NebGuide

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Research-Based Information That You Can Use

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Understanding and Using a Feed Analysis Report

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

Why Test Feeds?

Livestock are most productive when fed rations are balanced according to their nutrient needs. Unfortunately, many rations are balanced using average values for each feedstuff. These "book values" often result in over- or under-feeding some nutrients. More economical and better-balanced rations can be formulated using nutrient concentrations determined from feed analysis. This NebGuide focusses on explaining and applying the results from a feed analysis. *Table I* lists common nutrients and units reported in a nutrient analysis of a feed or forage.

Methods of Feed Testing

Once a feed sample has been collected properly, it can be sent into the laboratory and 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. Sometimes key minerals may be identified for a more in-depth laboratory analysis. Results of nutrients are reported on an as-is and dry-matter basis. Nutrients should always be balanced in a ration/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, convert values to an as-is basis, using the feed's moisture content to determine the actual amount of feed (as-is) that it is delivered.

Table 1. Feed Nutrients and their units of measure.

Nutrient	Common Units
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. Physical evaluations alone are rarely not sufficient for predicting animal performance because there is not a standard for measuring qualities like color and leafiness.

Chemical. Nutrient analyses most commonly are done by chemically reacting or extracting compounds from a feed or forage in a laboratory and determining their concentration. When representative feed samples are tested chemically, accurate predictions of animal performance can be made. Nutrient requirements that are reported for livestock were also determined using chemical composition of feeds and matched to animal performance.

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, identify the type of feed/forage being submitted so that at the laboratory, the correct feed library is used during the analysis. The NIR method will not accurately evaluate a full mineral profile of a feed or forage but will accurately determine calcium and phosphorus.

NIR does not accurately measure energy (TDN) content of the distillers grains, a feed by-product of the ethanol industry. In an NIR analysis, TDN is estimated using ADF. ADF measures cell wall content of a feed. Because distillers grains have a highly digestible fiber component and can be high in fat (7% to 13%), NIR will underestimate the energy content. Research at the University of Nebraska indicates the TDN content of distillers grains is between 102% to 108% with wet having a higher energy content than dry. 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, NE_m, NE_g, NE_l), calcium, phosphorus, vitamin A, and certain trace minerals. Relative Feed Value (RFV) and Relative Feed Quality (RFQ) are important in the dairy industry because RFV and RFQ are indicators of forage digestibility and therefore forage intake. For beef cattle, RFV and RFQ are not used in ration formulation.

For some feeds, before testing for some nutrients, compare the cost of analyses to the cost of supplements. 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 in developing rations. Routine chemical analyses for calcium, phosphorus, and trace minerals generally are not recommended. Instead, consider periodically analyzing 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, 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—rumen degradable protein (RDP)—versus the rumen undegradable protein (RUP) fraction. However, most commercial labs cannot measure the rumen degradability of protein. Therefore, formulate rations using analyzed CP values and average values for RDP and RUP that can be found in the 2016 National Research Council Nutrient Requirements of Beef Cattle: Eighth Revised Edition. The edition of the nutrient requirements for dairy cattle can be found in the Nutrient Requirements of Dairy Cattle: Eighth Revised Edition.

Rumen Degradable Protein (RDP): The fraction of the crude protein that 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. RDP also includes non-protein nitrogen found in feeds.

Rumen Undegradable Protein (RUP): 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 RUP (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 RDP or RUP supply. This linkage is mainly due to overheating when hay or forage 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. When heat damage is greater than 10% of the crude protein, 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.

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.

Neutral Detergent Fiber (NDF): NDF is the 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. 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. Low NDF usually is desired. As the plant becomes more mature at harvest, 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.

NDF Digestibility: This is an estimate of the proportion of NDF digested by ruminal microbes over a given period (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 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 less mature and usually higher in energy.

Digestible Dry Matter: Estimates the percentage of forage that is digestible. It is calculated from ADF using the equation: DDM (%) = 88.9—[ADF (%) × 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 developing beef cow rations. When moderate to high amount of the ration is grains, 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 concentrates relative to forage.

