# Forage Quality Interpretations

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**http://osufacts.okstate.edu**

High quality forages are crucial for the livestock industry. They furnish essential energy, proteins, vitamins, minerals, and fibers. In fact, diets of most domestic livestock consist principally (if not entirely) of forages.

Compared to cereal grains and pulses (dry, edible legume seeds), quality factors of forages vary greatly among species and can even vary within a single forage species. Forage quality is dependent upon species mixtures, stage of maturity, growing environment, soil fertility levels, and forage harvesting. For these reasons, evaluating the quality of forages for the production of meat, milk, and wool is complex.

**The best single measure of forage quality is animal productivity.** Animal productivity is in turn affected by forage intake, digestibility, and nutrient utilization efficiency.

Forages have historically been evaluated on **physical factors** which include color, leafiness, maturity, smell, softness, and purity. These factors are still important in assessing forage quality, but they remain very subjective and difficult to standardize.

**Chemical analyses** are useful tools in estimating certain forage quality factors. Direct chemical tests are usually accurate, but are somewhat slow and must be conducted in standard laboratory conditions. During the last decade, Near Infrared Reflectance Spectroscopy (NIRS) has been improved and has become popular. NIRS results are highly correlated to direct chemical procedures for alfalfa, when properly calibrated. NIRS units are relatively portable, fast, and precise, but sometimes results are not accurate, when inadequately calibrated.

Principal forage analysis values used in ration formulations are: Crude Protein (CP); Acid Detergent Fiber (ADF); and Neutral Detergent Fiber (NDF). ADF estimates forage digestibility, and NDF provides an estimate of forage intake for some forages. Crude protein, estimated from total nitrogen concentration, is always important in rations because it is usually the highest-priced nutrient.

Forage quality analyses (using direct chemical analysis, or NIRS) normally measure four different attributes: %Total Nitrogen, %ADF, %NDF, and %Moisture. Sometimes the concentration of certain minerals (e.g., calcium and phosphorus) is also determined. Other properties listed in forage analysis reports are mathematically derived from the measured attributes. These usually include digestible protein (DP), total digestible nutrients (TDN), net energy (NE), digestible dry matter (DDM), dry matter intake (DMI), and relative feed value (RFV), as shown in Figure 1. Both measured and derived values are used by hay buyers and sellers to estimate the value of forages.

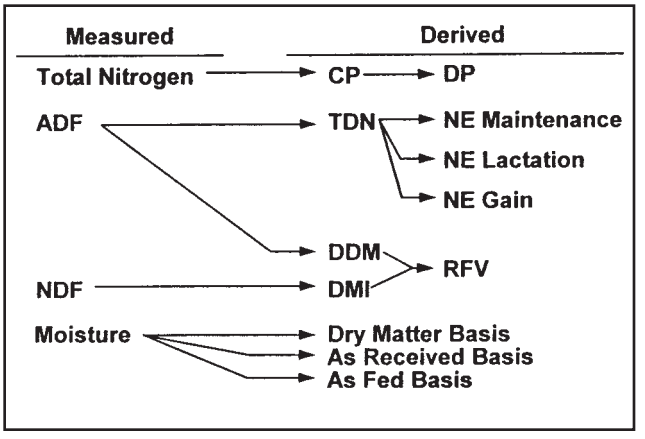


**Figure 1. Forage Quality Properties Determined by Laboratories.**

Conducting chemical analyses and assessing physical characteristics by sight, smell, and feel are the best ways to develop an overall evaluation of forage. This fact sheet describes some chemical factors in forage analysis and how they can be used. Other OSU Cooperative Extension Facts are available at County Extension Offices. **Hay Judging** (PSS-2588) concentrates on assessment of physical characteristics and their relative importance for various livestock. **Utilization & Value of Alfalfa in Dairy Rations** (ANSI-4013) emphasizes the value of different qualities of alfalfa hay for dairies.

