HOW TO SAMPLE ALFALFA TO OBTAIN AN ACCURATE QUALITY ANALYSIS

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Abstract: The feeding quality of alfalfa hay can be best estimated by combining a visual analysis with a chemical analysis. Sampling is the major factor affecting the accuracy of forage quality analyses. A minimum of 20 core subsamples, taken at random, one core per bale, should be taken at right angles to the surface of the end of each bale, not slanting up, down, or sideways, and combined into one composite sample. The coring device must enter the bale a minimum of 12 inches. Samples should never be divided before being ground and thoroughly mixed at the laboratory. Core samples and laboratory samples should be stored in a polyethylene freezer bag, along with the lab sheet properly identifying each sample. Unacceptable samples include alfalfa "flakes", samples obtained by using a "hay hook", or very small core samples which obviously don't represent a full 20 core set of subsamples. Proper sampling procedures and all details relating to the chemical analysis of alfalfa hay for sale in California are contained in the University of California Leaflet No. 21457.

Keywords: Predicting alfalfa hay quality, Modified crude fiber, Acid detergent fiber, Sample variation, Sampling method, Sampling equipment, Sample handling

INTRODUCTION

Alfalfa hay is the principal harvested forage produced in California, and is currently providing about 70% of the total forage requirements of our dairy industry. Consumers, particularly dairymen, but increasingly horse owners and stable managers, have long recognized the desirability of growing and buying high quality alfalfa hay. Identification of high quality lots of alfalfa hay, and the proper sampling of those lots will be discussed in this paper.

VALUE OF ALFALFA QUALITY STANDARDS

In the past, alfalfa hay has been marketed for at least the last 50 years, probably longer, on an "equivalent to USDA No. 1, No. 2 leafy, No. 2, etc." basis in the principal hay marketing areas. These federal hay grade standards were developed many, many years ago, and have provided, at best, only a rough approximation of quality in negotiating prices between producers and consumers. However, all federal hay grades were abandoned by the USDA in 1987. In 1984-85, about half of the states adopted new terminology and descriptive standards, "premium", "good", "fair", and "low or other". When these new visual grade standards were adopted, the Association of State Departments of Agriculture, who developed and promoted these visual standards, were contacted but refused to add chemical analysis to these standards, despite my repeated appeal to their executive office in Washington, DC. They were of the opinion that not enough people were analyzing alfalfa hay chemically to warrant their consideration. Of course we here in the west know differently! The California Department of Food and Agriculture were willing to listen, and we developed together the definitions for the four grades with their corresponding chemical analyses that are presently in use by the California Hay Market News in quoting alfalfa hay prices in California, Nevada, Utah, Oregon, and other states.

VISUAL INSPECTION NECESSARY BUT IT IS NOT ENOUGH!

Although alfalfa consumers have long recognized the desirability of buying quality alfalfa hay, many on a chemical analysis basis, growers have been less enthusiastic about adopting meaningful quality standards. However, during the last 20 to 30 years, many growers have learned that producing quality alfalfa hay will insure a quick sale and a higher price by discriminating consumers. We all know the difficulty in arriving at the correct quality grade by simply visually estimating that quality. A subjective, visual system is based on individual preferences. For example, when I was a young man attending Utah State University, I fed beef cattle in northern Utah in partnership with my father. My idea of quality alfalfa was leafy, tobacco-brown hay! My criteria was that there were never any stems left in the manger that had to be pitched out into the feedlot and trampled

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into the manure. We now know experimentally that tobacco-brown hay has lost some of its digestibility, particularly protein digestibility, through excessive heating in the bale. Another technique had to be developed in order to more accurately predict alfalfa quality than was available through visual analysis.

However, subjective visual estimates of alfalfa hay quality are necessary because they allow us to more accurately predict factors that are important in palatability, and consequently, intake that are not discernible through a chemical analysis. These include harvesting conditions, which will affect the moldiness or dryness of a lot of hay, foreign material, which mostly involves weeds, and green color, which is useful in determining whether or not a lot of alfalfa has been properly cured, or rain damaged.

