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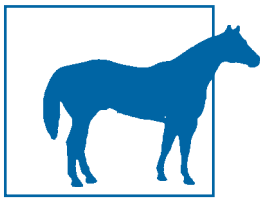

Horse Feeding Management

Feed Sampling and Analysis

Horse owners should routinely evaluate the nutrient content of their horses' feed. Learning how to interpret feed analysis reports will help you understand the actual nutrient content of feeds and develop balanced, cost-effective diets. Consult your county Extension agent for additional information.

Feed analysis services are provided by state departments of agriculture, feed companies, and commercial laboratories. Feed analysis will help you:

- Increase the accuracy of feed formulations.
- Monitor the accuracy of feed mixing services.
- Identify the quality of feed ingredients.
- Identify inadequate rations before damage occurs.
- Maintain a cost-effective feeding program.

It can also help equine professionals diagnose nutrition-related diseases. An accurate feed analysis depends upon obtaining and properly handling a representative feed sample. The procedures and definitions described here will help you obtain a proper sample and interpret an analysis report.

Laboratory Procedures

Laboratory analysis includes conventional *wet chemistry* analysis, which. involves drying and burning procedures prescribed by the Association of Official Analytical Chemists (AOAC) to determine the major chemical components in a feedstuff. This method is based on sound chemical and biochemical principles. More recent advances to the chemical analysis include the *Van Soest system* of cell-wall evaluation of feedstuffs. This system more efficiently partitions out the energy derived from fiber than the earlier crude fiber estimates. Most feed-testing laboratories use the Van Soest system for fiber determination and the *proximate analysis* (an analysis of the feed's components) to determine:

- dry matter content (100 percent minus the moisture content)
- crude protein
- mineral analysis
- digestible energy (calculated from equations)
- crude fat
- nonstructural carbohydrates

North Carolina Feed Testing Service

A complete feed analysis service is provided by the North Carolina Department of Agriculture and Consumer Services (NCDA&CS). North Carolina county Cooperative Extension offices maintain a supply of NCDA&CS feed testing forms, which can also be found online at http://www.ncfeedandforage.com. The information sheet must be completed as accurately as possible. The sample, along with the $10 analysis fee, should be sent to the NCDA&CS, Food and Drug Protection Division, Forage Testing Laboratory, 1070 Mail Service Center, Raleigh, NC 27699-1070 (919-733-7366).

Copies of the feed analysis will be returned to you, your county Cooperative Extension livestock agent (if you indicated a need for Extension assistance

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on the form), and the Extension Horse Husbandry Program at North Carolina State University (if you indicated horses on the form.) Your livestock agent can help you interpret the laboratory results and develop balanced rations.

The quality of the feed analysis is only as good as the sampling technique, the sample's representativeness, and the information provided on the analysis information form. Mix the sample well, and completely fill the sample bag with the ingredient. When completing the form, make certain you properly identify the feedstuff as either a grain mix, legume forage, grass forage, or legume-grass mixed forage. You should also identify the forage species (such as fescue or orchardgrass), the horse's proper production stage, and any special analysis you require. Special analyses can be conducted for the following toxins:

- nitrates (analyzed only in forages)
- aflatoxin (analyzed only in grains)
- crude fat (analyzed only in grains)
- mycotoxins (analyzed in grains, concentrate mixes, and forages)

There is no additional fee for the special tests; however, you must specifically request the tests and submit a sample of adequate size. A $75 additional fee is charged for a fumonisin (FB_1) analysis. A letter from your veterinarian requesting the mycotoxin analysis in relationship to a disease situation with your horse must accompany the feed testing form. Figures 1 and 2 illustrate typical analyses of grass and legume forage samples submitted to the NCDA&CS feed testing laboratory.

