Protein	%
Total Digestible Nutrients	%
Neutral Detergent Fiber	%
Acid Detergent Fiber	%
Net Energy	Mcal / lb
Calcium	%
Phosphorus	%
Copper, Zinc	ppm
Vitamins	IU / lb

Physical. Although frequently misleading, sight, smell, and touch are useful indicators of feed value. Musty and foul odors can indicate lower quality due to deterioration in storage. A soft, pliable texture may be desired by some livestock. Physical evaluations alone rarely are sufficient for predicting eventual animal performance, partly because they lack a good means of measuring such qualities as color and leafiness.

Chemical. Nutrient analyses most commonly are done by chemically reacting or extracting important compounds in a laboratory and determining their amount in the feed. When representative feed samples are tested chemically, accurate predictions of animal performance usually can be made because the nutrient requirements also were determined using chemically tested feeds.

Near-infrared reflectance (NIR) spectroscopy. NIR is a rapid, reliable, low-cost, computerized method to analyze feeds for their nutrient content. Feeds can be analyzed in less than 15 minutes using NIR, compared to hours or days for chemical methods. This rapid turnaround and the resulting cost savings in labor make NIR an attractive method of analysis. When sending a sample for NIR testing, you must identify the type of feed/forage being submitted to make sure that the right feed library is being used. This method will not accurately evaluate a full mineral profile of a sample, but will fairly accurately determine calcium and phosphorus.

NIR does not do an adequate job of measuring the energy (TDN) content of the distillers grains that are feed byproducts from the ethanol industry. In an NIR analysis, TDN is estimated using ADF. ADF measures cell wall content of a feed. Because distillers grains are high in fat NIR will underestimate their energy content. NIR will adequately measure moisture, percent crude protein, calcium, and phosphorus in distillers grains.

***In vivo* and *in vitro* Digestibility.** Digestibility often is determined using *in vivo* and *in vitro* methods. *In vivo* procedures are used only in research because they require test animals, take weeks to run, and are expensive. *In vitro* procedures are conducted in test tubes that simulate the animal's digestive system, but are relatively expensive and take several days to complete.

What Analyses Should be Made?

Nutrients of primary concern in feeding beef and dairy cattle are moisture content, percent crude protein, energy (% TDN), calcium, phosphorus, vitamin A, and certain trace minerals. Relative Feed Value (RFV) is important for dairy cattle because Relative Feed Value (RFV) and Relative Feed Quality (RFQ) are indicators of forage digestibility and therefore forage intake. For beef cattle, RFV and RFQ are not used in ration formulation.

Before testing, compare the cost of analyses to the cost of supplements. Consider the extent of deviation of a nutrient in various samples of feed from average values, and the nutritional importance of this variation. For example, the calcium content of grain is low, and the variability is small; thus the cost of calcium analysis relative to cost of calcium addition is rather high. As another example, analyses for moisture, protein, and energy are most important for beef cattle. Routine analyses of calcium, phosphorus, vitamins and trace minerals generally are not recommended as a basis for formulating rations. Instead, periodically analyze samples of the total ration for calcium, phosphorus, magnesium, zinc, copper and sulfur. Compare these results to animal requirements to assure that all nutrient needs are being met.

Sampling

Sampling is the key to accurate feed analyses. Feed tests are useful only when the sample collected closely resembles the feed to be fed. See NebGuide 331, *Sampling Feeds for Analysis*, for instructions on how to collect a representative sample.

Interpreting Test Results

Moisture

Dry Matter (DM): Dry matter is the moisture-free content of the sample. Because moisture dilutes the concentration of nutrients but does not have a major influence on intake (aside from severe deprivation), it is important to always balance and evaluate rations on a dry-matter basis.

Digestible Dry Matter (DDM): Calculated from acid detergent fiber (ADF; see below); the proportion of a forage that is digestible.