## Relative Feed Value

Both buyers and sellers continue to seek common means of estimating hay quality in terms of its value as a feed for livestock. **Relative Feed Value** (RFV) is gaining acceptance as the best single value to estimate alfalfa forage quality for dairy cattle. Hay buyers want to know RFV, making it a valuable marketing tool.

That should not imply RFV is the only important forage quality estimator. For example, **RFV does not say anything about protein concentration or physical characteristics.** Protein and physical characteristics must be evaluated along with RFV for a complete assessment of forage quality.

The formula for estimating RFV from Digestible Dry Matter (DDM) and Dry Matter Intake (DMI) is:

RFV = (% DDM) X (% DMI) X (0.775)

DDM and DMI are derived from ADF and NDF, respectively. Laboratories may use slightly different formulae to calculate DDM and DMI, but final estimated values are similar.

The common formula for estimating **Digestible Dry Matter** (DDM) from ADF is:

% DDM = 88.9 - (0.779 X %ADF)

**Example:** If ADF = 28%, then
% DDM = 88.9 - (0.779 X 28)
= 88.9 - 21.8
= 67.1%

The formula for estimating **Dry Matter Intake** (DMI), as % of animal body weight from NDF, is :

$$\%\ DMI = \frac{120}{\%\ NDF}$$

**Example:** If NDF = 38%, then

$$\%\ DMI = \frac{120}{38}$$

= 3.15 % of body weight.

From the above examples, a forage with ADF = 28% and NDF = 38% would have RFV of 164.

RFV = (67.1) X (3.15) X (0.775) = 164.

Table 1 eliminates the tedious calculations of RFV. RFV can be determined by locating the percent NDF along the top and percent ADF along the left side.

**What does RFV = 164 mean?** RFV has no specific nutritional meaning and is used only as an index of

**Table 1. Relative Feed Values (RFV)* for selected values of Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF).**

| | NDF, % | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 |
| **ADF, %** | | | | | | | | | | | | | | |
| 20 | 227 | 213 | 201 | 189 | 179 | 171 | 162 | 155 | 148 | 142 | 136 | 131 | 126 | 122 |
| 21 | 225 | 211 | 198 | 187 | 178 | 169 | 161 | 153 | 147 | 141 | 135 | 130 | 125 | 121 |
| 22 | 223 | 209 | 196 | 185 | 176 | 167 | 159 | 152 | 145 | 139 | 134 | 128 | 124 | 119 |
| 23 | 220 | 206 | 194 | 183 | 174 | 165 | 157 | 150 | 144 | 138 | 132 | 127 | 122 | 118 |
| 24 | 218 | 204 | 192 | 181 | 172 | 163 | 155 | 148 | 142 | 136 | 131 | 126 | 121 | 117 |
| 25 | 215 | 202 | 190 | 179 | 170 | 161 | 154 | 147 | 140 | 135 | 129 | 124 | 120 | 115 |
| 26 | 213 | 200 | 188 | 177 | 168 | 160 | 152 | 145 | 139 | 133 | 128 | 123 | 118 | 114 |
| 27 | | 197 | 186 | 175 | 166 | 158 | 150 | 143 | 137 | 132 | 126 | 121 | 117 | 113 |
| 28 | | 195 | 184 | 173 | 164 | 156 | 149 | 142 | 136 | 130 | 125 | 120 | 116 | 111 |
| 29 | | | 181 | 171 | 162 | 154 | 147 | 140 | 134 | 129 | 123 | 119 | 114 | 110 |
| 30 | | | 179 | 169 | 160 | 152 | 145 | 139 | 133 | 127 | 122 | 117 | 113 | 109 |
| 31 | | | | 167 | 159 | 151 | 143 | 137 | 131 | 125 | 120 | 116 | 112 | 108 |
| 32 | | | | 165 | 157 | 149 | 142 | 135 | 129 | 124 | 119 | 114 | 110 | 106 |
| 33 | | | | | 155 | 147 | 140 | 134 | 128 | 122 | 118 | 113 | 109 | 105 |
| 34 | | | | | 153 | 145 | 138 | 132 | 126 | 121 | 116 | 112 | 108 | 104 |
| 35 | | | | | | 143 | 137 | 130 | 125 | 119 | 115 | 110 | 106 | 102 |
| 36 | | | | | | 142 | 135 | 129 | 123 | 118 | 113 | 109 | 105 | 101 |
| 37 | | | | | | | 133 | 127 | 121 | 116 | 112 | 107 | 103 | 100 |
| 38 | | | | | | | 131 | 125 | 120 | 115 | 110 | 106 | 102 | 99 |
| 39 | | | | | | | | 124 | 118 | 113 | 109 | 105 | 101 | 97 |
| 40 | | | | | | | | 122 | 117 | 112 | 107 | 103 | 99 | 96 |
| 41 | | | | | | | | | 115 | 110 | 106 | 102 | 98 | 95 |
| 42 | | | | | | | | | 114 | 109 | 105 | 101 | 97 | 93 |
| 43 | | | | | | | | | | 107 | 103 | 99 | 95 | 92 |
| 44 | | | | | | | | | | 106 | 102 | 98 | 94 | 91 |
| 45 | | | | | | | | | | | 100 | 96 | 93 | 89 |
| 46 | | | | | | | | | | | 99 | 95 | 91 | 88 |
| 47 | | | | | | | | | | | | 94 | 90 | 87 |
| 48 | | | | | | | | | | | | 92 | 89 | 86 |
| 49 | | | | | | | | | | | | | 87 | 84 |