Figure 1. Orchardgrass hay analysis: Example from the North Carolina Department of Agriculture and Consumer Services Forage Testing Lab

John Doe		Tel# 704-555-555
Box 22, Anywhere, NC 55555		Stanly County
Sample number:	1001	
Description:	Hay, First Cutting	
Forage type:	Orchardgrass	
Forage form:	Hay	
Species:	Horse	
Production stage:	Maintenance	
Maturity	Grasses	
Laboratory results	As-fed basis	Dry-matter basis
Dry matter, %	89.93	
Crude protein, %	11.41	12.69
Unavailable protein, %	1.12	1.24
Adjusted crude protein, %	11.41	12.69
Acid detergent fiber, %	33.98	37.78
Crude Fat, %	4.17	4.64
Calcium, %	0.40	0.45
Phosphorus, %	0.23	0.26
Sulfur, %	0.18	0.20
Magnesium, %	0.28	0.31
Sodium, %	0.02	0.02
Potassium, %	1.51	1.68
Copper, ppm	4.00	5.00
Iron, ppm	139.00	155.00
Manganese, ppm	192.00	214.00
Zinc, ppm	31.00	34.00
Nitrate ion, %	0.00	0.00
Digestive Energy, Mcal/lb	0.88	0.98
Ash, %	5.69	6.33
Neutral Detergent Fiber, %	54.60	60.71
Nonstructural Carbohydrate, %	14.06	15.63

Figure 2. Alfalfa hay analysis: Example from the North Carolina Department of Agriculture and Consumer Services Forage Testing Lab*

John Doe		Tel# 704-555-555
Box 22, Anywhere, NC 55555		Stanly County
Sample number:	1002	
Description:	Alfalfa Sample 1	
Forage type:	Alfalfa	
Forage form:	Hay	
Species:	Horse	
Production stage:	Lactating Mare	
Maturity	Mid bloom	
Laboratory results	As-fed basis	Dry-matter basis
Dry matter, %	86.56	
Crude protein, %	17.13	19.79
Unavailable protein, %	1.62	1.87
Adjusted crude protein, %	17.13	19.79
Acid detergent fiber, %	27.88	32.21
Crude Fat, %	1.51	1.75
Calcium, %	0.61	0.70
Phosphorus, %	0.26	0.30
Sulfur, %	0.19	0.23
Magnesium, %	0.20	0.23
Sodium, %	0.02	0.02
Potassium, %	2.56	2.96
Copper, ppm	7.00	8.00
Iron, ppm	74.00	86.00
Manganese, ppm	34.00	39.00
Zinc, ppm	23.00	26.00
Nitrate ion, %	0.18	0.21
Digestive Energy, Mcal/lb	1.02	1.18
Ash, %	7.21	8.33
Neutral Detergent Fiber, %	35.26	40.73
Nonstructural Carbohydrate, %	25.45	29.40
Aflotoxin, ppb	21.0	24.0
Zearolenone, ppb	0.00	0.00
DON, ppb	163.0	184.0

**Includes mycotoxin analysis*

Converting Dry-Matter and As-Fed Values

Nutrient values are expressed on both a *dry-matter* and an *as-fed* (or *as-sampled*) basis. Dry-matter (DM) values indicate the nutrient content of feed with water removed so you can compare different feeds at varying moisture contents. Because horses eat on a dry-matter basis, the DM value is considered the best indicator of nutritive value. Typically, horses will consume a feedstuff until they have eaten their needed amount of dry matter. So usually they will eat more of a high-moisture feed than a low-moisture feed.

In Figures 1 and 2, all values listed under the *as-fed* heading show nutrients with the moisture included in the feed. Due to water dilution, as-fed nutrient values will always be lower than dry-matter values. To convert as-fed values to dry-matter values, divide by the percent of dry matter. Using Figure 1, for example, you would convert 11.41 percent crude protein (CP) on an as-fed basis to a dry-matter basis by dividing by .8993 because the dry-matter value is 89.93 percent:

11.41 ÷ .8993 = 12.69 percent crude protein on a dry-matter basis.

Similarly, to convert from dry-matter to as-fed values, multiply the nutrient value by the percent of dry matter. Using Table 1 again, you would convert 12.69 percent crude protein on a dry-matter basis to an as-fed basis by multiplying 12.69 by .8993:

12.69 × .8993 = 11.41 percent crude protein on an as-fed basis.