Protein

Crude Protein (CP): Crude protein measures the proportion of nitrogen in a feedstuff multiplied by 6.25 and this includes both true protein and non-protein nitrogen. In ruminants, it's important to evaluate the fraction that is degradable in the rumen — degradable intake protein (DIP) — versus the rumen-undegradable fraction, undegradable intake protein (UIP). However, most commercial labs cannot measure the rumen degradability of protein. Therefore, formulate rations using analyzed CP values and average values for DIP and UIP that can be found in the 2000 National Research Council Nutrient Requirements of Beef Cattle. The 2001 National Research Council Nutrient Requirements of Dairy Cattle uses the term “rumen degradable protein” (RDP) and “rumen undegradable protein” (RUP). These terms are used interchangeably with DIP and UIP in the NRC publication for beef cattle.

Degradable Intake Protein (DIP): The fraction of the crude protein which is degradable in the rumen and provides nitrogen for rumen microorganisms to synthesize bacterial crude protein (BCP), protein supplied to the animal by rumen microbes. DIP also includes non-protein nitrogen found in feeds or ingredients.

Undegradable Intake Protein (UIP): The rumen-undegradable portion of an animal's crude protein intake. Commonly called “bypass protein” because it bypasses rumen breakdown and is mainly digested in the small intestine. Bypass protein is utilized directly by the animal because it is absorbed as small proteins and amino acids.

Metabolizable Protein (MP): MP is protein that is available to the animal that includes microbial protein (BCP) synthesized by the rumen microorganisms and UIP (by-pass protein).

Heat Damaged Protein or Insoluble Crude Protein (ICP): Nitrogen that has become chemically linked to carbohydrates and thus does not contribute to either DIP or UIP supply. This linkage is mainly due to overheating when hay is baled or stacked with greater than 20 percent moisture, or when silage is harvested at less than 65 percent moisture. Feedstuffs with high ICP are often discolored and have distinctly sweet odors in many cases. When the ratio of ICP:CP is 0.1 or greater, meaning more than 10 percent of the CP is unavailable, the crude protein value is adjusted. Adjusted crude protein (ACP) values should be used for ration formulation.

Adjusted Crude Protein (ACP): Crude protein corrected for ICP. In most nutrient analysis reports, when ACP is greater than 10 percent of CP, the adjusted value is reported. This value should be used in formulating rations when ICP:CP is greater than 0.1.

Digestible Protein (DP): Reported by some laboratories, do not use without the guidance of a nutritionist. Digestible protein values are not needed for most ration formulation because nutrient requirements and most formulation tools are already adjusted for protein digestibility. Furthermore, protein digestibility is influenced by external factors.

Fiber

Crude Fiber (CF): Crude fiber is a traditional measure of fiber content in feeds. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) are more useful measures of feeding value, and should be used to evaluate forages and formulate rations.

Neutral Detergent Fiber (NDF): Structural components of the plant, specifically cell wall. NDF is a predictor of voluntary intake because it provides bulk or fill. In general, low NDF values are desired because NDF increases as forages mature.

Because NDF can be used to predict intake, it is one of the most valuable analyses to have conducted on forages for dairy rations, and can be useful for beef rations that rely on primarily forages. Low NDF usually is desired. As maturity of the plant at harvest increases, cell wall content of the plant increases, and NDF increases. Because the NDF assay may differ between labs, it is generally recommended to compare values generated from the same lab.

For feeds used for developing dairy rations, the use of alpha-analyse is recommended for feeds containing starch and sodium sulfite and is also recommended to remove all nitrogen from contaminated samples.

NDF Digestibility: This is an estimate of the proportion of NDF digested by ruminal microbes over a given period of time (i.e. 30 hours). Currently, laboratories may report NDF digestibility at different times, but the most common times are either 30 or 48 hours. The greater the NDF digestibility, the higher the intake of a forage and, for dairy cows, a more positive effect on production. As NDFD decreases, lignin increases.

