

Sampling hay, silage, and total mixed rations for analysis

Dan Undersander, Randy Shaver, Jim Linn, Pat Hoffman, and Paul Peterson

The key to successful forage analysis is taking a good, representative forage sample on the farm.

Laboratory analysis can determine the quality of a submitted forage sample, but the results will not help balance rations if the submitted sample does not represent forage actually being fed to your animals. The largest error in forage analysis is improper sampling methods on the farm. A representative sample of forage needs to be taken from every hay or silage lot. These samples will reflect the variation in forage quality that occurs across your fields and during harvesting.

What to sample

A "lot" of hay or silage is the forage harvested within one day from one field and/or from a specific variety/hybrid. It is taken from the same cutting, is at the same stage of maturity, and has a uniform amount of grass, weeds, or rain damage. A hay or silage lot also is uniform in other qualities: odor, amount of mold, color, stem texture and size, and leafiness.

To efficiently sample a forage lot, a complete inventory of hay and silage lots must be kept. Segregate forage lots at harvest and in storage, and note the approximate number of bales, silo depth, or location in the bag or bunker. The entire height and width of one face of a hay lot should be exposed for visual evaluation and sampling.

The distribution of leaves, stems, weeds, and other material is not uniform in stored forages. Knowledge of forage stratification within a storage structure is critical to adequate sampling for analysis. Refer to table 1 for a summary of leaf and stem distribution as well as where to sample based on forage type. Small square bales, when viewed from the end, tend to have more leaves in the lower, tight side of the bale, round bales tend to be uniform on the circumference, and large square bales tend to be more uniform across the end face but may vary throughout their length. Chopped material should be examined for uniform distribution of leaves, stems and grain (if present). Use a technique that will obtain a representative sample of the various concentrations of leaves and stems in the stored forage.

How to sample

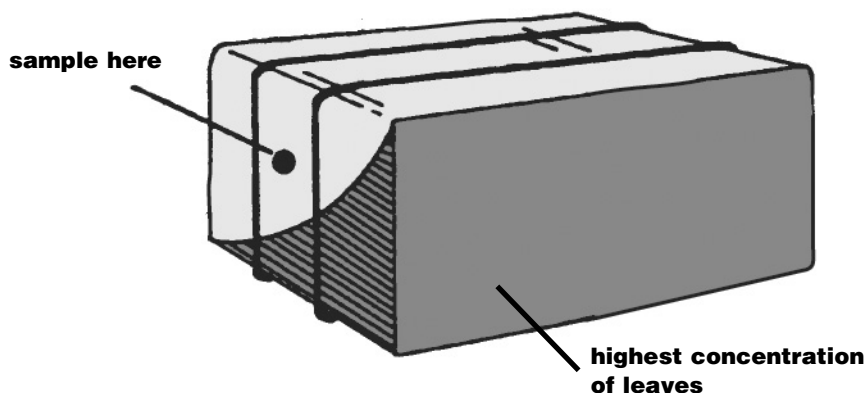
Sampling baled hay and baleage

A hay bale is not uniform in composition. The baling process (picking up, transferring, and packing hay) affects the leaf and stem distribution within the bale. Field variation, windrow differences, hay condition, and environmental conditions at baling also affect bale structure. Due to variation among bales from the same lot, it is important to sample 20 small rectangular bales or 8 to 10 large bales.

The small, rectangular two-string bale has been studied more than others. The leaves in these bales tend to concentrate toward the tight and solid sides of the bale (figure 1). The best place to core sample small rectangular bales is through the center of one end.

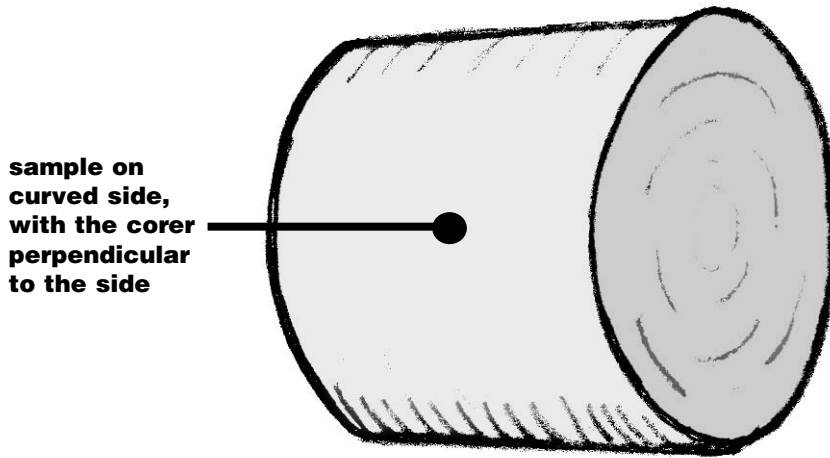
For other square bale types, inspect each bale for the distribution of