Additional information concerning expected nutrient ranges for grasses, legumes and mixed grass legume forages grown in North Carolina can be found in the factsheet entitled *Interpreting Horse Feed Analysis.*

Table 1. Expected feed consumption by horses*

	Forage	Concentrate	Total
	(% body weight)		
Mature Horses			
Maintenance	1.5 to 2.0	0 to 0.5	1.5 to 2.0
Mares, late gestation	1.0 to 1.5	0.5 to 1.0	1.5 to 2.0
Mares, early lactation	1.0 to 2.0	1.0 to 2.0	2.0 to 3.0
Mares, late lactation	1.0 to 2.0	0.5 to 1.5	2.0 to 2.5
Working Horses			
Light work	1.0 to 2.0	0.5 to 1.0	1.5 to 2.5
Moderate work	1.0 to 2.0	0.75 to 1.5	1.75 to 2.5
Intense work	0.75 to 1.5	1.0 to 2.0	2.0 to 2.5
Young Horses			
Nursing foal (0 to 3 months)	0	1.0 to 2.0	2.5 to 3.5
Weanling foal (4 to 11 months)	0.5 to 1.0	1.5 to 3.0	2.0 to 3.5
Short yearling (12 to 17 months)	1.0 to 1.5	1.0 to 2.0	2.0 to 3.0
Long yearling (18 to 23 months)	1.0 to 1.5	1.0 to 1.5	2.0 to 2.5
Two-year-old (24 to 36 months)	1.0 to 1.5	1.0 to 1.5	2.0 to 2.5

*Air dry feed (about 90 percent dry matter). Adapted from the National Research Council's Nutrient Requirements of Horses (1989).

Calculating Digestible Energy (DE)

Digestible energy (DE) is the preferred energy measurement for horse feed. The following equations are used to calculate digestible energy at the laboratory. Substitute as-sampled acid detergent fiber (ADF) and crude protein (CP) values to solve the equations (see *Nutrient Requirements of Horses*, National Research Council, 2007).

For hays and fresh forage/ pastures:

DE + 2.118 + 0.01218CP – 0.00937ADF – 0.00383(NDF – ADF) + 0.04718EE + 0.02035NFC – 0.0262 Ash

Where NFC = 100 – % NDF – % CP – % EE – % Ash

For energy feeds (grain mixes) and protein supplements:

DE (Mcal/kg) = 4.07 – 0.055 (% ADF)

For fats and oils:

DE = (-3.6 + 0.211CP + 0.421EE + 0.015CF) ÷ 4.184

Using Nitrate-Ion Information

Nitrate ions are the common form of fertilizer nitrogen; they consist of one atom of nitrogen and three atoms of oxygen. Nitrate poisoning occurs when an animal consumes excessive amounts of nitrate present in plants and (rarely) in water. Excessive intake of nitrates decreases the blood's oxygen-carrying ability, which causes anxiety, increased respiration rate, and breathing difficulty. Severe cases result in loss of coordination, muscle twitching, and death. Excess levels of nitrates can occur where more fertilizer nitrogen is applied than needed and from drought stress on plants.

Horses seem to be more tolerant of high nitrate levels than ruminants. But little scientific research is available that clarifies the maximum allowable level of nitrates in equine diets. Consequently, the safe level of nitrates in equine diets is assumed to be the same level as in ruminant diets. Forages containing greater than 1 percent nitrate in their dry matter content are not considered safe for ruminant or equine feed (Table 2). Ideally, the total ration should contain no more than 0.5 percent nitrate. Roughages containing greater than 0.5 percent nitrate should be fed in combination with grain or forages containing no nitrate. This combination will dilute the nitrate content and maintain the nitrate content of the total ration at less than 0.5 percent. Figure 3 provides an example of how to dilute high-nitrate forages with grain.

