DRAFT

TITLE: Trading Standards for Alfalfa Hay

PURPOSE: To develop standards for the trading of alfalfa hay.

FOR: Texas Cattle Feeders Association
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RECOMMENDATIONS

Alfalfa Hay Standards - Southwest Modification

1. For samples of pure alfalfa hay, crude protein is recommended as the assay for quality determination. Percentage adjustments could then be made in price/ton for quality differences using table 5.

2. For mixed samples of alfalfa hay and grasses or forbs, or when quality appears to have been reduced due to weathering or heating, % acid detergent fiber (ADF) should be determined and a % quality adjustment factor could be taken from table 5.

3. A monitoring system should be established to compile data obtained through minimal analyses of sampled alfalfa hay and from nutritionists who send their information to the collection point.

4. The standards are proposed for use with baled, loose or cubed alfalfa hay.

Introduction

Alfalfa hay is widely used in varying amounts in most finishing rations for feedlot beef cattle in the Southwest. There is rather large variance in quality among lots of alfalfa hay in this area due to many factors, but primarily to variable weather conditions, different management practices, and a demand for the product, which occassionally is in limited supply, by two different industries, dairies and cattle feedlots. Furthermore, the inconsistent quality of alfalfa hay merchandized and utilized by feed yards is difficult to appraise because there is no standard upon which to base judgments. The purpose of this report was to review the current literature and other sources of information, then compile the results of the survey into a table of standards which could be used in the trading of alfalfa hay.

Selected Review of Resources

Generally accepted forage quality factors within a species are stage of maturity, leafiness, color, and freedom from mold and foreign material. Evaluation of these characteristics is usually accomplished by qualitative, visual appraisal (Handbook, U.S. Official Hay and Straw Standards). There is an essential need for the quantitative measurement of these characteristics in forages. Considerable research has been conducted to develop quantitative techniques to estimate the feeding value of forages. According to Rohweder *et al.* (1976), most scientists and animal nutritionists working with forage quality indicated that the acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyses of Goering and Van Soest (1970) were the chemical assays of choice to estimate *in vivo* dry matter digestibility and dry matter intake, respectively. The basic scheme of forage analysis according to Van Soest

(1971) is shown in table 1. A description of the composition of each fraction obtained by the Van Soest procedures (ADF and NDF) is outlined in table 2 (Jorgensen, 1971/Rohweder, et al., 1976). Van Soest's procedures divide forage organic matter into cell contents (readily digestible) and cell walls (indigestible).

Rohweder et al. (1976) reported results of a recent study conducted by the Forage Analysis Subcommittee of the Hay Marketing Task Force - American Forage and Grassland Council. These investigators obtained forage samples with known analytical data from different locations in the United States to determine the precision of various techniques being used to measure nutritional quality of forages grown under a variety of climatic conditions. Results of their investigations indicated that acid detergent fiber is highly correlated with in vivo digestible dry matter in alfalfa (table 3). Their work was confirmed by Lema and Jorgensen (1971) who found that for pure samples of alfalfa, correlations between in vivo digestible dry matter and crude protein ($r = .82$) and between digestible dry matter and acid detergent fiber ($r = .83$) were not improved by correlating digestible dry matter with the combined values for crude protein plus acid detergent fiber ($r = .84$). However, when grasses were involved, the combined values improved the prediction of digestibility by over 20%. Data from Rohweder et al. (1976) would suggest use of the following regression equation for predicting in vivo digestible dry matter for alfalfa: % Digestible Dry Matter = 71.1 + .593 ADF% - .0221 ADF%^{2} ($r = .84$; $r^2 = .71$; sd = 3.61).

The effect of heating on alfalfa quality was reviewed by Van Soest (1970). Heating induces a process termed the "Maillard reaction" which causes amino groups of the forage protein to react with carbonyl groups of carbohydrates

TABLE 1. Basic Scheme of Forage Analysis[1]

Fraction	Reagent	Treatment	Yield
Neutral detergent fiber (NDF)	Na lauryl sulfate EDTA pH 7.0	Boil 1 h	Total plant cell wall (CW)
Acid-detergent fiber (ADF)	Cetyl trimethyl ammonium bromide in 1N H_2SO_4	Boil 1 h	Lignocellulose + SiO_2
Lignin	$KMnO_4$ pH 3.0	1 1/2 h at 20°C	Lignin as loss in wt. by oxidation
Cellulose	None	Ash residue from lignin step	Loss in wt.
Silica (SiO_2)	Conc HBr (48%)	Treat ash drop-wise 1 h 25°C	Residue is SiO_2
Hemicellulose	None	Calculate as NDF-ADF	

[1]Rohweder et al. (1976).