Again, NIR analysis method does not accurately estimate the energy (TDN) content of distillers grains plus solubles. Research from the University of Nebraska suggests that wet distillers grains plus solubles (WDGS) and dry distillers grains plus solubles (DDGS) are 120 percent the energy value of corn in forage diets. Therefore, if corn is 90 percent TDN on a dry-matter basis, then WDGS is 108 percent TDN (90% x 1.20). The TDN value of DDGS is 102% and MDGS is about 104% TDN. Originally, distillers grains plus solubles would test about 13% crude fat. More recent processes remove more fat from the solubles and the fat content is closer to 7%, but there is variation within and amongst ethanol plants.

Net Energy (NE): Mainly referred to as the net energy system, which includes net energy for maintenance (NEm), net energy for gain (NEg), and net energy for lactation (NEl). 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, NEg 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 (NEm), producing weight gain (NEg), or milk production (NEl). 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, it assigns a net energy value for the whole diet and not individual feeds estimates. Numbers in *Tables II* and *III* may be useful when formulating dairy rations when computer software requires an estimate of energy for individual feeds.

Minerals: When calcium and phosphorus supplements are needed, or when precise amounts are needed daily, periodically analyze feeds minerals. An example is precise amounts of calcium and phosphorus levels needed in non-lactating cow rations of a dairy herd plagued by milk fever. As another example, grain by-product feeds from the production of ethanol can vary in phosphorus and sulfur.

Table II. Estimates of energy values of legumes from ADF%

ADF	DDM[1]	TDN[3]	NE_l[2]	NE_m[4]	NE_g[5]
%	%	%	Mcal/100 lb	Mcal/100 lb	Mcal/100 lb
20	73	77	81	84	56
22	72	75	78	82	53
24	70	73	76	78	50
26	69	71	73	75	48
28	67	69	71	72	45
30	66	67	69	69	42
32	64	64	66	66	40
34	62	62	64	63	37
36	61	60	62	60	34
38	59	58	59	57	31
40	58	56	57	53	28
42	56	54	54	50	25
44	55	52	52	47	22
46	53	49	50	43	18
48	52	47	47	40	15
50	50	45	45	36	12
52	48	43	43	33	9
54	47	41	40	29	5
56	45	39	38	25	2

[1]DDM = 88.9—(.779 x ADF).
[2]NE_l = 104.4—(1.19 x ADF).
[3]TDN = 4.898 + (NE_l x .89796).
[4]$NE_m = (137 \times ME)—(30.42 \times ME^2) + (5.1 \times ME^3)—50.8$.
[5]$NE_g = (142 \times ME)—(38.36 \times ME_2) + 5.93 \times ME_3)—78.84$.
ME = TDN x .01642.

Table III. Estimates of energy value of corn silage from its ADF.

ADF	DDM[1]	TDN[3]	NE_l[2]	NE_m[1]	NE_g[1]
%	%	%	Mcal/100 lb	Mcal/100 lb	Mcal/100 lb
20	73	74	80	78	50
22	72	72	77	77	49
24	70	71	75	76	48
26	69	70	73	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

[1]See Table I for these measures.
[2]NE_l = 104.4—(1.24 x ADF).
[3]TDN = 31.4 + (NE_l x .531).

Ethanol plants provide a printout of the phosphorus and sulfur content and are usually a plant average. Laboratories can analyze feeds for trace minerals but are expensive. It may be worth the expense to measure trace minerals periodically and may help identify the cause when performance is low.

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 is not used for ration formulation. RFV is used in the dairy industry to price alfalfa. The higher the RFV, the higher the price.

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)*.

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 grown in drought conditions, hailed, stunted, or harvested before maturity may contain high levels of nitrates. Analyze nitrate levels on these forages to determine nitrate level and level of toxicity. NebGuide 1779, *Nitrates in Livestock Feeding*, discusses nitrate toxicity in detail. Immature sorghums and sudan grasses and especially the re-growth 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, a prussic analysis may be helpful.