Figure 1. Sampling small square bales.



2 Sampling hay, silage, and total mixed rations for analysis

Figure 2. Sampling round bales.



leaves and stems and core sample from areas that do not contain disproportionate concentrations of either leaves or stems. Data from several studies have shown that medium and large square bales do not vary in distribution of leaves and stems across the ends as small square bales do. Therefore, medium and large square bales can be sampled any place on the bale ends or sides (at a 45-degree angle to the side). Round bales should be sampled perpendicular to the circumference of the bale (figure 2). If round bales have surface spoilage/mold and will be fed intact (e.g., not mixed in a TMR), the outer spoiled layer should be discarded from the sample as livestock will likely not consume that portion of the bales.

Table 1. Sampling locations for various types of bales.

Forage type	Distribution of leaves and stems	Best place to sample
Baled hay		
Small square bales	When viewed from the end, leaves are primarily concentrated on the tight side of the bale.	Take a core sample through the center of either end.
Large square bales	Uniform across the end face, but may vary throughout the length.	Take a core sample anywhere on the bale. Insert the corer at a 45-degree angle to the side or a 90-degree angle to the end.
Round bales	Uniform on the circumference.	Take a core sample from the curved side of the bale. If the surface is moldy, remove the outer layer before sampling. The corer should be perpendicular to the side.
Chopped forage		
Prior to ensiling	Edges vs. center of load.	Collect three to five grab samples as the wagon or truck is unloading.
Tower silos	Inner vs. outer ring of silo.	Take 1- to 2-pound samples from the silo unloader while it is operating from morning and evening feedings of the same day.
Bunker silo	In layers as filled.	Submit five to eight grab samples scraped or shaved from the bunker face.
Silo tube	Along length of tube.	Collect several samples from face before and after feeding.

Using a core sampler is better than taking a grab sample because it causes less separation of leaves and stems. Many cores taken from the same lot will yield a more accurate analysis (see figure 3). Combine 15 to 20 cores from a hay lot into one sample for analysis. Fifteen cores may suffice for a hay lot that is expected to have minimal variation among bales. However, 20 cores should be taken for lots with known or suspected sources of field/bale-to-bale variation in species, baling moisture unevenness, or landscape/soil differences.

Sampling instructions:

1. Test each forage lot separately. Mark the location of each lot in the barn or storage shed for easy reference when feeding.
2. Take 15 to 20 widely separated cores or samples from each lot.

3. Use a bale core sampler to reduce error. The core sampler should have an internal diameter of at least 3/8-inch and a length of 12 to 24 inches. Consult the National Forage Testing Association web site for a list of corers and suppliers (alfalfa.ucdavis.edu/SUBPAGES/ForageQuality/ListofHayProbes.htm). Keep the core sampler tip sharp so it cuts through bales rather than pushes stems aside. The core sampler works with either a variable speed 1/2-inch drill or a hand brace. Using the drill or brace, insert the core sampler at a 90-degree angle into the center of the end of small square bales (figure 1) or on the curved sides of round bales. For medium and large square bales, insert the sampler at a 90-degree angle on the end or at a 45-degree angle anywhere along the side.