Lignin: This represents the highly indigestible portion and is associated with fiber. The greater the lignin content of a plant, expressed either on a dry-matter basis or as a percentage of the NDF, the lower the digestibility of the forage. Lignin content of a plant increases as the plant matures.

Acid Detergent Fiber (ADF): The least digestible plant components, including cellulose and lignin. ADF values are inversely related to digestibility, so forages with low ADF concentrations are usually higher in energy.

Digestible Dry Matter: estimates the percentage of forage that is digestible. It is calculated from ADF using the equation:

$$\text{DDM (\%)} = 88.9 - [\text{ADF (\%)} \times 0.779]$$

Energy

Total Digestible Nutrients (TDN): The sum of the digestible fiber, protein, lipid, and carbohydrate components of a feedstuff or diet. TDN is directly related to digestible energy and is often calculated based on ADF. TDN is useful for beef cow rations that are primarily forage. When moderate to high concentrations of concentrate are fed, net energy (NE, see below) should be used to formulate diets and predict animal performance. TDN values tend to under-predict the feeding value of concentrate relative to forage.

The NIR analysis method does not estimate the energy (TDN) content to wet (WDGS) or dry (DDGS) distillers grains plus solubles very well. Our data suggests that WDGS and DDGS are 125 percent the energy value of corn in forage diets. Therefore if corn is 90 percent TDN on a dry-matter basis then WDGS is 112.5 percent TDN (90% x 1.25)

Net Energy (NE): Mainly referred to as net energy for maintenance (NE_m), net energy for gain (NE_g), and net energy for lactation (NE_l). The net energy system separates the energy requirements into fractional components used for tissue maintenance, tissue gain, and lactation. Accurate use of the NE system relies on careful prediction of feed intake. In general, NE_g overestimates the energy value of concentrates relative to roughages.

Net energy is the energy available to an animal in a feed after removing the energy lost as feces, urine, gas and heat produced during digestion and metabolism. NE is the most useful energy estimate for formulating rations. The net energy value of a feed depends on whether the feed is used for maintenance (NE_m), producing weight gain (NE_g), or milk production (NE_l). These values are obtained from digestible dry matter using formulas shown in *Tables II* and *III*.

Although the current NRC publication outlines the nutrient requirements of dairy cattle assigns a net energy value for the whole diet and not individual feeds estimates in *Tables II* and *III* may be useful when formulating dairy rations when computer software requires an estimate of energy for individual feeds.

Table II. Estimates of energy values of legumes from ADF %.					
<i>ADF</i>	<i>DDM</i> ¹	<i>TDN</i> ²	<i>NE_l</i> ³	<i>NE_m</i> ⁴	<i>NE_g</i> ⁵
(%)	(%)	(%)	------(Mcal/100 lb)-----		
20	73	77	81	84	
22	72	75	78	82	56
24	70	73	76	78	53
26	69	71	73	75	50
28	67	69	71	72	48
30	66	67	69	69	45
32	64	64	66	66	42
34	62	62	64	63	40
36	61	60	62	60	37
38	59	58	59	57	34
40	58	56	57	53	31
42	56	54	54	50	28
44	55	52	52	47	25
46	53	49	50	43	22
48	52	47	47	40	18
50	50	45	45	36	15

52	48	43	43	33	12
54	47	41	40	29	9
56	45	39	38	25	5
					2

¹DDM = 88.9 - (.779 x ADF).
²TDN = 4.898 + (NE₁ x .89796).
³NE₁ = 104.4 - (1.19 x ADF).
⁴NE_m = (137 x ME) - (30.42 x ME²;) + (5.1 x ME³;) - 50.8.
⁵NE_g = (142 x ME) - (38.36 x ME²;) + (5.93 x ME³;) - 74.84.
ME = TDN x .01642

