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Fact sheet

Analysis of Feeds and Forages for Horses

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When is Feed Analysis Necessary?

Before rations can be evaluated or formulated it is necessary to know the nutrient content of the feeds used. Visual evaluation cannot accurately predict the nutrient value of a feed. Published values for feeds may be used to estimate general nutrient content of rations (NRC, 1989). However, protein, soluble fiber and minerals in forages vary with climate, maturity, soil type, and fertilization, and may differ significantly from the average values. Regional averages based on common soil types and growing season may be available from local extension agents or commercial analysis laboratories, but even these may be inadequate if dealing with horses with special needs. Forages fed to lactating, pregnant, or growing horses should be analyzed rather than relying on published averages if at all possible.

Other situations in which feed analyses are recommended include: 1) use of non-traditional or commercial mixed feeds for which complete analyses are not available, and 2) suspected nutritional problems based on clinical signs of imbalances or poor performance.

On farms where hay is purchased at greater than three-month intervals, a sample from each load of hay purchased should be submitted for at least a near infrared refractometry or proximate analysis (see below). If small amounts are purchased frequently it is not practical to sample each load. In this case sample every third or fourth lot to get an average for the source being used.

How to Sample Feeds

Getting a sample that truly represents the overall feed is not always easy. Techniques differ according to the type of feed sampled and equipment available.

Dry Forages

Ideally, a forage sampler (see Table 1 for vendors) should be used to drill core samples from 20 small bales or 20 sites on large, round bales of hay.

If a forage sampler is not available, "grab samples" may be taken by hand, though it will not be as accurate, and harder to mix for subsampling. If sampling by hand, latex gloves should be worn, especially if trace minerals are of concern. Contamination from trace minerals on the skin may greatly alter the analyses. Samples should be taken from the inner section of 20 small bales, or taken deeply as possible from 20 sites on large, round bales. If long stem forages are sampled by grab sample, the samples should be chopped to facilitate mixing. Be sure to use stainless steel utensils, as rusty or aluminum implements will potentially contaminate the sample. Mixing is easier if the sample is dried before cutting or grinding, however the moisture content should be determined if submitting a dried sample for nutrient analysis (see below).

Grains or Concentrates

Samples (2 to 3 ounces each) should be taken from at least 20 sites and at a variety of depths in binned or bulk feeds. If sacks or bags are used to store the feeds, samples should come from at least two sites from ten bags. Commercially mixed grains which contain supplemental protein and/or mineral in powder form should be sampled only after thorough mixing or from both top and bottom of the bags to avoid bias due to settling of "fines." The samples should be mixed and a representative subsample submitted (at least 3 ounces) for analysis. Ideally, the scoop normally used to deliver feed to the animals should be used to obtain the samples.

Pastures

To obtain representative samples from pastures, ten sites should be selected in areas utilized by the animals. Do not take samples from overgrown areas which are obviously not being grazed. Though easier to sample, these would not represent what the animals were consuming. If the entire pasture is being utilized in a fairly uniform fashion, you should mark sampling sites at regular intervals in an X pattern from each corner to insure a truly representative sample. Ideally, at each site a 1-foot-square area should be marked out and all forage within the square

clipped to 0.75-inch height with stainless steel scissors. Do not, however, take plants which are obviously avoided by the animals. Samples from all sites should be mixed and 1/5 of the total subsampled for analysis.

Methods of Analysis: Selecting a Laboratory

It is important to ascertain if the laboratory to which you are submitting samples is equipped to do the requested analysis. It is also necessary to specify which analyses you want performed, rather than submitting a feed sample with the request to "analyze the nutrient content." Without specific instructions, many laboratories will give more or less information than desired.

Ask local extension agents or feed stores if there are feed analysis laboratories in the region. Large feed companies will often perform forage analyses for their clients. Complete listings of certified laboratories are available from:

National Forage Testing Association
P.O. Box 371115
Omaha, Nebraska 68137
(402)333-7485

Methods of Analyses: What to Request

The most common nutrient concerns when balancing rations are the water, energy, fiber, protein, calcium, and phosphorus content of the feed. Virtually all feed analysis laboratories are equipped to provide estimates of these in one form or another. Most laboratories also provide analyses of sodium (Na), magnesium (Mg), chloride (Cl), potassium (K), copper (Cu), iron (Fe), zinc (Zn), manganese (Mn), sulfur (S), and cobalt (Co). Certain trace mineral analyses such as selenium (Se), iodine (I), aluminum (Al), and molybdenum (Mo) require special analytical methods and are not commonly available.