Feed Analysis Definitions

As submitted (As fed) basis — the nutrient amounts in a feed in the form in which it is fed, including the water it contains. Expressed as a percentage.

Dry matter basis — the nutrient amounts in the feed with the water removed. Expressed as a percentage.

Crude protein (CP) — total protein equivalent, including nitrogen from protein and nonprotein sources (nitrogen times 6.25 = crude protein). Expressed as a percentage.

Unavailable protein (UP) — measured as fiber-bound protein. UP in excess of 10 percent of crude protein indicates heat damage and improper curing in forages. Unavailable protein contents greater than 10 percent are not considered safe. Expressed as a percentage.

Table 2. Methods of adjusting the nitrate content of rations when feeding forage high in nitrates*

Nitrate %	Forage	Grain
	Maximum % of total ration	Minimum % of total ration
0.5	100	0
0.75	(0.5 ÷ 0.75) = 67	(100 – 67) = 33
1.0	(0.5 ÷ 1.0) = 50	(100 – 50) = 50
1.25	(0.5 ÷ 1.25) = 40	(100 – 40) = 60
1.5	Don't feed: it would require too much grain.	

*Adapted from L.D. Lewis (1995).

Figure 3. Determining the grain required to dilute the effect of high-nitrate forage

Example: Consider a 1,000-pound mature horse at maintenance consuming a forage containing .75 percent nitrate.

Step 1: Consult Table 1 and observe that a 1,000-pound horse consumes about 1.5 percent of its body weight in forage: 1.5 x 1,000 = 15 pounds of feed.

Step 2: Consult Table 2 and observe that forages with a nitrate level of .75 percent should not account for more than 67 percent of the total ration.

Step 3: Multiply the amount of forage the horse consumes (Step 1) by the maximum allowable percentage (Step 2): 15 x .67 = 10 pounds of forage. You can also multiply the corresponding grain percentage in Table 2 to check the amount of grain you should add: 15 x .33 = 5 pounds of grain.

Results: Feeding 5 pounds of a grain mix containing no nitrates and 10 pounds of a forage containing .75 percent nitrates would reduce the nitrate level of the ration to an acceptable level of .5 percent nitrate. Similar dilutions can be achieved by blending forage that has no nitrates with nitrate-containing forages.

Adjusted crude protein (ACP) — an estimate of heat-damaged crude protein; equal to CP minus UP in excess of 10 percent of CP. This value should be used in balancing ruminant rations. Expressed as a percentage.

Acid detergent fiber (ADF) — a measure of feed fiber consisting primarily of partially digestible cellulose, lignin, and silica. Approximately equal to 1.27 times crude fiber for forages or 2 times crude fiber for concentrates. Expressed as a percentage. Energy is inversely related to fiber. An ADF greater than 40 percent concentration indicates a low energy content and reduced forage digestibility.

Crude fat — the portion of the feed that is soluble in ether. Also referred to as *ether extract*. Expressed as a percentage.

Neutral detergent fiber (NDF) — a chemical analysis that separates forage samples into cell wall and cell contents. Represents the cell contents that are digestible. NDF levels will increase as a plant matures. An NDF greater than 70 percent indicates reduced voluntary intake of forages consumed at a slower rate.

Digestible energy (DE) — the portion of the gross energy of the feed that does not appear in the feces. The preferred energy measurement derived from equine research, when formulating equine diets. Expressed as megacalories per pound or kilogram of feed.

Macrominerals — include Calcium (Ca), Phosphorus (P), Magnesium (Mg), Sulfur (S), Potassium (K) and Sodium (Na). Expressed as percentages.

Microminerals (trace minerals) — include Iron (Fe), Zinc (Zn), Copper (Cu), and Manganese (Mn). Expressed in parts per million (ppm).

Nitrate ion — the common form of fertilizer nitrogen containing one atom of nitrogen and three atoms of oxygen. Expressed as a percentage of nitrate ion in feed.

Ash — the total mineral content of the feed. Expressed as a percentage.