Likewise, chemical analysis can only partially predict hay quality, even though maturity and leafiness are the most important in digestibility. Maturity and leafiness are much more accurately reflected by chemical analysis than by visual inspection. When used together, visual inspection and chemical analysis, it is possible to accurately predict the feeding value and palatability of a particular lot of alfalfa. Their interaction and value is indicated below for the five main hay quality factors of maturity, leafiness, harvest conditions or soundness of the alfalfa lot, foreign material and green color.

Quality Factor	Visual Inspection	Chemical Analysis
Maturity	Poor	Excellent
Leafiness	Fair	Excellent
Harvesting conditions	Excellent	Poor
Foreign material	Excellent	Poor
Green color	Excellent	Poor

CALIFORNIA DEVELOPED SYSTEM FOR PREDICTING ALFALFA HAY QUALITY IN 1950s

Researchers in California were the first to develop a system of predicting alfalfa hay quality from a chemical test. In the late 1950s, Drs. Jim Meyer and Glenn Lofgreen at UC Davis found that modified crude fiber (MCF) would predict total digestible nutrients (TDN) quite accurately (R = 0.89**) and could be adapted for wide-scale use in ranking, selling and feeding alfalfa hay. The MCF test to predict TDN has been used extensively in California since 1958, using 90% dry matter TDN values rather than 100% TDN values since most hay will dry to about 90% dry matter over a few months. The California MCF test is widely known both within and without the state, and among dairymen and producers.

More recent research at the University of California and the University of Nevada has demonstrated the value of a newer chemical analysis, acid detergent fiber (ADF), which is both more accurate and simpler, as well as less time consuming, than the old MCF test. Procedures have been established and published so that either the MCF or ADF can be used to predict TDN. This information can be found in a new University of California publication entitled "Testing Alfalfa for Its Feeding Value", University of California Leaflet No. 21457, (also Western Regional Extension Publication 109) published in March 1989. This publication also converts the presently used system of reporting TDN on a 90% basis to reporting TDN on either a 90% basis or 100% basis, and also describes the use of ADF to predict TDN on the same basis (Tables 1 and 2).

Nevada also offers the MCF and ADF test to predict TDN, since 26.1% of its 1988 crop was shipped to California, as determined at our quarantine stations located at strategic border points. This represents 32,509 tons of alfalfa cubes plus 257,243 tons of alfalfa hay, or 289,752 tons of a total hay production of over 1,000,000 tons. Utah is sending us 200,885 tons, (72,392 tons of cubes and 128,495 of hay) 10.0% of their production, and Arizona 13.0% (148,145 tons). All told in 1988, imports of alfalfa hay and cubes into California constituted 688,332 tons, or an amount equal to about 9.5% of the production within California -- a significant contribution to our alfalfa requirements. About 95% of these imports came from Nevada, Arizona, and Utah, but 10 states and Canada sent some products to us in 1988 (Table 3).

Most western states now offer the California hay analysis system since they are marketing so much hay within the state. This reduces confusion among purchasers who previous-

ly have had to deal with several different kinds of tests that gave different numbers. I believe it is safe to say that most California dairymen and alfalfa growers know what "54% TDN" means, either in the milk bucket or in the pocketbook. Today 54% is not high enough, and many buyers are requesting 55% TDN minimum on a 90% dry matter basis, or 61% on a 100% basis.

SAMPLING THE KEY TO CHEMICAL ANALYSIS

Taking an Adequate Sample

The validity of the testing program rests on obtaining a representative sample that accurately reflects the quality of a particular amount (called a "lot") of hay. Samples must be taken carefully and in a prescribed manner to represent the average value of the entire lot of alfalfa hay. Any chemical analysis offered to represent the lot is valid only to the extent that the sample represents the entire lot. Users of the chemical test must recognize that the true value of the lot will never be known since the value of the sample is only an estimate of the true value within a range, usually described as the average of the lot, plus or minus some kind of a confidence limit. Individual bales of hay will vary in quality. Sample variation is influenced not only by the natural variation of the hay, which can only be overcome by taking a sufficient number of samples per "lot" and combining them into one, but by sampling methods, sampling equipment, and sample handling. These will be discussed individually as follows:

1. Definition of a "Lot" of Alfalfa

A "lot" of hay is defined as hay taken from the same cutting, at the same stage of maturity, from the same variety, the same field, and harvested within a 48-hour period of time. A factor that might influence the formation of individual "lots" would include rain damaged hay, hay that contains higher amounts of grass and/or weeds, sharp and distinct soil differences within the same field, or hay that has been handled after cutting by different procedures.