the relative value of a forage. It combines into a single number **the digestibility of the forage** and **an estimate of how much forage will be consumed.**

The general relation between forage maturity and four quality estimators is illustrated in Table 2. As maturity advances, crude protein and RFV generally decrease, and ADF and NDF increase.

To establish a base-point to better determine where RFV's rate on the quality scale, it can be noted that an ADF of 41% and an NDF of 53% would relate to an RFV of 100. The RFV of alfalfa hay harvested at full bloom is expected to be about 100 (Table 2). The higher the RFV, the higher the quality of the forage.

**Table 2. Typical Crude Protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Relative Feed Values (RFV) for alfalfa hay at different maturities.**

| Stage of Maturity | %CP | %ADF | %NDF | RFV |
|---|---|---|---|---|
| Bud | 25 | 28 | 38 | 164 |
| Early Bloom | 23 | 30 | 40 | 152 |
| Mid bloom | 19 | 35 | 46 | 125 |
| Full Bloom | 16 | 41 | 53 | 100 |

## Using Forage Quality Information

A general rule-of-thumb to help remember forage quality analysis factors is **"20-30-40"**. High-producing dairy cows need hay with at least 20% CP, less than 30% ADF, and less than 40% NDF. This is equivalent to just over an RFV of 150. Forages with better CP, ADF, and NDF values are not necessarily better for milk production. When CP is more than 25%, ADF is less than 25%, and/or NDF is less than 35%, many nutrients pass through the rumen without being absorbed — essentially wasted.

**Forage quality analyses are no better than the procedures used to obtain the samples. Samples must represent a particular lot of forage (hay, silage, pasture, etc.). OSU Extension Fact Sheet F-2589, Collecting Forage Samples for Analysis, outlines good ways to obtain representative forage samples for analysis.**

There is no single way to assign dollar values to forages based strictly on forage analysis. Table 3 illustrates the relationship among various quality factors. These grade classes were developed by the American Forage and Grassland Council and are accepted by many forage buyers and sellers.

If alfalfa hay with an RFV of 160 is the only forage fed to lactating dairy cattle, then higher RFV's would have no additional value. However, dairymen sometimes mix very high quality forages with inferior forages to arrive at the desired forage digestibility and intake. In such cases, forages with RFV's higher than 150 have additional value and should demand higher prices.

