INHERENT PRODUCT (BALE TO BALE) VARIATION AND COMPARISON OF DIFFERENT SAMPLING PROBES

by Don Waite[1]

After many years of observation and contact with a wide variety of people in the hay business, I have become convinced that very few people have any idea of the inherent variation present in baled hay. The following study from the University of Minnesota, done in the fall of 1989, shows that this variation can be 8.3 percentage points of ADF variation among 20 bales when the probe contents of each bale is analyzed individually. This variation was present even though the hay sampled came from a single lot as defined in their study.

Minnesota Trial

This example evaluates three methods of sampling this lot: 1) the analysis of one probe from one bale; 2) the analysis of a grab sample taken from the center of one flake of one bale; and 3) an analysis of the composite of 20 cores taken from the 20 bales of the lot. The average of all tests of each bale is the most accurate, but it is too laborious and expensive. However, the analysis of the composite sample was more accurate than the grab sample which was more accurate than a single core sample; unless you chose to test bale number 20, 10, 6, 4, or 3. Choosing bale number 2, 8, 9 or 17 would have produced results farthest away from the true value ±2, ±4, and ±10 percentage points for CP, ADF and NDF, respectively or ±40 index points for RFV. Choosing the correct bale is a gamble; however, testing the cores from 20 bales selected at random from a hay lot provides the best method of repeating a 'true value'. The composite sample was mixed well because the two tests from the composite sample were very similar (Table 1)—within 0.7 of a percentage point for CP, ADF, and NDF.

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[1]Petaluma Hay Analysis Company

Table 1.	Quality tests of single bales (probe from "butt" end) and tests of composite of all bales of alfalfa hay.[1]							
Bale no.	Sample wt., g	DM	CP	ADF	NDF	RFV index	Ca	P
		- - - - - - - % of dry weight - - - - - -				index	- - % of d. wt. - -	
1	13.6	85.6	20.3	36.9	54.1	103	1.45	.29
2	9.8	86.7	18.4	35.8	48.7	117	1.02	.30
3	11.9	86.9	20.5	32.5	39.1	151	1.49	.27
4	11.2	87.4	20.5	32.0	30.2	152	1.42	.28
5	11.9	85.2	21.9	32.1	40.3	148	1.41	.29
6	11.1	88.0	20.3	31.5	38.5	156	1.47	.26
7	9.5	88.4	19.8	31.4	38.3	156	1.40	.27
8	10.2	86.6	18.4	36.1	44.3	128	1.42	.28
9	11.8	87.8	22.4	29.4	37.0	166	1.49	.27
10	10.7	85.9	20.3	32.7	40.0	148	1.61	.26
11	11.4	87.3	18.9	32.5	39.0	152	1.69	.23
12	11.2	86.4	20.8	31.5	41.2	145	1.42	.27
13	9.3	87.9	18.2	35.3	44.6	128	1.39	.26
14	11.2	87.1	19.8	32.7	41.5	142	1.48	.25
15	12.1	86.2	20.8	33.4	42.0	139	1.42	.29
16	10.3	84.7	21.3	31.4	38.5	156	1.44	.28
17	11.4	89.9	21.5	28.6	33.7	184	1.67	.26
18	12.3	86.8	21.4	29.3	33.9	181	1.72	.25
19	10.6	88.0	21.2	30.3	35.7	170	1.70	.25
20	10.0	85.5	20.4	32.1	40.6	146	1.65	.24
Min.	9.3	84.7	18.2	28.6	33.7	103	1.02	.23
Max.	13.6	89.9	22.4	36.9	54.1	184	1.72	.30
Avg.	11.0	86.9	20.4	32.4	40.5	148	1.49	.27
[2]Composite	___	88.1	20.7	31.5	40.7	147	1.48	.27
[2]Composite	___	88.0	20.3	31.7	41.0	146	1.47	.27
Grab	___	87.0	20.1	33.0	42.9	137	1.49	.26

[1]Forageurs probe used in this study.
[2]Composite sample of twenty bales replicated twice (repeatability of a test).
Taken from Minnesota Forage UPDATE Vol. XIV No. 4, Late Summer, 1989.