2. Number of Bales to Sample

A minimum of 20 core samples, taken at random, one core per bale, should be drawn and composited to develop one sample per "lot". Significantly fewer samples than the 20 will not allow an accurate sample, which will represent the "lot", to be taken. This fact was demonstrated in 1983 by Marble and Bishop (unpublished), who sampled the so-called "1-ton bale" with a Penn State electric-powered drill with a 3/4 inch inside diameter cutting edge (Table 4). In this study, only 19 bales were sampled and analyzed separately, averaging 23.71% MCF, 20.12% crude protein (CP), 1.46% calcium, and 0.20% phosphorus. When a composite sample of all 19 bales was taken, the composite values respectively were 23.30, 20.60, 1.48, and 0.16, all lying within the 95% confidence limits except phosphorus. The TDN of the 19 bale average of individual samples and the composite value are very close, well within the plus or minus 1% TDN tolerance built into the California fiber test to predict alfalfa quality. However, notice that only five individual bale values are indicated in Table 4. These have been selected from the 19 to illustrate the variation in chemical analysis of individual bales. Notice bale number 15 had an MCF value of 16.6 and would have a predicted TDN of 60.2% contrasted with bale number 5 with 26.0% MCF and a predicted TDN value of 52.9, all on a 90% dry matter basis. But when the 19 individual bale samples were averaged, the values are extremely close to the values from the composited sample, as previously described.

The importance of sample size can also be demonstrated in Table 5. When the sample size is restricted to only six bales, the plus or minus confidence limit of the MCF, crude protein, or dry matter, is very high. When the total 19 bales are included, the confidence limits are reduced by more than half, thus increasing the accuracy of the predicted TDN value. The fact that two separate sampling activities, separated by 22 years, are represented, gives me a great deal of confidence in the need for a 19 or 20 bale sample size. This table tells us that with a confidence of 95%, we can say that the true average lies in this confidence limit range. The chance of drawing a sample with an average outside the confidence limits is only 5%. Thus one can easily see the necessity of sampling enough bales to adequately represent the "lot". The variation in error is greatly increased when a sample size less than 19 is used. If more than 19 samples are taken and composited, a more precise prediction of quality can be made with a higher level of confidence. However, the 20 bale sample is practical, gives good accuracy, is easy to remember, and is recommended.

3. Sampling Method

Bales should be probed in a uniform manner. The probe should be inserted into either end of each bale, with the probe entering at right angles to the surface and not slanting up, down, or sideways. Sampling of bales must be done at random. Randomness can be insured by sampling at various heights on the stack periodically, in a pre-set frequency, around the entire bale stack, truck load, or row of bales in the field. Integrity on the part of the sampler is an absolute requirement, since it has been demonstrated that individuals can select bales either to give a high TDN or a lower TDN, based on the appearance of the outside of the bale. Some hay analysis users have even advocated a certification program for samplers so that integrity can be insured.

4. Sampling Equipment or Coring Devices

Samples should be drawn with a core sampler. Many core samplers have been developed. Six examples are shown in Figure 1. Sampling equipment should not include a "hay hook" or "flake" of a bale of hay. Only core sampler tubes, or probes, are acceptable. They must be long enough to travel at least 12, but preferably, 18 inches into the hay bale, and have an internal diameter of at least 3/8 inch. They may be made in home shops from golf club shafts, ski poles, be made of conduit or steel tubing, with either a sharpened or serrated tip. They may be powered by a hand or electric drill. Core samplers with sharpened tips must be kept sharp in order to cut through hay, particularly damp hay, without selective sampling.