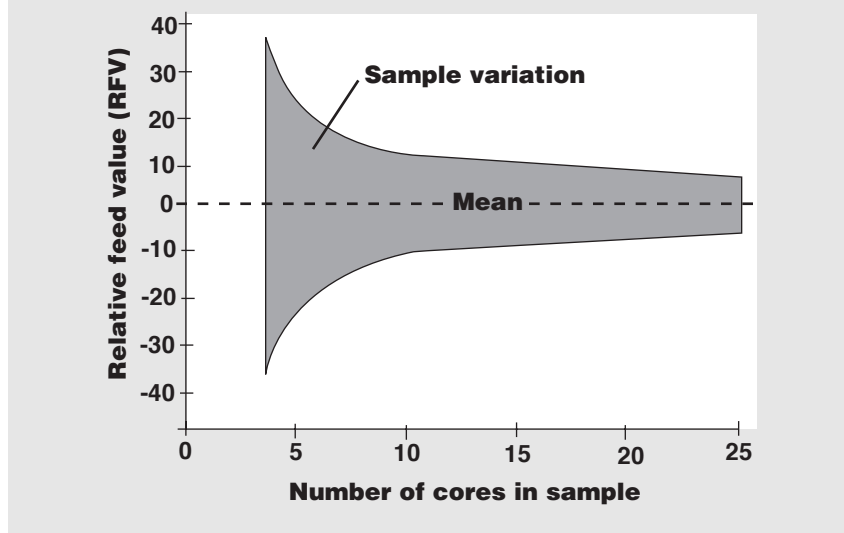
Core sampling tightly packed bales of high moisture hay can be difficult and a high power electric drill may be required.

4. Mix the cores in a clean pail. Place the entire sample in a clean plastic bag or other container and seal tightly. Do not divide the sample. It is normal for the leaves and stems to separate and settle in the sample.
5. Label each container with the farm name, address, a sample number, plus forage type (e.g., alfalfa, alfalfa-timothy, or red clover) and variety.

Sampling silages before ensiling

Sampling the forage before ensiling helps guide subsequent management decisions. Knowing the quality of forage stored in silos allows forages

Figure 3. Bale sample variation based on the number of cores per sample. The shaded area indicates the degree of reliability: the smaller the variation, the greater the accuracy of the analysis. Thus, when only three cores are used in a sample, there's a 95% chance that the relative feed value (RFV) will fall somewhere within a 72-point spread; an analysis of 20 cores cuts the spread to a more reliable 14 points.



4 Sampling hay, silage, and total mixed rations for analysis

to be inventoried by quality and purchase of supplemental feedstuffs based on forage quality needs.

As shown in table 2, while some nutrient fractions can change during fermentation, crude protein (CP) and fiber fractions (ADF and NDF) remain stable when good fermentation occurs. Nutrient composition may change when:

- forage is ensiled at too high a moisture content and seepage occurs (crude protein and non-fibrous loss resulting in higher fiber),
- forage is ensiled too dry and heats excessively (acid detergent fiber and acid detergent insoluble nitrogen increase), or
- fermentation is faulty.

Proper sampling before ensiling is essential. Distribution of leaves, stems, and, in the case of corn silage, grain will not be uniform throughout the chopper wagon or truck because leaves are lighter than stems or grain and often accumulate towards the back and sides. The center front of a

chopper wagon and the center of a truck will have the highest concentration of stems. Although these fractions separate during transportation, they are remixed as the wagon or truck is unloading and as the lot is distributed in the silo.

Sampling instructions:

1. Sample legume, legume-grass, grass haylage, corn silage, or other low-moisture silages from each field or variety/hybrid.
2. Collect three to five handfuls of haylage or corn silage from the middle of the load as the wagon is unloading or after the truck has unloaded. Place them in a plastic bag and immediately refrigerate or freeze. Follow the same procedure for several loads of forage throughout the day.
3. Combine refrigerated samples from a single harvested field or specific variety and mix well. Place the entire sample in a clean plastic bag or other container and seal tightly.
4. Label each container with the farm name, address, the sample number, and forage type.
5. Repeat for each field or specific variety if more than one field is harvested in any one day.
6. Keep an inventory of where each lot is in the silo or bag. Feeding colored plastic strips through the blower or silage press at the end of each lot may help identify the lots later. (A bushel of corn may also be used to mark haylage lots.)
7. At feedout, resample silage that is too wet or too dry. Seepage from excessively wet silage contains nitrogen and nonstructural carbohydrates. Loss of these nutrients will increase dry matter, acid detergent fiber and neutral detergent fiber, and will decrease crude protein. Similarly, forages containing less than 50 percent moisture may have overheated, causing increased acid detergent fiber and acid detergent fiber insoluble nitrogen.