Steve Orloff, Siskiyou County Farm Advisor, conducted another hay analysis study which examined the role the hay probe played in sample variation. Steve took the field samples and I ran the ADF analyses on 4 different lots of alfalfa in the Inter-Mountain region taken with 4 different sampling probes. Steve compiled the results and wrote the following paper describing the outcome of this trial.

Sampling Alfalfa Hay for Quality Analysis

Dairy producers recognize the importance of high quality hay and its effect on animal performance and milk production. Much of the alfalfa hay produced in the

Intermountain region of Northern California undergoes laboratory analysis to estimate its nutritional quality prior to being sold. The values obtained from the laboratory analysis are often used to set the price of the alfalfa. The price differential between "dairy test" hay and "non-test" hay is usually significant. Therefore, the values obtained from quality analyses are extremely important to both the dairyman and the hay producer. Because of the significance of these values, it is important that the results of the laboratory analysis adequately reflect the true nutritional value of the entire lot of alfalfa to be sold.

A number of different types of hay probes are used commercially to sample alfalfa hay. It has been suspected that the type of sampling probe used influenced the results. Hay sampled with some probe types tested significantly higher than other probes. A trial was conducted to determine if this suspicion was correct. Four different hay probe types were selected: the Penn State forage sampler operated with an electric drill, a probe constructed out of a sharpened golf club shaft, an auger type probe operated with an electric drill, and a Utah hay sampler operated with a hand brace. Alfalfa hay was sampled from four ranches in different locations within the Intermountain region. Twenty bales were sampled from an individual lot of hay at each location. Each bale was cored once with all four probe types. The alfalfa was analyzed to determine acid detergent fiber (ADF) content using "wet chemistry" methods. The percent total digestible nutrients (TDN) was estimated using standard equations. Each sample was split in the laboratory for duplicate analysis so the values presented in the table are an average of two analyses.

Samples taken with the auger type of probe had consistently higher TDN values (approximately three percentage units higher at all locations) than the other three probes. Apparently this probe selectively sampled the leaves. Previous studies have indicated that sampling devices that result in a significant amount of fines provide erroneously high TDN readings. There was no significant difference between the three other probes (Penn State, golf club, and Utah probes). Previous tests conducted in California and Minnesota also showed no significant difference between probes of this type.

There were large differences in the amount of forage obtained with 20 cores using these four different probes. The Penn State forage sampler had approximately three times as much material as any of the other probes. The problem with this type of sampler is that with such a large sample size, it discourages the operator from sampling an adequate number of bales.

Probe	% TDN					Sample Weight (g)
	Quail Valley	Macdoel	Dorris	Red Rock	Average	
Penn State	50.0	52.1	52.8	54.6	52.4	327.9
Golf Club	50.8	52.4	53.4	54.4	52.8	87.0
Auger	53.1	55.8	56.0	57.4	55.6	56.6
Utah State	50.6	52.8	53.6	54.4	52.8	109.2
LSD 0.05					0.5	19.6

Sampling is clearly the primary factor affecting the accuracy of alfalfa quality analysis. The sample needs to adequately reflect the quality of an entire lot of hay. Sources of sample variation include differences due to sampling method, sampling equipment, sample handling, and the natural variation in hay that occurs within an individual bale and within a lot of hay. The following sampling guidelines are proposed to help obtain a representative sample and to help minimize some of the variation that can occur.

A sample should represent a single lot of hay. A *lot* consists of hay from the same cutting; variety; field; stage of maturity; and harvested within a 48-hour period. A *lot* should not exceed 200 tons of alfalfa.

Bales should be sampled at random. This can be accomplished by walking around the entire stack and sampling bales at various heights.