Marble and Curley (unpublished) in 1961 at U.C. Davis, Table 6, found no significant differences between three very different sampling devices when tested for dry matter (DM), MCF, and predicted TDN. The Penn State sampler with a 3/4-inch diameter core, very rapidly fills a container and discourages taking the entire 20 samples. A cut-off golf club handle was not significantly different from the probe or the Penn State sampler, and has become a popular sampling tool in the western states. The 3/8-inch probe obtained a satisfactory sample. Grab samples from the bale as it was being ground, had significantly higher DM than all three coring devices, and was significantly higher in MCF than the golf club or 3/8-inch probe, but equal to the Penn State sampler. Apparently grinding the bale gave a significant moisture loss and also a loss of fine material from grinding which increased the MCF content and lowered the predicted TDN value significantly. Other workers (Hoffman et al., unpublished) in 1961 (Table 7) compared a golf club shaft, a 3/8-inch probe driven by an electric drill, and a 3/4-inch hand probe. No significant differences were found in TDN values among any of these sampling instruments. All of these sampling studies were done with conventional three-wire bales.

For your convenience, some of the most commonly used coring devices are listed below, along with the address and phone number, so you can obtain more information including the current price of each probe.

(1) Penn State Forage Sampler--an 18-inch probe with 3/4-inch internal diameter available in hand brace or electric drill modes. (Nasco Farm and Ranch Catalog, Nasco West, 1524 Princeton Avenue, Modesto, CA 95354, Phone: 209/529-6957).

(2) Techni-Serv E-Z Probe--a 12-inch probe with 1/2-inch internal diameter, equipped with sample collection box and electric drill mode. (Techni-Serv, Inc., P.O. Box 848, Madras, OR 97741, Phone: 503/475-2209).

Oakfield Hay Sampler. (Oakfield Apparatus, Inc., P.O. Box 65, Oakfield, WI 53065 Phone: 414/583-4114).

(4) 13 to 15-inch golf club shaft, 3/8 inch or larger inside diameter cutting edge. (Homemade)

Utah Hay Sampler--a 20-inch probe with 1/2-inch internal diameter and sample collection box. (Utah State Hay Sampler, P.O. Box 1141, Delta, UT 84624, Phone: 801/864-5380).

Forageurs Hay Sampler--a 24-inch probe with 5/8-inch internal diameter and sample collection box. (Forageurs Corp., 8500 210th Street West, Lakeview, MN 54044, Phone: 612/469-2596).

Hay Chec Hay Sampler--a 12-inch probe with 7/16-inch cutting edge, and sample collection plastic jar. (A.M. Hodge Products, P.O. Box 202005, San Diego, CA 92120).

5. Sample Handling

A 20-core sample provides a large amount of sample material, particularly if a sampler has a 3/4-inch internal diameter. A sample should never be divided before it has been ground and mixed at the laboratory. After coring, the whole sample should be placed in a polyethylene freezer bag and identified with sample number, name and address. The bag should be sealed tightly so the laboratory report of dry matter "as received" will approximate the dry matter content of the lot when it was sampled. After grinding, samples may be thoroughly mixed and subsamples taken for analysis. Samples should be stored in a cool place where plastic bags won't be punctured before being shipped to the laboratory. A completed 20-core sample should weigh no less than one-half pound, or 225 grams, or it probably doesn't include 20 core subsamples, or the shaft was not inserted far enough into the bale.

6. Unacceptable Samples

Alfalfa "flakes", samples obtained by using a "hay hook", very small core samples, and hand-mixed samples are not representative and should not be submitted for chemical analysis. Most problems involving chemical analysis of "duplicate" samples sent to different laboratories have been traced to hand mixing and subsampling of the cored sample prior to grinding. Sifting of fine leaves and stem parts cannot be avoided, and samples cannot be considered as really being duplicate samples when done in this way.

7. Sampling Alfalfa Cubes

Proper sampling of alfalfa cubes is similar to sampling baled alfalfa hay. A sampling procedure has been developed by the University of California in conjunction with the California Department of Food and Agriculture. This system involves selecting 40 cubes at random from the lot to be graded, and placing these cubes in one container for submission to the laboratory for grinding and analyses.