Table 2. Forage quality analysis before and after ensiling.

Forage type	Dry matter	Crude protein	ADF	NDF
Alfalfa haylage				
Before ensiling	44.1	19.9	32.3	40.5
After ensiling	42.4	20.7	34.8	40.4
Red clover haylage				
Before ensiling	45.5	15.9	32.1	45.9
After ensiling	46.6	15.9	33.7	48.9
Corn silage				
Before ensiling	34.4	9.7	29.2	49.5
After ensiling	34.1	11.1	29.0	48.8

Abbreviations: ADF = acid detergent fiber, NDF = neutral detergent fiber.

Source: University of Wisconsin Ashland Research Station, 1988–1989.

8. Recheck dry matter of silages at feedout. Fiber and protein are not likely to change significantly during storage, except as mentioned previously, but moisture can change.

Sampling silages from tower silos

It is preferable to sample silage prior to ensiling rather than sampling ensiled material as it is being fed.

Sampling instructions:

If sampling was not done before ensiling, wait until fermentation is complete and then sample from below the spoiled material at the top. Remove 2 to 3 feet of silage first.

1. Collect 1 to 2 pounds of silage from the silo unloader while it is operating. Collect samples from morning and evening feedings of the same day.
2. Combine the samples and mix well. Place the entire sample in a clean plastic bag or other container and seal tightly. Store immediately in a freezer or other cold place until shipping.

3. Label each container with the farm name, address, the sample number, forage type, and mixture.

Sampling from bunker silos

Taking hand grab samples from the face of bunker silos is not recommended because of poor sample representation and safety concerns. This sampling technique introduces a major source of variability (table 3). Cornell Extension workers reported extensive variation in dry matter, crude protein, and NDF contents within bunker, which emphasizes the importance of meticulous face management to obtain samples that are representative of what is being mixed and fed.

Sampling instructions:

1. Using a loader bucket or face shaver, carefully scrape across the face—either vertically or horizontally depending on how you are feeding—to create a pile of silage on the bunker floor. Do not scrape spoiled material from the top of the silo into the sampling or feeding pile.

2. *If feeding a total mixed ration (TMR):* Load silage from bunker into TMR mixer and mix well. Take two to three hand grab samples as dispensed from the mixer.

If not feeding a TMR or as an alternative: Collect five to eight hand grab samples off the pile scraped or shaved from the bunker face, combine in a 5-gallon pail, mix thoroughly and take a representative sample for analysis.

3. Place 1 to 2 pounds total in a clean plastic bag or other container and seal it tightly. Label each container with your name, address, sample number, and forage type (e.g. alfalfa, alfalfa-timothy, or red clover).
4. Send the sample to the lab for analysis. If necessary, store it in a freezer or other cold place until shipping.

Sampling from silo bags

While the technique described above can be used to sample silo bags, hand grab samples can be safely taken directly from the face of the bag and will yield a representative sample.

Sampling instructions:

1. Gather samples using one of these methods:
 - Collect several hand grab samples from different locations across the silage face. After silage has been removed from the bag, a second set of hand grab samples can be taken from the newly exposed face to increase the number of sample locations for a total of 10 grab samples.
 - Take 8 to 10 core samples through the sides of the tube at various distances along the length.

Table 3. Deviation across the face of nine haylage and eleven corn silage bunkers on nine commercial dairies in New York.

Forage type	Dry matter	Crude protein	NDF ^a
Haylage	———— % deviation ————		
Average deviation	21.0	17.6	14.7
Minimum deviation	5.2	3.3	5.4
Maximum deviation	44.7	52.1	24.8
Corn silage			
Average deviation	12.3	11.0	8.6
Minimum deviation	1.3	2.5	0.5
Maximum deviation	55.0	29.5	18.6

^a NDF = neutral detergent fiber.

Source: Stone et al., 2003

6 Sampling hay, silage, and total mixed rations for analysis

Tape holes in the plastic shut after sampling.

2. Combine all hand samples in a 5-gallon pail, mix thoroughly, and take a representative sample for analysis.
3. Place 1 to 2 pounds total in a clean plastic bag or other container and seal it tightly. Label each container with your name, address, sample number, and forage type (e.g., alfalfa, alfalfa-timothy, or red clover).
4. Send the sample to the lab for analysis. If necessary, store it in a freezer or other cold place until shipping.