Table III. Estimates of energy value of corn silage from its ADF.					
<i>ADF</i>	<i>DDM</i> ¹	<i>TDN</i> ²	<i>NE_l</i> ³	<i>NE_m</i> ¹	<i>NE_g</i> ¹
(%)	(%)	(%)	------(Mcal/100 lb)-----		
20	73	74	80	78	50
22	72	72	77	77	49
24	70	71	75	76	48
26	69	70	72	75	47
28	67	68	70	73	46
30	66	67	67	72	45
32	64	66	65	71	44
34	62	64	62	70	43
36	61	63	60	68	42
38	59	62	57	67	40
40	58	60	55	66	39

¹See *Table I* footnotes for these measures.
²TDN = 31.4 + (NE₁ x .531).
³NE₁ = 104.4 - (1.24 x ADF).

Minerals: When calcium and phosphorus supplements are needed, or when control of their levels is important, periodically analyze feeds for these elements. An example is the control of calcium and phosphorus levels in the dry cow ration of a dairy herd plagued by milk fever. In addition, grain by-product feeds from the production of ethanol can vary in phosphorus and sulfur. If the ethanol plant does not provide an analysis, test the feed for phosphorus and sulfur.

Trace minerals commonly are added as insurance against deficiencies. Because of high cost, trace-mineral analyses are not recommended routinely. However, trace minerals should be checked periodically, or when a specific case suggests the need.

Ether Extract (EE): The crude fat content of a feedstuff. Fat is an energy source with 2.25 times the energy density of carbohydrates.

Relative Feed Value (RFV): A prediction of feeding value that combines estimated intake (NDF) and estimated digestibility (ADF) into a single index. RFV is used to evaluate legume hay. RFV is often

used as a benchmark of quality when buying or selling alfalfa hay. RFV of feedstuffs other than alfalfa is not relevant. RFV is not used for ration formulation.

Relative Forage Quality (RFQ): Like RFV, RFQ combines predicted intake (NDF) and digestibility (ADF). However, RFQ differs from RFV because it is based on estimates of forage intake and digestibility determined by incubating the feedstuff with rumen microorganisms in a simulated digestion. Therefore, it is a more accurate predictor of forage value than RFV. Neither RFV nor RFQ are used in ration formulation (*Table IV*).

Table IV. Relationships among several estimators of alfalfa quality and suggested livestock uses.					
<i>Uses</i>	<i>Analyses Calculations</i>				
	<i>ADF</i>	<i>NDF</i>	<i>DDM</i>	<i>DMI</i>	<i>RFV</i>
	-----(% of DM)-----			(% of Body Weight)	
Prime dairy , fresh and high producers	<30	<40	>65	>3.0	>151
Good dairy , young heifers, excellent for backgrounding	31-35	40-44	62-65	2.6-3.0	125-151
Good beef , older heifers, marginal for dairy cows	36-40	47-53	58-61	2.3-3.5	103-124
Maintenance for beef or dry dairy cows	41-42	54-60	56-57	2.0-2.2	87-102
Poor quality*	43-45	61-65	53-55	1.8-1.9	75-86
*Requires supplementation with higher quality (energy) feeds as well as possibly other nutrients for most animals. This quality hay could be fed to dry beef cows under some circumstances.					

Dry matter intake (DMI): estimates the maximum amount of forage dry matter a cow will eat. It is expressed as a percent of body weight and is calculated from NDF using the equation:

$$\text{DMI (\% of body weight)} = \frac{120}{\text{NDF \%}}$$

Nitrates and Prussic Acid: Forages that are drought-damaged, hailed, stunted, or harvested before maturity may contain high levels of nitrates. Analyze nitrate levels on these forages to determine whether the forage is potentially toxic. NebGuide 1779, *Nitrates in Livestock Feeding*, discusses nitrate toxicity in detail.

Immature sorghums and sudans and *especially the regrowth* of previously harvested, stunted forage may have excessively high prussic acid levels. However, prussic acid is rarely a problem in harvested forages. If toxic levels are suspected, an analysis may be helpful.