8. Sampling Limits

Lots of baled alfalfa hay or alfalfa cubes should not exceed 200 tons. It should be remembered that the smaller the lot, the more likely the sample will represent the actual feeding value of the lot.

Sampling devices with a dull edge, or a diameter of less than 3/8 inch, may not cut through tough or wet stems and should not be used.

Very small samples of a few core probes cannot represent the true quality of the lot and should not be submitted. A 20-core sample should weigh no less than one-half pound and preferably three-fourths pound (225-350 grams).

LABORATORY CERTIFICATION

Different analytical procedures have been used to predict alfalfa forage quality in different states and regions. Methods and terms of reporting are also variable. The development of a national program of alfalfa forage quality evaluation by the National Alfalfa Hay Testing Association has provided a mechanism to eliminate these two problems. However, variation in individual chemical analysis between laboratories has taken longer to resolve. At the request of the National Alfalfa Hay Testing Association, the American Forage and Grasslands Council (AFGC) and the National Hay Association (NHA) have volunteered to serve as umbrella organizations to sponsor the certification of laboratories throughout the United States.

The voluntary laboratory certification program has the following objectives:

(1 To provide a voluntary mechanism for laboratories and hay testing facilities that evaluate alfalfa hay quality to certify the accuracy of their procedures for acid detergent fiber (ADF) and crude protein (CP).

(2) To use certification of laboratories to improve quality control of test results and thereby increase grower confidence in the information they receive.

To accomplish these objectives, a manual of instructions describing the program and procedures to be used has been prepared. Eight homogenus alfalfa hay samples obtained from various regions of the country have been prepared. A copy of the manual and subsamples are sent to requesting laboratories four times per year. The labs run triplicate analyses for ADF, crude protein, and dry matter, and report these back to the National Alfalfa Hay Quality Testing Association who run the statistics using a statistical outlier test to determine which values are outside of an acceptable range. Certified laboratories have been defined as those falling within an acceptable range for three out of four samples submitted per year. This has helped immeasurably to standardize techniques among laboratories.

There are currently about 100 laboratories certified throughout the nation, 10 of them n California.

SUMMARY

We have just completed the publication of a new University of California Leaflet No. 21457, and Western Regional Extenison Publication WREP 109, entitled "Testing Alfalfa for its Feeding Value". This new leaflet was published about the end of December 1988, and contains the latest procedures and recommendations that we use here in California. Some excerpts from this bulletin have been provided in this discussion for your information in case you don't have access to the new publication, which is available from your farm advisor's office for $1.50. Do not use the 1972 U.C. Leaflet 2323, "Alfalfa Hay Testing", as it is now out-of-date.

The changes we are recommending include:

(1 Changing from 90% MCF and its predicted TDN to a 100% value. Tables have been provided but this can be done very easily simply by dividing the TDN value at 90% dry matter by 0.9. For example, a 54% TDN at 90% DM = 60% TDN with the new 100% DM standard.

(2) Including in the publication tables for using ADF (Table 1) instead of/or MCF (Table 2). ADF is an easier test to perform, requires less steps and time and therefore is slightly more accurate.

(3) Since most alfalfa that is tested is used in dairy rations, a table to convert to net energy for lactation (NEL) has been included for both MCF and ADF.

(4) A suggested report form has been developed (Table 8) which identifies the sample, how many bales were sampled, and reports different quality analyses three ways: 1) as received; 2) 90% DM; and 3) 100% DM basis for ADF, MCF, CP, TDN, NEL, and digestible dry matter (DDM).

(5) A hay quality rating system has been devised (Table 8) using the classifications of premium, good, fair, and low, classified by ADF or MCF analyses, reported on a 100% dry basis, and TDN or 90% and 100% dry matter basis.

(6) An attempt is being made to educate chemical analysis test users to rely directly on the chemical analysis reported, either ADF or MCF rather than transposing those values to TDN. In this way NEL can be calculated directly using the appropriate equations listed in UC Leaflet No. 21457.

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Table 1. Net energy for lactation (NEL), total digestible nutrients (TDN) and digestible dry matter (DDM) of alfalfa estimated from its acid detergent fiber (ADF) content.