Nonstructural carbohydrates (NSC) — the chemically analyzed fraction of a feed that includes mono and disaccarides, oligosaccharides (fructan), and starch. NSC levels greater than 22 percent of the total diet have been implicated in colic and laminitis cases in horses with excessive body condition.

Mycotoxin Analysis Definitions

Ideally, all horse feeds should be mycotoxin free. Table 3 lists the maximum recommended mycotoxin levels for mature nonbreeding horses. The recommendations are based upon field observations with limited scientific data related to equine. Controlled scientific studies are needed to clarify specific mycotoxin tolerance and toxicity levels for horses. Definitions and allowable limits are listed below

Aflatoxin (AFL) — a carcinogenic fungal toxin produced in damaged or improperly stored feeds. Expressed in parts per billion (ppb). Twenty ppb is the maximum allowable limit for interstate shipment of grain. Ideally, horse diets should be free of aflatoxin. However, 50 ppb is considered the maximum acceptable level.

Deoxynivalenol (DON) — produced by *Fusarium* molds; most commonly found mycotoxin; causes reduced feed intake; implicated in colics; 400 parts per billion is considered the maximum acceptable limit. High levels of DON indicates a likelihood of contamination by additional mycotoxins.

T-2 toxin (T_2) — produced by *Fusarium* molds; causes digestive-tract irritation and colic; presence of T_2 and DON in feeds has been implicated in colics. Ideally, no T_2 toxin should be present in the sample; levels of 50 parts per billion in absence of DON have been fed for short periods with no effect.

Table 3. Maximum mycotoxin levels for mature, nonbreeding horses[a,b]

Mycotoxin	Level[c]
Aflatoxin	50 ppb
T-2 toxin	50 ppb
DON	400 ppb
Zearalenone	100 ppb

[a]Heat stress, weight loss, crowding, disease exposure, the presence of more than one mycotoxin, and drug interactions, as well as other factors, increase an animal's susceptibility to mycotoxins. Thus, these recommendations must be tempered with a knowledge of specific animals.

[b] See North Carolina Cooperative Extension Service publication AG-523, Effects of Mycotoxins in Livestock Feed and Forage.

[c]PPB = parts per billion.

Zearalenone (F_2) — produced by *Fusarium* molds; reduces fertility and reproductive performance; 100 parts per billion considered the maximum acceptable limit.

Fumonisin (FB_1) — *Fusarium* mold implicated in impaired immune function, liver and kidney damage, and leukoencephalomalacia (moldy corn poisoning); samples should contain no FB_1; levels of 10 parts per million (10,000 parts per billion) are toxic. Laboratory analysis on FB_1 performed upon special request for a $75 fee.

A complete nutrient analysis of all feed ingredients in a ration and accurate information on the daily intake of those ingredients will help you to determine appropriate nutrient levels. To determine your horse's nutrient requirements, consult *Nutrient Requirements for Horses* (AG-558-1). It describes nutrient requirements for various production stages.

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For Additional Information

Related publications are available from your county North Carolina Cooperative Extension Center.

Horse Feed Management Series

- AG-558-1, *Nutrient Requirements for Horses*
- AG-558-2, *Estimating Body Weight of Horses*
- AG-558-3, *Selection of Feedstuffs for Horses*
- AG-558-4, *Water Intake, Sweat Production, and Electrolyte Supplementation in the Horse*
- AG-558-6, *Interpreting a Feed Analysis* (forthcoming)

Mare and Foal Nutrition Series

- AG-491-1, *Feeding Management of the Broodmare*
- AG-491-2, *Body Condition Scoring: A Management Tool for the Broodmare Owner*
- AG-191-3, *Feeding the Newborn Foal*
- AG-491-4, *Feeding Orphan Foals*
- AG-491-5, *Weaning the Foal*
- AG-491-6, *Feeding the Weanling and Yearling*
- AG-491-7, *Creep Feeding Foals*

Additional publications can be found on the N.C. State University Extension Horse Husbandry Web site:
www.cals.ncsu.edu/an_sci/extension/horse/hhmain.html

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