When forages are fed to animals in limited quantities, such as supplements for cow-calf herds and dry cows, the importance of RFV changes. The **herdsman limits forage intake** by providing only a certain quantity per animal, and the NDF of the forage becomes less important. Digestibility (estimated by ADF) and CP are the main quality factors to consider in these situations.

Care should be exercised when applying RFV to forages other than alfalfa, because most of the calibration work and formulae for calculating digestibility and intake are currently based on alfalfa hay. Consequently, underlying assumptions may not apply to certain other forages. As more information is accumulated for other

**Table 3. Market hay grades for legumes, legume-grass mixtures, and grasses — American Forage & Grassland Council, Hay Marketing Task Force.**

| | | Description | | | | |
|---|---|---|---|---|---|---|
| Grade | Species and Stage | %CP | %ADF | %NDF | %DDM | RFV |
| Prime | Legume, pre-bloom | >19 | <31 | <40 | >65 | >151 |
| 1 | Legume, early bloom, 20% grass-vegetative | 17-19 | 31-35 | 40-46 | 62-65 | 125-151 |
| 2 | Legume, mid-bloom, 30% grass-early-head | 14-16 | 36-40 | 47-53 | 58-61 | 101-124 |
| 3 | Legume, full bloom, 40% grass-headed | 11-13 | 41-42 | 54-60 | 56-57 | 86-100 |
| 4 | Legume, full bloom, 50% grass-headed | 8-10 | 43-45 | 61-65 | 53-55 | 77-85 |
| Fair | Grass-headed and/or rain-damaged | <8 | >45 | >65 | <53 | <77 |

forages, RFV's (perhaps with different conversion factors) can be calculated for them.

**Establishing market grades of forages** similar to those set up for many agricultural products has not received wide spread acceptance. One reason is variation from one type of forage to another. The American Forage and Grassland Council's Hay Marketing Task Force developed the grades and descriptions shown in Table 3. This grading system works well for a single forage species utilized for a single purpose. For example dairymen feeding alfalfa hay can use these grades. Depending upon supply and demand at a particular time during the year, most lots of "prime" alfalfa hay may be sold for a fairly narrow range of prices. The same could be said for other grades.

The system is more difficult to use for feedlot operators using a grass hay such as sorghum-sudangrass or bermudagrass. Prime and grade 1 may not be needed because the nutritive value of grade 2 or 3 may meet the roughage needs of feeders. Therefore, prime and grade 1 may be of no added value. Another complication enters with grass-legume mixtures.

## What Affects Forage Quality?

Almost everything can affect forage quality in one way or another. Soil moisture and soil fertility, while the forage is growing, are important. Generally, the better the growing conditions, the higher the forage quality.

With good growing conditions, the most important factor affecting forage quality is **stage of growth** at harvest. More mature forage is less nutritious. Older plants generally have a lower proportion of leaves and a higher proportion of stem material (highly **indigestible** fiber). Young tender stems, leaves, and flowers provide the highest quality forage.

Forage producers and users recognize that **quality does not improve after harvesting.** The harvesting process can, however, reduce forage quality. For example, leaf loss caused by rain or excessive raking lowers forage quality. Baling hay too wet can cause excessive heating and mold to develop.

Forage quality can also be reduced during storage. Uncovered hay stored outside loses nutrients by the leaching action of rain. When hay becomes wet (from rain or absorbing moisture from the soil) it can rot, even though it was dry when baled (OSU Extension Fact Sheet BAE-1716).

**In summary, high-quality forage is the end product of good growing conditions, correct timing of harvest, and proper handling from harvesting to utilization.**

**OSU Extension Facts and Current Reports for Improving Forage Quality**

Hay Judging. PSS-2588
Collecting Forage Samples for Analysis. PSS-2589
Round Bale Hay Storage. BAE-1716
How to Get a Good Soil Sample. PSS-2207
OSU Soil Test Interpretations. PSS-2225
Alfalfa Stand Establishment. PSS-2089
Blister Beetles and Alfalfa. PSS-2072



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