	(100% DM basis)		
ADF	TDN	NEL	DDM
(%)	(%)	(Mcal/lb)	(%)
20	67.4	.694	73.3
21	66.6	.686	72.5
22	65.8	.677	71.8
23	65.1	.669	71.0
24	64.3	.661	70.2
25	63.6	.652	69.4
26	62.8	.644	68.6
27	62.1	.636	67.9
28	61.3	.627	67.1
29	60.6	.619	66.3
30	59.8	.611	65.5
31	59.1	.602	64.8
32	58.3	.594	64.0
33	57.6	.585	63.2
34	56.8	.577	62.4
35	56.1	.569	61.6
36	55.3	.560	60.9
37	54.6	.552	60.1
38	53.8	.544	59.3
39	53.1	.535	58.5
40	52.3	.527	57.7
41	51.6	.519	57.0
42	50.8	.510	56.2
43	50.1	.502	55.4
44	49.3	.494	54.6
45	48.6	.485	53.8

Table 2. Net energy for lactation (NEL) and total digestible nutrients (TDN) of alfalfa estimated from its modified crude fiber (MCF) content.

(100% DM basis)		
MCF	TDN	NEL
(%)	(%)	(Mcal/lb)
16	67.4	.694
17	66.5	.685
18	65.7	.676
19	64.8	.666
20	64.0	.656
21	63.1	.647
22	62.2	.638
23	61.4	.628
24	60.5	.618
25	59.7	.609
26	58.8	.600
27	58.0	.590
28	57.1	.580
29	56.2	.571
30	55.4	.562
31	54.5	.552
32	53.7	.542
33	52.8	.533
34	52.0	.524
35	51.1	.514
36	50.3	.504
37	49.4	.495
38	48.5	.486

Table 3. Four year summary of short tons of alfalfa cubes and bales trucked into California, 1984-1988. California Federal-State Market News, 1988 Alfalfa Summary.

	1985			1986			1987			1988		
	Cubes	Hay	Total	Cubes	Hay	Total	Cubes	Hay	Total	Cubes	Hay	Total
Arizona	4,152	183,053	187,205	1,388	204,366	205,754	481	161,079	161,560	1,877	146,268	148,145
Colorado	1,366	2,992	4,358	3,754	3,850	4,604	3,798	1,690	5,488	3,604	498	4,102
Idaho	1,460	2,267	3,727	855	766	1,621	1,150	3,259	4,409	753	4,809	5,562
Montana	422	300	722	235	220	455	374	403	707	509	205	714
Nebraska	--	--	--	22	--	22	46	26	72	--	--	--
Nevada	119,265	287,135	406,391	61,309	212,337	273,646	34,532	233,751	268,283	32,509	257,243	289,752
New Mexico	--	--	--	113	24	137	--	--	--	--	--	--
North Dakota	121	100	221	81	24	105	68	72	140	68	26	94
Oregon	4,183	15,402	19,585	1,728	13,257	14,985	937	25,201	26,138	172	36,069	36,241
Texas	22	230	252	--	180	180	--	96	96	12	--	12
Utah	87,115	108,823	195,938	73,874	68,373	142,247	84,293	105,780	190,073	72,392	128,493	200,885
Washington	45	75	120	--	23	23	--	93	93	--	29	29
Wyoming	69	28	97	408	88	496	1,788		1,788	2,605	48	2,653
Canada	--	22	22		22	22	--			16	24	40
Total	218,140	600,458	818,598	143,767	503,540	647,307	127,467	531,472	658,939	114,597	573,735	688,332

Table 4. Sample variability of five factors of selected bales from 19 individually sampled, one-ton bales. All samples compared to their mean, standard deviation from the mean, 95% confidence level and values of one composite sample taken from the same 19 bales. Chino, California, September 9, 1983.