Sampling total mixed rations (TMR)

Sampling instructions:

1. Mix TMR as per normal procedures, and distribute in bunk.
2. Fill a 5-gallon bucket two-thirds full with handfuls of TMR taken across the entire length of the TMR windrow and pulled from the top, middle, and bottom.
3. Tip the bucket upside down on a large clean surface and carefully lift it off, leaving the coned sample intact.
4. Using a thin piece of wood or sheet metal, cut the sample in half, and in half again.
5. Keep one quarter of the sample for analysis and discard the rest. Total mixed rations should be analyzed using wet chemistry techniques.

Sampling silages for mold, mycotoxin, or fermentation analysis

Sampling silages for mold, mycotoxin, or fermentation analysis requires special handling procedures because the microbiological or fermentation profile can change rapidly if samples are not properly handled.

Sampling instructions:

1. Sample silages (or hay) as previously described for the appropriate storage system.
2. Immediately refrigerate the sample to stabilize the temperature. Samples can be frozen unless testing for mold (freezing may alter mold counts).
3. Label the container with the farm name, address, sample number, forage type, and variety.
4. Place the sample in an insulated mailing container, along with freezer packs to keep the sample cold in route to the lab.
5. Do not ship samples late in the week to avoid having them sit in the post office or laboratory over the weekend.
6. If possible, use express mail to minimize travel time.

Sampling for nitrates or prussic acid

If analyses for these toxins are necessary, follow the sampling procedure outlined for molds and mycotoxins through step 4. Nitrates and prussic acid are unstable compounds and their concentrations in a sample can change quickly with heating and aerobic conditions. These samples should be delivered to the lab the same day they were taken, ideally within hours of sampling.

Sending multiple samples to improve accuracy

Every forage analysis has an error associated with the estimate. Errors refer to the range within which repeat results would be expected to occur two-thirds of the time. The value should be less than 2 for dry matter and NDF, and less than 7 for NDFD.

Errors may be introduced during sampling and/or laboratory technique. Sending multiple samples is one of the practical ways to improve the accuracy of forage analysis results.

As shown in figure 4, errors decrease dramatically when the results from multiple samples are averaged together. For example, submitting three samples will reduce the analysis error from 4.0 to 2.3, giving better estimates of the true energy and fiber of the hay or silage. This can be cost effective.

Some growers request wet chemistry analysis, assuming that it will be more accurate than near infrared analysis (NIR). While NIR has a somewhat higher rate of errors, sampling and technique errors still exist for wet chemistry. The big advantages of NIR are that it is much less expensive and more repeatable. Therefore, when the cost would be the same or less, it's possible to get better results by running multiple samples by NIR than a single sample by wet chemistry.

Where to send samples

For accurate results, forage samples should be analyzed at a laboratory that participates in the National Forage Testing Association certification program. A listing of these laboratories is available on their web site at www.foragetesting.org.

Laboratories participating in the NIRS Forage and Feed Consortium with the Universities of Wisconsin and Minnesota verify that their near-infrared instruments are working properly and that the equations they are using are appropriate for samples being tested. This listing of laboratories can be obtained at www.uwex.edu/ces/forage/NIRS/home-page.htm.

Forage sampling information sheets can be obtained from numerous web sites or from your county Extension agent, nutritionist, or forage testing laboratory. Fill out an information sheet for each lot, answering all ques-

tions. It is important to label forage types clearly and to note when silage has had special additives such as ammonia, urea, or enzymes added prior to ensiling.

Keep silage samples frozen in airtight containers. Place containers in insulated bags, and mail them early in the week—rather than over the weekend—to prevent molding and decay, which might change the analysis results.