Example

Client Sample ID: 1st Cutting Alfalfa

Analysis

	As Received Basis	Dry Matter Basis
Moisture, %	15.0	0.0
Dry Matter, %	85.0	100

This hay is 15.0 percent moisture and 85.0 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% CP as-is ÷ 0.85 = 23.2 % CP on a DM basis

	As Received Basis	Dry Matter Basis
Crude Protein, %	19.8	23.2
Heat Damaged Protein, %	0.8	0.9
Available Protein, %	19.8	23.2

Because the heat-damaged protein is not 10 percent or more of CP, 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.

A beef cow, one month after calving, weighing 1,200 lb, with moderate milk production, consuming medium to high quality forages, should eat about 2.5% of her body weight on a dry matter basis. This cow requires a diet that is 10% CP and 60% TDN. This same cow should have a DM intake of about 30 lb/day. If she is consuming a forage that is 7% CP and 55% TDN, how much alfalfa hay would be needed to meet the CP and TDN requirement?

30 lb/day intake × 0.10 CP requirement = 3.0 lb/ day CP requirement

30 lb of forage × 0.07 CP = 2.1 lb/day CP from forage

3.0 lb/day CP required—2.1 lb/day CP from forage = 0.9 lb/day CP needed from alfalfa

0.9 lb/day CP needed ÷ 0.167 CP = 5.4 lb DM supplemental alfalfa/hd/day to meet protein requirement

The 0.167 (.232—.07) is the percent crude protein difference between alfalfa (23.2% CP) and forage (7.0% CP)

The alfalfa is 85.0% dry matter and 15.0% moisture. When feeds are fed, they are fed "as-is" with the moisture in them; therefore 5.4 lb dry matter basis ÷ 0.85 = 6.4 lb/hd/day of the alfalfa "as-fed".

	As Received Basis	Dry Matter Basis
Acid Detergent Fiber, %	27.0	31.6
Neutral Detergent Fiber, %	31.1	36.6
Total Digestible Nutrients, estimate, %	55.6	65.4

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

At a 65.4% TDN, this is high-quality alfalfa.

In the protein example above, supplementing 5.4 lb of alfalfa hay on a dry matter basis is needed to meet the protein requirements of the lactating cow described.

At 30 lb/day DM intake, she needs a diet that is about 60 percent TDN to meet her energy requirements. Will 5.4 lb/day of alfalfa meet the energy needs if the forage she consumes is 55 percent TDN?

30 lb DM intake × 0.60 TDN required = 18.0 lb/day TDN required

24.6 lb of forage × 0.55 TDN = 13.5 lb/day TDN from the forage

5.4 lb alfalfa × 0.654 TDN = 3.5 lb TDN from alfalfa

13.5 lb/day TDN from the forage + 3.5 lb/day TDN from alfalfa = 17.0 lb/day TDN = 1.0 lb TDN deficient

1.0 lb TDN deficient ÷ 0.104 = 9.6 lb more of alfalfa to meet energy requirement.

0.104 is the difference in the energy (TDN) value of alfalfa (65.5%) and forage (55.0%).

Alfalfa fed, dry matter basis:

5.4 lb/hd/da + 9.6 lb/hd/da = 15 lb/hd/da

Forage fed, dry matter basis:

30 lb/hd/da (total dry matter intake)—15.0 lb/hd/da (dry matter basis) alfalfa = 15 lb/hd/da.

15.0 lb of alfalfa x 0.654 TDN = 9.81 lb TDN

15.0 lb of forage x 0.55 TDN = 8.25 lb TDN

18.0 TDN required

18.06 lb TDN supplied

If the forage is 85.0% dry matter and the alfalfa is 85.0% dry matter, then the ration on an "as-fed" basis is:

15.0 lb/hd alfalfa ÷ 0.85 = 17.6 lb/hd /da alfalfa
15.0 lb/hd forage ÷ 0.85 = 17.6 lb/hd/da forage

This amount of each feed (alfalfa and forage) will meet both the protein and energy (TDN) requirement.

Relative Feed Value (RFV) 164.4

Although RFV is recorded for all forages, RFV is only pertinent for those forages that are alfalfa (alfalfa haylage, alfalfa hay). Remember, RFV is an index used to compare the quality of forages relative to the feed value of full bloom alfalfa. RFV is used to compare similar forages for two important qualities—how well it will be consumed and how well it will be digested.

This publication has been peer reviewed.

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