	Percent				
	MCF[1]	CP	Ca	P	TDN[1]
Bale number 1	20.7	22.3	1.45	0.22	57.0
5	26.0	18.6	1.42	0.20	52.9
10	19.0	24.6	1.20	0.25	58.3
15	16.6	26.5	1.34	0.27	60.2
18	28.6	15.7	1.66	0.16	50.9
19 bale average	23.71	20.12	1.46	0.20	54.72
Standard deviation	0.66	0.63	0.039	0.006	
95% confidence level ±	1.32	1.26	0.078	0.012	
Composite value	23.30	20.60	1.48	0.16	54.99

[1]Values at 90% dry matter. All others on a dry basis.

V. L. Marble and S. E. Bishop, 1983, unpublished.

Table 5. Effect of sample size on alfalfa hay sampling variation, expressed as the 95% confidence limits ± a 19 bale average value. Data from: Marble and Bishop, Chino, California, 1983 (unpublished), and Marble and Curley, U.C. Davis, 1961 (unpublished).

	Percent			
	Chino, 1983		Davis, 1961	
Sample Size	MCF[1]	CP	DM	MCF[1]
6 Bales	3.04	2.91	2.32	2.29
8	2.42	2.32	1.85	1.82
10	2.07	1.98	1.58	1.56
12	1.84	1.76	1.40	1.39
14	1.67	1.60	1.28	1.26
16	1.54	1.48	1.18	1.17
18	1.44	1.38	1.10	1.09
19	1.39	1.33	1.07	1.04
19 bale average	23.71	20.12	88.59	31.90

[1]MCF on a 90% dry basis. All others on a 100% dry basis.