The type of analysis used by the laboratory is important. There are a number of techniques used to determine nutritional content of feeds which differ in their accuracy and therefore usefulness. Most laboratories are equipped to do more than one type of analysis. The one(s) employed on a given sample should be selected on the basis of both cost and need for accuracy. Common systems used in commercial laboratories to determine nutrient content are discussed in ascending order of accuracy and cost of obtaining results.

A. Near Infrared Reflectance Spectroscopy

Near Infrared Reflectance Spectroscopy (NIRS) is based on the assumption that the spectrum of radiation absorbed and emitted by the organic components of feed is similar between feeds of the same chemical and biochemical composition. It is calibrated on the basis of complex mathematical equations and computer prediction models which compare NIRS spectra of feeds to the chemical analysis. NIRS is useful in the evaluation and formulation of rations, but is of limited value when non-traditional feeds or forages from different regions than those used to calibrate the equipment are used. The technique is more rapid than traditional assays and relatively inexpensive. NIRS reports usually include dry matter, crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), net energy for maintenance (NEm) and lactation (NEl) of dairy cattle, Ca, P, Mg, and K.

B. "Wet Chemical" Analyses

These laboratory assays involve a variety of chemical and biochemical techniques to accurately measure mineral and biological materials. They are considered to be the most accurate (and traditional) methods of analysis. However, there are problems even with these standard techniques.

1. Proximate Analysis

In a series of chemical extractions, the crude fiber, crude protein (Kjeldahl analysis of nitrogen content x 6.25), crude fat (ether extract), and ash (total mineral) content of feeds are determined on either a dry matter or as-fed basis. From these values the nitrogen free extract (NFE), which theoretically reflects the soluble carbohydrate content of the feed, is calculated. Total digestible nutrient (TDN) content of the feed is then calculated based on proximate analysis. Until recently it was considered to be the standard feed analysis, and virtually all feed analysis laboratories are equipped to perform it.

Despite its widespread use, there are many inaccuracies inherent in proximate analysis which limit its usefulness. Ether extraction removes not only fats but also waxes and other fat soluble materials, which may result in erroneously high estimates of fat content. Use of Kjeldahl analysis of feed nitrogen to derive the estimated total crude protein is based on several assumptions.

A. All proteins contain 16% nitrogen.
B. All nitrogen in a feed is in the form of protein.
C. The protein in the feed is totally digestible.

These assumptions frequently are not true, and protein availability may be grossly overestimated.

The Weende method of fiber determination commonly used in proximate analysis is considered to be inadequate for herbivorous animals in that it does not distinguish between the fermentable (cellulose and hemicellulose) and nonfermentable (lignin) components of fiber.

Calculation of nitrogen free extract compounds the above potential errors. Digestibility of protein and energy sources are not estimated by this technique. Proximate

analysis does not measure individual minerals or vitamins.

Proximate analysis is still useful to obtain a rough, inexpensive estimate of a feed's value. However, proximate analysis of fiber and protein is being rapidly replaced by the detergent fiber system in most laboratories.

2. Detergent Fiber (Van Soest) Analysis

This system is a modification of proximate analysis which uses improved methods for estimating the value of fiber and protein.

It has recently been accepted as the standard technique for analysis of forages for food animals. It uses a series of neutral and acid detergent extraction for analysis of fiber quality. Used in conjunction with Kjedahl analysis of nitrogen and a variety of other chemical treatments, detergent system analysis provides an estimate of the digestible versus indigestible portions of both fiber and protein in addition to soluble carbohydrates and ash. It is important to note that the "soluble carbohydrates" in this system include fibrous materials that are only available as energy sources to herbivorous animals such as horses and cows. Ether extraction is still used to give an estimate of fat content.

Results of detergent system analysis usually include values for dry matter, soluble carbohydrates, neutral detergent (NDF), and acid detergent fiber (ADF), digestible protein and ash. Many laboratories routinely include it in their "basic" feed analyses. This system does not estimate individual minerals or vitamins.

3. "Wet" Mineral Chemistries

Laboratories conducting chemical determination of minerals most commonly use atomic absorption, calorimetric, or spectrophotometric techniques. Some techniques are more adequate for a given mineral than others, but in general most wet chemistries for the macrominerals are fairly accurate. Problems arise in trace mineral analyses, which are extremely susceptible to errors due to contamination and improper sampling either in the laboratory or at the farm. In a survey of commercial laboratories it was found that there were significant differences in the reported trace mineral content of duplicate samples of sweet feed (Ralston, 1992). If an analysis contains values that are higher or lower than anticipated, resubmit a sample of the feed to another laboratory before assuming that the feed is imbalanced.

