Forage Analysis as Influenced by Sampling Position and Processing[1]

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Highlight

Collecting a representative sample of conserved forage is necessary if such practices as forage testing are to be meaningful. When uniform samples of Coastal bermudagrass and alfalfa were systematically sampled in nine different ways, the coefficient of variation for crude fiber and protein averaged approximately 5%. Sampling procedures satisfactory for one species may well be unsatisfactory for another.

Chemical analysis has been the time-honored method of evaluating feedstuffs and forage evaluation has attracted much research attention in recent years attesting to the popular interest and economic importance of forage-based enterprises. A large number (Anonymous, 1963) of state forage-testing programs are based primarily on crude protein and crude fiber analyses. These activities have as an objective, establishing the nutritive value of a forage so that supplemental feeding may be designed to complement the forage fed.

Attempts to establish forage "quality" have often ended in frustration or in technical procedures that met with less than complete acceptance (Sullivan, 1962; Van Soest, 1965). Problems associated with forage quality measurements are diverse and include: (a) errors in sampling due to lack of homogeneity in the sampled forage, (b) significant interactions for species x sampling meth-

od making standards for one species inappropriate for another species, (c) analytical variation due to the variable nature of carbohydrates and particularly the fiber fraction, (d) changes due to processing, and (e) within and among laboratory analytical variations. Several experiments have shown that grinding and pelleting a forage results in an apparent reduction in crude fiber (Brooks et al., 1962; Haught et al., 1960; King et al., 1963).

The research reported here was conducted to establish the effects of sampling location within bales and sampling at various points in the grinding and pelleting operation on the fiber, protein, ash, and ether extract (crude fat) content of Coastal bermudagrass (*Cynodon dactylon*, Poir) and alfalfa (*Medicago sativa*, L.). A part of this objective was to determine the size of the sampling error which is obtained under forage testing conditions for the different components at a given sampling location for each of the species. Another objective was to determine whether grinding or grinding and pelleting affected the chemical compositions of the forages.

Table 1. Treatment means as % of dry matter for sampling coastal bermudagrass.

Sampling position	Crude fiber	Crude protein	Ash	Ether extract
Bale End				
1. Center	33.7	8.1	5.1	1.6
2. Edge between ties	34.1	7.9	5.1	1.9
3. Sheared Corner	32.6	8.1	5.0	1.5
4. Pressed Corner	32.7	8.7	5.1	1.9
Bale Sides				
5. Flat-side between ties	32.9	8.0	5.1	1.5
6. Sheared Edge	32.3	8.0	5.0	1.6
Processed				
7. Ground	32.3	7.5	4.9	1.5
8. Mixed	32.2	8.1	5.0	1.6
9. Pelleted	31.2	7.9	4.9	1.3
Average	32.7[b]	8.0	5.0	1.6[a]
C.V. (%)	2.8	4.7	2.0	9.7
Standard Deviation[c]	0.7	0.3	0.1	0.1

[a] Significant at 0.05 probability level.
[b] Significant at 0.10 probability level.
[c] Within treatment standard deviation.

Procedure

Thirty bales of Coastal bermudagrass from the Southeast Georgia Branch Station, Midville and 30 bales of alfalfa from the College Station, Athens, were used as test material. The bermudagrass was from a lot of hay that had been fertilized with 500 lb/acre of 0-10-20 in April and 75 lb of N on May 10. It was mowed on June 16, baled on June 17, and stored until December 5. The alfalfa had been fertilized with 1000 lb/acre of 0-10-20 in March, mowed and conditioned on May 5, baled May 7, and stored.

The bermudagrass and alfalfa were allotted to three replications of 10 bales each. The ten bales were sampled individually at six points with a Pennsylvania State forage sampler having a new cutting head. Four sample locations were from the end of a bale and 16 inches deep: (1) in the center, (2) on the side of the bale and between the ties, (3) on the sheared edge outside the tie, and (4) on the pressed edge outside the tie. They were also sampled (5) from the flat side of the bale between the ties near the center and approximately 30° from the perpendicular and (6) from the sheared edge of the bale toward the pressed edge and 30° from the perpendicular.