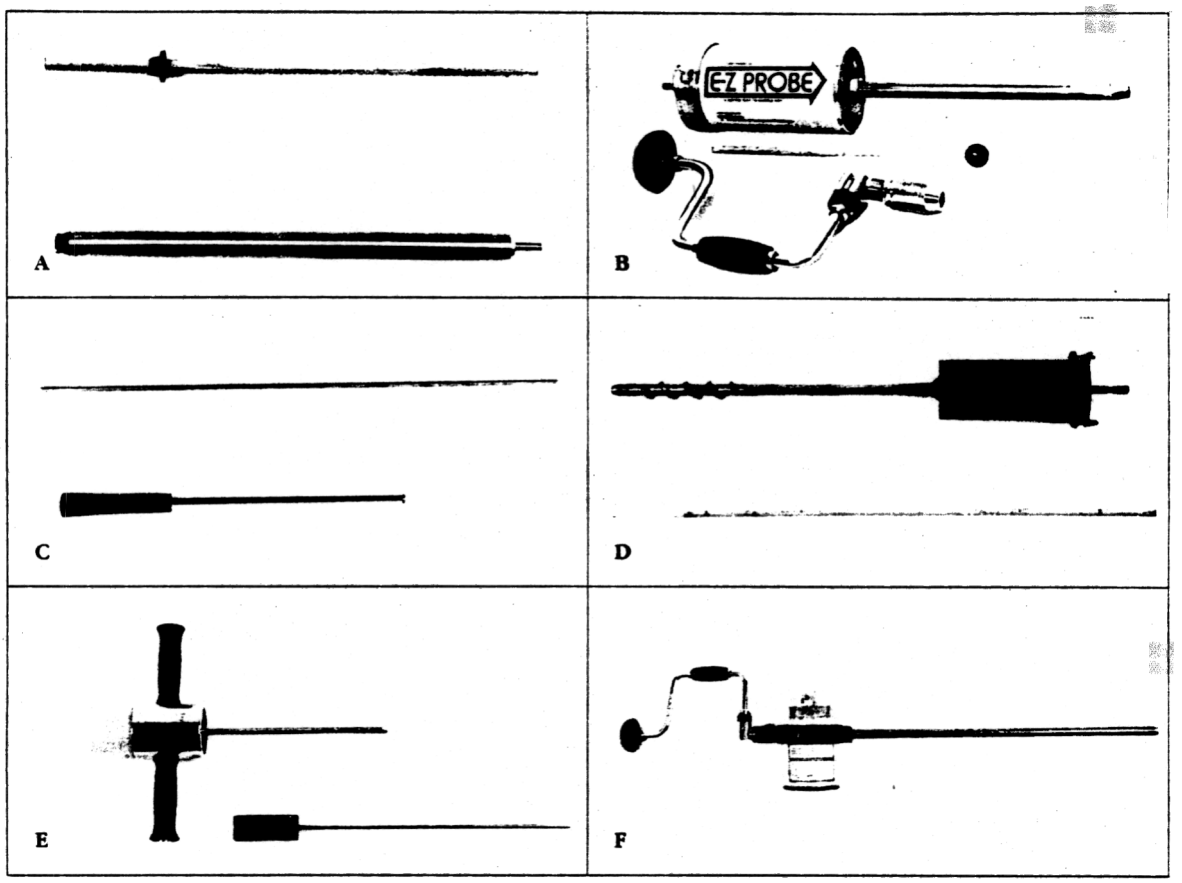

Figure 1. Representative coring devices for sampling alfalfa hay bales: **A**, Penn State forage sampler; **B**, Techni-Serv E-Z probe; **C**, sharpened golf club shaft; **D**, Utah hay sampler; E, Hay chec hay sampler; **F**, Forageurs hay sampler.

Table 6. Comparisons of three hay sampling tools with samples from 19 ground bales, to determine dry matter (DM) and modified crude fiber (MCF), dry basis.

Sampler	Percent		
	DM	MCF	Predicted TDN[1]
A. Ground bale	90.24 a	33.42 a	52.47 a
B. Penn State 3/4" x 11"	88.74 b	32.15 ab	53.58 ab
C. Golf club handle 11/32" x 13"	87.25 b	31.03 b	54.51 b
D. Probe 3/8" x 17"	88.12 b	31.02 b	54.52 b
	88.59	31.90	53.77
% CV	2.5	6.2	6.2
LSD .05	.44	1.28	
Standard deviation	2.21	1.96	

V. L. Marble and R. G. Curley, 1961, U.C. Davis, Unpublished

81.07 - 0.8558 MCF

Table 7. Comparisons of dry matter, modified crude fiber and total digestible nutrient content from samples taken with three types of sampling devices. Based on 8 samples, each from 19 bale composite samples. October 25, 1961.

Sampler	Percent		
	DM	MCF	Predicted TDN
Golf club, 3/8" diameter	93.11	23.20	53.11
Probe driven by electric drill, 3/8" diameter	92.29	23.39	52.95
Probe, hand driven, 3/4" diameter	92.29	23.59	52.75
Mean	92.56	23.39	52.94
LSD .05	0.54	ns	ns
.01	0.75	ns	ns
Standard deviation	0.50	0.86	0.76

E. C. Hoffman, J. C. Oliver, V. L. Marble and R. G. Curley, 1961, unpublished.

Table 8 Suggested laboratory form for reporting chemical and nutrient values of alfalfa.

Lab. number: _____

Date received: _____

Date sampled: _____

Number of bales sampled: _____

Name _____ Total bales or tons in lot

Address _____ Cutting number: _____

_____ Weight of original sample:

Laboratory Analyses	Dry Matter Basis		
	As received	90% DM	100% DM
Dry matter (DM), %	87.0	90.0	100.0
Acid detergent fiber (ADF), %	26.1	27.0	30.0
Modified crude fiber (CP), %	21.6	22.3	24.8
Crude protein (CP), %	17.4	18.0	20.0

Estimated Energy Values (Calculated from ADF or MCF):

Total digestible nutrients (TDN), %	52.1	53.9	59.8
Net energy for lactation (NEL), Mcal/lb	0.531	0.550	0.611
Digestible dry matter (DDM), %	57.0	59.0	65.5

Hay Quality Rating for This Sample:
(ADF and MCF values on a 100% DM basis)

			TDN %	
			90% DM	100% DM
Premium	(29% ADF or less) or	(24% MCF or less)	54 or more	61 or more
Good	(29.1 to 32% ADF) or	(24.1 to 27% MCF)	52-53	
Fair	(32.1 to 37% ADF) or	(27.1 to 31% MCF)	50-51	
Low	(more than 37% ADF) or	(more than 31% MCF)	49 or less	54 or less