A minimum of 20 cores, one core per bale, should be taken per lot of hay. The core samples should be combined into a single sample.

The coring device must be a sampling tube or probe and not an auger. The inside diameter of the cutting edge must be no less than 3/8 inch and no more than 3/4 inch. The cutting edge must be kept sharp. The cutting edge should be flat and not angled. Golf club or golf club type samplers are acceptable and convenient, as they do not require a drill or a generator and sample size is adequate without providing a sample that is so large that it discourages sampling of at least 20 bales.

Bales should be probed near the center at one end and at least 12 inches into the bale. The probe should enter at a right angle to the surface of the end of the bale, not slanting up, down, or sideways.

The sample should be stored in a polyethylene freezer bag and sealed so that dry matter "as received" can be determined.

The sample should weigh approximately 1/2 pound.

When growers want to send samples to different laboratories for duplicate analysis, samples should never be divided prior to grinding. Fine leaves and stem parts sift to the bottom and it is not possible to accurately divide the sample without grinding first.

Quality analysis is a tool for estimating the nutritional quality of alfalfa hay and assessing its value. However, we need to be reminded that the accuracy of forage quality testing is plus or minus one full percentage point. The accuracy is even less if the above mentioned guidelines are not followed. Therefore, while quality analysis is useful and necessary, growers, brokers, and dairymen need to recognize the limitations of forage analysis and that proper sampling procedures are essential for reliable results.

Petaluma Hay Analysis Year End Sampling Summary

At the end of every season I have been compiling a summary of "average" quality from three different regions: Valley, Inter-Mountain, and Nevada. The last table in this section shows those values for this year; but because of "deadline" requirements, October 4th was the last date that samples could be included. The summary includes a total of 1126 samples that could be identified as to region and cutting of origin. It is important to realize that these are not "random" samples, but in many cases, are lots that are visually screened and in many cases thought to be lots that might "test high". It should be obvious that "random" samples would produce overall lower averages of quality.

SUMMARY OF THE ANALYTICAL RESULTS OF ALFALFA HAY SAMPLES
SUBMITTED TO THE PETALUMA HAY ANALYSIS SERVICE

1993 SEASON up to Oct. 4)

ADF (Acid Detergent Fiber) values are on a 100% Dry Matter basis.
Energy and TDN values are converted to a 90% DM basis.

--VALLEY REGIONS--

Cut-ting	No. of Samples	Avg.% D.M.	Dry Mat. Std.Dev.	Avg.% ADF	ADF Std.Dev.	Avg.NEL Mcal/lb.	Avg.% TDN
	134	84.7	2.07	30.6	2.58	.545	53.5
	84	86.0	1.99	30.0	3.76	.550	53.9
	145	87.2	1.53	30.5	2.12	.546	53.5
	85	86.7	1.39	30.5	2.21	.546	53.5
	74	86.2	1.41	29.4	2.17	.554	54.3
	41	86.0	1.17	28.6	1.86	.560	54.8

--INTER-MOUNTAIN--

Cut-ting	No. of Samples	Avg.% D.M.	Dry Mat. Std.Dev.	Avg.% ADF	ADF Std.Dev.	Avg. NEL Mcal/lb.	Avg.% TDN
1st	242	87.3	2.60	29.1	2.64	.556	54.5
	94	87.3	2.27	30.5	2.55	.546	53.6
3rd	90	86.0	2.03	28.0	2.23	.565	55.2

--NEVADA--

Cut-ting	No. of Samples	Avg.% D.M.	Dry Mat. Std.Dev.	Avg.% ADF	ADF Std.Dev.	Avg. NEL Mcal/lb.	Avg.% TDN
1st	89	89.1	2.68	28.9	2.64	.558	54.6
	17	88.4	1.77	30.2	1.91	.548	53.7
	31	87.8	1.59	28.4	1.90	.562	54.9