The bales were then run through a hammer mill with 5/16-inch screen and further sampled as follows: (7) from base of the collector, (8) between the conditioning chamber and pellet mill, and (9) after pelleting.

Positions 7, 8, and 9 were sampled by "grabbing" 20 to 25 samples per replication. Samples from all sampling locations were composited by species and sample location within replications. The composited samples were ground through a Wiley mill and analyzed for crude fiber, crude protein, ether extract and ash[2]. To make the results comparable with those from forage testing programs, a single chemical analysis was made of each sample.

Results and Discussion

Coastal bermudagrass sampling positions 1 and 2 had the highest fiber content (33.7% and 34.1%) and the pelleted forage had the lowest (31.2%). The spread between the highest and lowest fiber was 2.9%, or approximately 10% of the mean. Other positions showed less than 1% variation from the mean and ranged between 32.2% and 32.9%. There was a difference in replications which was found in randomly selected 10 bale samples from an apparently uniform lot of grass. This effect may have been due to chance or to some biological effect for which an explanation is not readily apparent. Combining replication and error sums of squares produced a coefficient of variation (C.V.) of 5.3%. The C.V. for fiber due to sampling positions and with replication effects removed was 2.8%. Under field conditions, an average variation of 5% of the mean in fiber would appear to be the expected range of error on single samples from specified locations within a bale. With random samplings errors might be either smaller or larger but probably would average about 5% of the mean or about 1.5% of crude fiber in samples containing 30% fiber. Differences in fiber between sampling positions was significant at approximately the 8% level of probability (Table 1).

Protein content for different locations for Coastal bermudagrass was not significantly different and the 4.7% C.V. indicates that protein was not uniformly distributed and/or consistently stratified throughout the bale. The variation by sampling position ranged from 7.5% on position 7 to 8.7% on position 4. The C.V. within sampling position for protein was 4.6% and shows that for a specific element such as N, sampling errors

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Table 2. Treatment means as % of dry matter for sampling alfalfa.

Sampling position	Crude fiber	Crude protein	Ash	Ether extract
Bale End				
1. Center	28.7	16.4	7.6	2.0
2. Edge between ties	31.5	16.4	7.7	2.1
3. Sheared Corner	29.9	16.1	7.4	2.0
4. Pressed Corner	31.9	16.3	7.9	2.0
Bale Sides				
5. Flat-side between ties	31.6	16.2	7.5	2.0
6. Sheared Edge	30.4	17.4	7.8	2.0
Processed				
7. Ground	35.2	15.4	7.0	2.0
8. Mixed	33.5	16.0	7.7	2.1
9. Pelleted	32.4	16.1	7.6	2.1
Average	31.7[b]	16.2	7.6	2.0[a]
C.V. (%)	6.0	3.0	3.6	2.3
Standard deviation[c]	1.9	0.5	0.3	0.05

[a] Significant at 0.05 probability level.
[b] Significant at 0.10 probability level.
[c] Within treatment standard deviation.

as large as 5% of the mean can be expected and that the sampling treatments studied were not effective in reducing the variation.

In Coastal bermudagrass, ether extract showed a C.V. of 9.7% and a significant difference between sampling positions. However, ether extract is a very minor component of the grass and thus the variation is quite small as a percentage of the dry matter. Positions 2 and 4 were highest in ether extract and suggests that plant parts high in this component were stratified in the bale. Position 2 was also highest in protein. The high C.V. suggests that no sampling position was especially efficient in measuring ether extract. Nutritionally, ether extract content in forages is of little importance and in forage evaluation can be largely ignored.