Availability of the minerals to the animal, however, can only be determined accurately by digestion trials. For example, a ration suspected to be deficient in selenium, based on clinical signs exhibited by animals consuming it, is submitted for selenium analysis. The results come back as low normal selenium. This does not necessarily mean the animals are not suffering from selenium deficiency. The ration should be examined for substances that reduce the absorption or enhance the excretion of selenium, such as arsenic, aluminum, copper, and molybdenum. Unfortunately the interactions of minerals are quite complex and not entirely understood at this time.

4. Vitamin Assays

Vitamin assays are much less available than are mineral assays. The only vitamin routinely measured at commercial laboratories is vitamin A. Usually assays for vitamin A measure total carotenoids, which will overestimate the actual amount of vitamin A activity, but at least gives an idea of the vitamin value of the feed. With increasing use of high performance liquid chromatography, assays for vitamin C, B-vitamins, and vitamin E may become more available. Biologic assays, using either animal or bacterial response to extracts of the feed or substance in question, also are used to determine concentrations of most vitamins. These assays are lengthy and expensive. Vitamins which serve as co-enzymes in specific biochemical reactions (ie: niacin, riboflavin, thiamine) may be determined by measuring byproducts of the vitamin mediated reaction by either calorimetric reactions or high performance liquid chromatography (HPLC). These assays, however, require a level of sophistication usually found only in research laboratories.

C. Forage Moisture

The quality of hay is determined in large part by the moisture at which it was baled. All commercial laboratories will do determinations of moisture content. It is, however, sometimes advantageous to be able to dry a forage before submitting it for nutrient analysis. If this is done, the moisture content should be determined at the same time. Freeze drying is the most accurate method which results minimal alterations in the nutrient composition of the feed. If freeze drying equipment is not available, moisture determination can be performed with a commercially available moisture probe which is used directly on the bales or in the silos or by the microwave technique described below.

Determining moisture content of a forage in a microwave oven requires minimal equipment: a microwave oven, a postal or gram scale for weighing the samples, paper plates, and a glass of water. Weigh a paper plate for each sample to be analyzed and write the weight on the plate. Weigh approximately 3 ounces (100 gms) of chopped forage onto the plate (samples taken by a forage sampler will not have to be chopped). Spread the material evenly over the plate and place it in the microwave. Put a half-full glass of water in the microwave at the same time to reduce the chance of burning the sample. Pasture samples assumed to contain over 50% moisture should be heated at medium for four minutes initially. Hay samples (usually less

than 30% moisture) should be heated for only three minutes initially. After heating, remove the sample from the oven and weigh it. Stir the forage on the plate and replace it in the oven for another minute. Weigh, stir, and reheat for 30 seconds. Continue drying and weighing until weight becomes constant. If the sample gets charred, you must redo the analysis on a fresh sample, using shorter drying times. The final weight divided by the original weight multiplied by 100 then subtracted from 100 will give you the percent water in the feed.

D. Summary

When formulating or evaluating reations, it is necessary to know the nutrient content of the ingredients. While published average values for concentrates may be used, it is strongly recommended that, when economically feasible, forages be submitted for chemical analysis. To sample a feed, at least 20 individual samples should be taken from a variety of sites in the lot, thoroughly mixed and a subsample submitted for nutrient analysis. To insure getting a truly representative sample of hay, it is strongly recommended that a hay corer be used rather than taking "grab samples." If grab samples are taken or samples are mixed by hand, latex gloves should be worn, especially if concerned about trace mineral content. It is important that the type of analyses desired be specified. NIRS is the most rapid and inexpensive analysis. It may be inaccurate, however, if forages from outside of the region or nontraditional feeds are submitted. Proximate analysis provides a reasonable estimate of forage quality, but is not as accurate as the newer detergent system of analysis. Vitamin A is the only vitamin for which commercial laboratories commonly have assays.

Table 1: Suppliers of forage core samplers

Forageurs Corp.
8500 210th Street West,
Lakeville, Minnesota 55044
(612)469-2596

NASCO
901 Janesville Avenue
Fort Atkinson, Wisconsin 53538
(800)558-9595

Techni-Serv. Inc.
P.O. Box 848
Madras, Oregon 97741
(503)475-2209

Hodge Products Inc.
P.O. Box 1326
El Cajon, California 92022
(619)444-3147

Oakfoeld Apparatus, Inc.
P.O. Box 65
Oakfield, Wisconsin 53065
(414)583-4114

Utah Hay Sampler
P.O. Box 1141
Delta, Utah 84624
(801)864-5380

REFERENCES

National Research Council. 1982. US-Canadian Tables of Feed Analysis. National Academy Press, 2101 Constitution Avenue, NW; Washington, DC 20418.

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