Using forage analyses

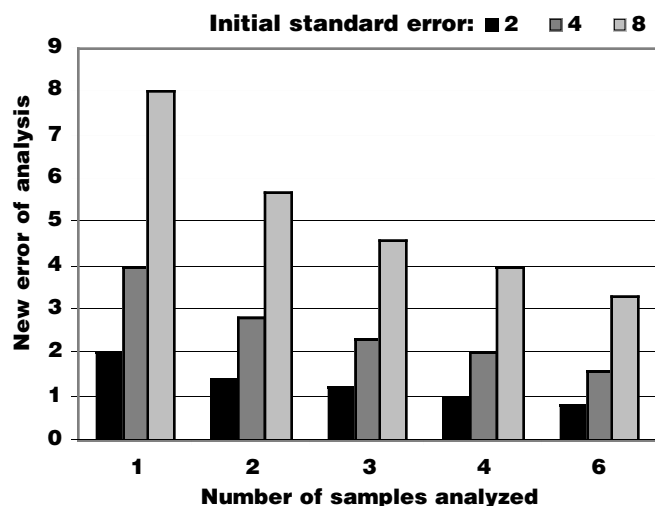
Nutrient analysis of forage has value if used to formulate rations or to sell or buy forages. Four important forage analyses results are dry matter (DM), neutral detergent fiber (NDF), NDF digestibility, and protein (CP). Relative feed value (RFV) and relative forage quality (RFQ) are two useful calculated indices. The importance and use of each is described below.

Dry matter (DM). Dry matter is the percentage of the sample that is not water. It is important in hay and silage marketing because buyers want to buy dry matter not water. Dry matter also provides an indication of whether the hay or silage will store properly if the dry matter is in an appropriate range for the storage system. Forage dry matter is important when balancing rations because animals need a specific amount of dry matter and, since most forages are fed on an as is basis, if the dry matter is less than expected the animals are receiving more water and fewer nutrients than intended.

Neutral detergent fiber (NDF). Neutral detergent fiber represents the slowly digestible and indigestible components in plants (cellulose, hemicellulose, lignin, and ash). It is the most accurate predictor of how much dry matter an animal can consume. An increase in NDF means an animal will consume less of that forage.

NDF digestibility (NDFD). NDF digestibility impacts both animal intake (because animals fed forages with more digestible NDF can consume more feed) and forage energy content (because the energy content of the forage is higher if fiber digestion is more extensive).

Figure 4. Effect of multiple samples on error size.



8 Sampling hay, silage, and total mixed rations for analysis

Relative feed value (RFV). Relative feed value is an index that ranks cool-season legumes, grasses, and mixtures by potential digestible dry matter intake based on acid detergent fiber and NDF. It should be used to allocate forages to the proper live-stock class with a given level of expected performance. It can also be used to relate price and forage quality when buying or selling hay.

Relative forage quality (RFQ).

Relative forage quality value is an index which ranks cool-season legumes, grasses, and mixtures by potential digestible dry matter intake calculated from NDF and NDF digestibility. It can be used for inventorying feeds, allocating forages to the proper livestock class with a given level of expected performance or relating price and forage quality when buying or selling hay. It does a better job than the RFV at matching animal performance across a wide range of forages and environments.

Crude protein (CP). Crude protein is 6.25 times the nitrogen content for forage or 5.7 times the nitrogen content for grain. Overfeeding and underfeeding protein are both costly to production and, potentially, animal health.

For additional information on forage types, analysis and rationing, contact your nutritionist or county Extension agent.



Copyright © 2005 by the Board of Regents of the University of Wisconsin System doing business as the division of Cooperative Extension of the University of Wisconsin-Extension. Send inquiries about copyright permission to: Manager, Cooperative Extension Publishing, 432 N. Lake St., Rm. 103, Madison, WI 53706.

Authors: Dan Undersander is a forage agronomist, and Randy Shaver and Pat Hoffman are dairy nutritionists with the College of Agricultural and Life Sciences, University of Wisconsin-Madison, and University of Wisconsin-Extension Cooperative Extension. Jim Linn is a dairy nutritionist and Paul Peterson is a forage agronomist with the University of Minnesota and Minnesota Extension Service. Produced by Cooperative Extension Publishing, University of Wisconsin-Extension.

University of Wisconsin-Extension, Cooperative Extension, in cooperation with the U.S. Department of Agriculture and Wisconsin counties, publishes this information to further the purpose of the May 8 and June 30, 1914 Acts of Congress. An Equal Employment Opportunity / Affirmative Action employer, University of Wisconsin-Extension provides equal opportunities in employment and programming, including Title IX requirements.

This publication is available from your Wisconsin county Extension office or from Cooperative Extension Publishing. To order, call toll free 877-WIS-PUBS (947-7827) or visit cecommerce.uwex.edu.