Differences in Coastal bermudagrass ash due to sampling were not significant and the C.V. was 2.0%. Apparently ash is the factor most uniformly distributed throughout Coastal bermudagrass and ether extract is the most variable. However, both are generally of minor significance in forage evaluation. Variations in fiber appeared to be more consistent by positions within the bale and protein variability was much more random. The data suggest that when a given lot of Coastal is systematically sampled and analyzed for fiber and protein, errors are likely to average approximately 5% of the mean. However, when random hay samples are collected and single determinations made, errors should be higher.

Variation within alfalfa samples for fiber was approximately three times as high as for Coastal bermudagrass. Fiber varied from 28.7% at position 1 to 35.3% for position 7. This is a difference of 6.60 percentage points or 20% of the mean. It is obvious from the results that "grabbing" (position 7) samples of ground alfalfa collects more stems than leaves. This did not appear to be as serious a problem with the Coastal bermudagrass. Why position 1 should be 1.2% lower in crude fiber than the next value (position 3) and 3.0% lower than the average is not understood (Table 2).

The pelleted alfalfa had 32.4% fiber and ranked 3rd from the highest. It appears that pelleting alfalfa had no influence on fiber content. This is in contrast to previous work and may be associated with pelleting conditions such as temperature, etc. It is interesting that Haenlein and Holden (1965) concluded that variations within sample position was due to sampling error.

The C.V. for alfalfa fiber was 6.5% and when combined with the widely divergent position effect raises a question as to the reliability of normal sampling techniques. When sampling errors are combined with analytical and random errors which may be expected under field conditions, considerable variation should be expected.

Crude fiber is a variety of compounds and varies both qualitatively and quantitatively with forage age (Miller et al., 1963) and between species (Sullivan, 1964). More analytical variation is normally obtained in the empirical crude fiber determinations than is experienced when a definite material such as N (crude protein) is being measured.

Protein content of alfalfa as influenced by position of sampling varied a total of 2.0 percentage points. The low value of 15.4% was on position 7 and was probably low due to stems staying in the container while leaves were lighter and flowed around. The same sampling position also had the lowest level of crude protein in the Coastal bermudagrass.

Sampling alfalfa from the cut edge of the bale (position 6) increased the protein 1.2% above the average. The C.V. for protein was 3.0% and it appears that positions 1, 2, 3, 4, 5, and 9 would be closest to the average.

Ash followed a trend similar to protein and no differences were evident. The C.V. for ash was 3.6% and shows the variation that can be expected in a single lot of similarly treated alfalfa.

The position by species interaction for fiber was highly significant indicating that a sampling procedure satisfactory for one species may not be valid for another. The species difference obtained here is not surprising as Sullivan (1962) has noted that for a number of chemical measurements species differences were very wide.

Summary

Uniform lots of Coastal bermudagrass and alfalfa were divided into three replications of 10 bales each and systematically sampled by bales in six different locations. Three additional samples were collected at various stages of grinding and pelleting. Samples were composited within replications and analyzed for ash, crude protein, ether extract and fiber. Data collected show that differences in ether extract and fiber can be expected within the same lot of Coastal bermudagrass depending upon where the sample is collected. In addition, variations of 5% of the mean in fiber content should be expected when single composite sam-

ples from 10 bales of Coastal are analyzed. Ether extract showed considerable error between samples and a C.V. of 9.7%. Since the amount of ether extract is quite small this large percentage error is not of great importance. Protein was not uniformly or consistently distributed through a bale of Coastal and the within treatment coefficient of variation was 4.7%.

Fiber in alfalfa was more variable both within and among treatments than in Coastal bermudagrass and ranged from 28.6 to 35.2%, a difference of 20% of the mean, at different positions sampled. The within treatment C.V.'s of alfalfa and Coastal were 6.0 and 2.8%. Differences due to sampling positions in alfalfa for protein and ether extract were significant. The "grab samples" of ground alfalfa contained the highest level of fiber and may be the least desirable sampling method.

Pelleted Coastal bermudagrass had the lowest average fiber content of any position sampled. The fiber level of the pelleted alfalfa was above the mean of all samples. The sampling position by species interaction for fiber was highly significant indicating that a sampling procedure valid for one species may not be as reliable for another.

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