TABLE 2. Division of Forage Organic Matter by the System of Analysis Using Detergents[1]

Fraction	Components	Nutritional Availability	
		Ruminant	Non-Ruminant
A. Cell Contents (Soluble in neutral detergent)	Lipids	Virtually complete	Highly available
	Sugars	"	"
	Organic acids and water	"	"
	Soluble matter	"	"
	Starch	"	"
	Nonprotein nitrogen	"	"
	Soluble protein	"	"
	Pectin	"	"
B. Cells Walls (Fiber insoluble in neutral detergent ---- NDF)			
(1) Soluble in acid detergent	Hemicellulose	Partial	Very low
(2) Insoluble in acid detergent (Acid detergent Fiber- (ADF)	Cellulose	"	"
	Lignin	Indigestible	Indigestible
	Lignified N compounds	"	"
	Heat damaged proteins	"	"
	Keratin	"	"
	Silica	"	"

[1]Jorgensen per Rohweder et al. (1976).

to form an indigestible compound commonly referred to as "artifact lignin." Van Soest (1970) indicated that the only reliable basis for correction of the Maillard effect was acid detergent fiber or nitrogen content of lignin. Acid detergent insoluble nitrogen can be conducted when analyzing for acid detergent fiber. This method (acid detergent insoluble nitrogen) appears to be about equal to the pepsin insoluble nitrogen technique for explaining the variation in nitrogen availability (r^2 = .86 and .83, respectively), but acid detergent insoluble nitrogen better explained the variation in energy digestion (r^2 = .81 and .63, respectively).

Numerous other laboratory procedures have been developed to aid in determining forage quality. Pepsin solubility is a technique which involves treating a sample with hydrochloric acid and pepsin for 28 to 48 hours with most of the cell contents being removed (Donefer, 1970). Rohweder et al., (1976) indicate that this procedure behaves much the same as neutral detergent fiber, but takes longer than the neutral detergent fiber analysis and that it is satisfactory for determining protein digestibility in cool-season grasses.

Some limited data obtained from the Texas High Plains area yielded the following information for nine samples of alfalfa hay. Crude protein ranged from 12.5% to 18.6% with a mean of 15.5%; pepsin digestibility of protein ranged from 26.6% to 78.9%, with an average of 68.3%. The correlation between crude protein and pepsin digestible protein for these samples was r = .65. Bath et al. (1972) at the University of California developed an alfalfa hay testing program which is widely, but seemingly exclusively, used in California as a standard for determining the quality of alfalfa hay. This system is based upon "Modified Crude Fiber," which is the A.O.A.C. crude fiber analysis

modified to include part of the soluble ash. Rohweder et al. (1976) indicate that the Modified Crude Fiber system performs less well where alfalfa has been grown on high silica soils or when alfalfa contains a mixture of grasses.

Rohweder et al. (1976) report that infrared reflectance spectroscopy may offer rapid, accurate determinations of crude protein and the detergent fiber analyses in the near future. They indicate that a study has been funded at the U. S. Regional Pasture Research Laboratory to develop this technique. It was suggested that the infrared analysis procedures be computerized to allow telephone contact with a central computer to obtain results in two minutes or less. Much work needs to be done before this system will be available for use by the industry.

The extensive work of the Forage Analysis Subcommittee (reported by Rohweder et al., 1976) resulted in a proposed new system for establishing market hay grades shown in table 3. This grading system is based upon Van Soest's acid detergent fiber and neutral detergent fiber analyses. Their proposed grading standards for hay are in the evolutionary process, and with additional input, the system should become more precise.

Discussion

Results of a survey and of a research project conducted by the Forage Analysis Subcommittee/American Forage and Grassland Council indicated that the two most preferred analytical methods for determining forage quality were Van Soest's acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyses; ADF to estimate digestible dry matter and digestible energy, but NDF to predict voluntary dry matter intake (table 4; Rohweder et al., 1976).

ABLE 3. Proposed Market Hay Grades for Legumes and Legume-Grass Mixtures (Hay Marketing Task Force)[1]

ades	Stage of Maturity International Term	Definition	Physical Description	Typical Chemical Composition - %a CP %	ADF %	NDF %	Relative Feed Value %
Legume hay	Pre bloom	Bud to first flower; stage at which stems are beginning to elongate to just before blooming.	40 to 50% leaves*; green; less than 5% foreign material; free of mold, musty odor, dust, etc.	>19	<31	<40	>140
Legume hay	Early bloom	Early to mid bloom; stage between initiation of bloom and stage in which 1/2 of the plants are in bloom.	35 to 45% leaves*; light green to green; less than 10% foreign material; free of mold, musty odor, dust, etc.	17-19	31-35	40-46	124-140
Legume hay	Mid bloom	Mid to full bloom; stage in which 1/2 or more of plants are in bloom.	25 to 40% leaves*; yellow green to green; less than 15% foreign material; free of mold, musty odor, dust, etc.	13-16	36-41	47-51	101-123
Legume hay	Full bloom	Full bloom and beyond	less than 30% leaves*; brown to green; less than 20% foreign material; slight musty odor, etc.	<13	>41	>51	100
Sample Grade** Hay which contains more than a trace of injurious foreign material (toxic or noxious weeds and hardware) or that definitely has objectionable odor or is under cured, heat damaged, hot, wet, musty, moldy, caked, badly broken, badly weathered or stained, extremely overripe, dusty, which is distinctly low quality or contains more than 20% foreign material or more than 20% moisture.							