Example Client Sample ID: 1st Cutting Alfalfa

Analysis
As Received Basis Dry Matter Basis

Moisture, %	14.4	0.0
Dry Matter, %	85.6	100.0

This hay is 14.4 percent moisture and 85.6 percent dry matter. For ration formulation you should always use the dry-matter composition. The DM composition can be found by dividing as-is value by the percent DM. For example: $19.8\% \text{ CP as-is} \div 0.856 = 23.2\% \text{ CP on a DM basis}$

	As Received	Dry Matter
Crude protein, %	19.8	23.2
Heat dam, protein, %	0.8	0.9
Available protein, %	19.8	23.2

Because the heat-damaged protein is not 10 percent or more of the CP, the ACP is the same as CP. Available protein estimates are generally only reduced when heat damaged (unavailable) protein accounts for greater than 10 percent of CP. Let's assume you are supplementing late gestation cows with a 38 percent protein cake. If you feed 2 lb/hd, then the amount of CP supplemented is $2 \text{ lb/hd} \times 0.38 \text{ CP} = 0.76 \text{ lb/hd CP}$.

In another context, the NRC tables indicate that one month after calving a 1,200 lb cow with moderate milk production requires a diet that is about 10 percent CP. This same cow should have a DM intake of about 27 lb/day. If she is consuming low-quality forage that is only 5 percent CP, how much of this first cutting alfalfa do you need to provide to meet her CP requirement?

$27 \text{ lb/day intake} \times .10 \text{ CP requirement} = 2.7 \text{ lb/ day CP requirement}$
 $27 \text{ lb low quality forage} \times 0.05 \text{ CP} = 1.35 \text{ lb/day CP from forage}$
 $2.7 \text{ lb/day CP required} - 1.35 \text{ lb/day CP from forage} = 1.35 \text{ lb/day CP needed from alfalfa}$
 $1.35 \text{ lb/day CP needed} \div 0.232 \text{ CP in alfalfa} = 5.8 \text{ lb DM supplemental alfalfa/day to meet protein requirement}$

	As Received	Dry Matter
Detergent Fiber, %	27.0	31.5
Neutral Detergent Fiber, %	31.1	36.4

For formulating beef cow rations, ADF and NDF are of limited usefulness. Instead, use TDN, which is calculated from ADF but is easier to use.

	As Received	Dry Matter
Total Digestible Nutrients est., %	55.6	64.9

This is relatively high-quality hay with a high TDN value. In the protein example above, we calculated that we should supplement 5.8 lb of this hay to meet the protein requirements of our hypothetical cow. Remember this cow calved 1 month ago, weighs 1,200 lb, and has moderate genetic potential for milk. At 27 lb/day DM intake, she needs a diet that is about 58 percent TDN to meet her energy requirements. Will 5.8 lb/day of this alfalfa meet her energy needs if the low quality forage she consumes is only 50 percent TDN?

$27 \text{ lb DM intake} \times .58 \text{ TDN required} = 15.7 \text{ lb/day TDN required}$
 $22.2 \text{ lb low quality forage} \times .50 \text{ TDN} = 11.1 \text{ lb/day TDN from low quality forage}$

5.8 lb alfalfa x 0.649 TDN = 3.75 lb TDN from alfalfa

11.1 lb/day TDN from low quality forage + 3.75 lb/day TDN from alfalfa = 14.85 lb/day TDN

Therefore, we can see that this cow will lose some body condition even when fed supplemental alfalfa.

Relative Feed Value (RFV) 164.4

Do not use RFV for formulating rations, TDN is much more useful.

Notice in the example NIR analyses that nutrients are reported in both dry matter and as-received basis. Although RFV is recorded for all forages, RFV is only pertinent for those forages that are alfalfa (alfalfa haylage, alfalfa hay).

5.8 lb per head per day DM ÷ 0.856 (DM content of the alfalfa in decimal form)

That equals 6.8 lb/hd/day “as-fed” supplemental alfalfa.

This publication has been peer reviewed.

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Issued September 2008