a Chemical analyses expressed on dry matter basis. Chemical concentrations based on research data from NC and NE States and orida. Dry Matter (moisture) Concentration can affect market quality. Suggested moisture levels are: Grades 1 and 2 < 14%, ade 3 < 18%, and Grade 4 < 20%.

* Proportion by weight.

** Slight evidence of any factor will lower a lot of hay by one grade.

CP = Crude Protein; ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; Relative Feed Value = Digestible dry matter take.

ohweder et al. (1976).

Table 4. Correlation (r) of Acid Detergent Fiber (ADF) with Digestible Dry Matter (DDM) and Neutral Detergent Fiber (NDF) with Dry Matter Intake (DMI) from Several Trials Conducted in U.S. (Rohweder et al., 1976)

Species	Location	ADF/DDM	NDF/DMI
Alfalfa	Wisconsin	r= -0.83	r= -0.48
	Wisconsin/Pennsylvania	-0.84	-0.75
	Florida	-0.91	-0.44
	Combined	-0.82	-0.62

The resource review would suggest that where pure samples of alfalfa hay were involved, crude protein would be as reliable an indicator of quality as acid detergent fiber. However, for mixtures of alfalfa hay and grasses or when quality appeared to be reduced due to weathering or overheating, then Van Soest's acid detergent fiber analysis would be the best indicator of quality. Therefore, the proposal is being made to utilize these two analyses only, as the assays upon which to base the Alfalfa Hay Standards - Southwest Modification. The proposed Alfalfa Hay Standards - Southwest Modification differ from the proposed grading standards of the Forage Analysis Subcommittee in that the standards would apply only to alfalfa hay or cubes, a lower percentage crude protein is involved, NDF is not utilized, and the adjustment factors are based upon a percentage adjustment from grade number 2 rather than from grade number 4. The grades, stage of maturity international term, definition, and physical description would be unchanged and used in the Southwest Modification. Table 5 shows the Alfalfa Trading Standards - Southwest Modification.

Table 5. Alfalfa Trading Standards - Southwest Modification[1]

Grades	Stage of Maturity International Term	Definition	Physical Description	Dry Matter Chemical Composition, % CP	ADF	Quality Adjustment Factor, %
1	No Change	No Change	No Change	21.1	26	+20
1				20.6	27	+17.5
1				20.0	28	+15
1				19.4	29	+12
1				18.9	30	+ 9
2				18.3	31	+ 6
2				17.7	32	+ 3
2				17.1	33	0
2				16.5	34	- 3
2				16.1	35	- 6
3				15.7	36	- 8
3				15.1	37	-11
3				14.5	38	-14
3				13.9	39	-17
3				13.4	40	-19.5
4				13.0	41	-22.5
4				12.4	42	-24
4				11.8	43	-27
4				11.1	44	-30
4				10.7	45	-32

Sample Grade**
- No Change

[1]Adapted from proposed market hay grades for legumes and legume-grass mixtures, Hay Marketing Task Force/American Forage and Grassland Council (Rohweder et al., 1976).

Estimated times for conducting the analytical procedures are shown in table 6. The times are based upon receiving the sample into the commercial laboratory before noon on a Monday morning to the time results are mailed from the laboratory. Analytical fees would be approximately $3.00 per sample for crude protein and about $4.00 per sample for each of the other analyses in table 6 and for pepsin soluble protein and for modified crude fiber.

Table 6. Estimated Times for Various Analytical Procedures

Analysis	Approximate time (days)
Crude protein	2-3
Pepsin digestible protein	4
Modified crude fiber	2-3
Acid detergent fiber	4
Neutral detergent fiber	4

These comments would be offered regarding two other procedures used for estimating quality of forages.

1. The California Modified Crude Fiber Analysis was not selected because it offers only a slight improvement over crude fiber and errors are involved when forages contain silica (alfalfa hay in the Southwest contains a relatively high level of silica) and mixtures of grasses.

2. Pepsin digestible protein estimates nitrogen and cell contents solubility with results similar to neutral detergent fiber rather than acid detergent fiber and the time for analysis is longer than for neutral detergent fiber.

Resources Cited

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Trade standards for alfalfa products. Cubes, meal, pellets. Calif. Grain and Feed Assoc. 3333 Watt Ave. Sacramento, Calif. 95821.