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Relating quality changes to storage time for baled alfalfa

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Abstract

The relationships between storage time and several chemical indices for forage quality were established for alfalfa hay baled at two moisture levels (29.9 and 19.7%) in conventional and laboratory bale s made at 1.0, 1.5, and 2.0 times the density o f parent, conventional bales. Bales were sampled after 0, 4, 11, 22, and 60 days. For the high-moisture bales, most quality indices indicated substantial nutrient loss early in the storage period, particularly between days 4 and 11, with little change after 22 days. A nonlinear mathematical model was constructed to describe how neutral detergent fiber and several other quality indices changed with storage time. Acid detergent fiber was related poorly to storage time. Little change occurred in the low (19.7%) moisture bales.

Keywords

Cattlemen's Day, 1995; Kansas Agricultural Experiment Station contribution; no. 95-357-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 727; Beef; Alfalfa; Bale density; Hay; Laboratory bales; Storage

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RELATING QUALITY CHANGES TO STORAGE TIME FOR BALED ALFALFA [1]

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Summary

The relationships between storage time and several chemical indices for forage quality were established for alfalfa hay baled at two moisture levels (29.9 and 19.7%) in conventional and laboratory bales made at 1.0, 1.5, and 2.0 times the density of parent, conventional bales. Bales were sampled after 0, 4, 11, 22, and 60 days. For the high-moisture bales, most quality indices indicated substantial nutrient loss early in the storage period, particularly between days 4 and 11, with little change after 22 days. A nonlinear mathematical model was constructed to describe how neutral detergent fiber and several other quality indices changed with storage time. Acid detergent fiber was related poorly to storage time. Little change occurred in the low (19.7%) moisture bales.

(Key Words: Alfalfa, Bale Density, Hay, Laboratory Bales, Storage.)

Introduction

Hay quality degrades during storage when moisture levels at baling exceed about 20.0 percent. These changes, facilitated by microbial activity and the subsequent heat generation, include oxidation of carbohydrates, dry matter (DM) loss, mold growth, and increased concentrations of fiber components and artifact (unavailable) nitrogen. These changes decrease the relative feed value and decrease animal performance.

Previous research designed to study changes in forage quality during bale storage has relied on sampling at a single time, normally after microbial activity has ceased. By that time, internal bale temperature has returned to near ambient, following an initial rise. The quality changes that occur early in storage, i.e., when bales are actively generating heat, has largely been ignored. Such information is important to the mechanisms that cause deterioration in hay quality.

Our objective was to establish how quality of alfalfa hay in laboratory-scale and conventional bales changed during storage.

Experimental Procedures

A 3-year-old stand of `Kansas Common' alfalfa was harvested (fourth cutting) at 10% bloom with a mower-conditioner on September 9, 1992 near Keats, Kansas. The forage was allowed to dry undisturbed, until the desired high- and low-moisture levels were reached on September 11. Actual moisture levels averaged out to 29.9 and 19.7%. Densities of conventional bales were 19.4 and 11.7 lb/ft^3 (as-is basis) for the high- and low-moisture alfalfa, respectively. Laboratory-scale bales were subsequently made from the same alfalfa at 1.0, 1.5, and 2.0 times the density of the conventional bales using a method described previously (KAES Report of Progress 678, page 31). Specific bale characteristics for each treatment appear in Table 1. All bales were stored in small haystacks.

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Hay was sampled prebaling and at 4, 11, 22, and 60 days postbaling. Sampling dates were chosen prior the study to approximately coincide with specific points on typical temperature vs. time curves for alfalfa hay during storage. These curves are characterized by two prominent temperature maxima. The first is short duration (1 to 4 days) and occurs immediately after baling. The second maximum is normally a broad peak or group of peaks, which occurs after the internal bale temperatures has decreased after the first maximum (i.e., about 5 to 20 days post-baling). Bales were sampled on day 4 to separate effects of the first and second temperature maxima. Additional sampling at 11 and 22 days was targeted at the second temperature maximum. By day 60, we considered nutritional quality to be stable.

Samples were analyzed for nitrogen (N), NDF, ADF, and acid detergent insoluble N (ADIN). Acid detergent-insoluble N concentrations were calculated and reported based on a total DM (ADIN-DM), total N (ADIN-N), and total ADF (N-ADF).

Results and Discussion

Each of these quality indices was regressed against storage time within each moisture level. Various linear and nonlinear models were used to determine the best relationship. For all indices, quality changes over time were best fit by the nonlinear function;

$$Y = A - Be^{-kt^2}$$

where $\boldsymbol{A}$ = asymptotic maximum of the response variable, $\boldsymbol{B}$ and $\boldsymbol{k}$ are constants computed by fitting the model, and $\boldsymbol{t}$ = time (days). Comparisons of prestorage alfalfa quality traits at both moisture levels indicated no significant differences between bale types within a given moisture level (Table 2). This establishes that the laboratory-scale baling process did not affect forage quality, and all treatments of the same moisture content had a common starting point before entering storage.

During the storage period, low-moisture (19.7%) bales exhibited relatively minor changes in alfalfa quality indices (data not shown). This was expected, because 20% moisture has been suggested as the threshold for negative quality changes during storage. At the high (29.9%) moisture level (Table 3), quality changes for all baling treatments were much more pronounced.

All high-moisture treatments exhibited significant increases in NDF during storage, but none of these increases occurred between 22 and 60 days, suggesting that the changes occurred within the first month of storage. NDF increases ranged from 3.4 to 4.8 percentage units in the high-moisture bales over the first 4 days of storage, suggesting that they might be associated with the first temperature maximum.

Increases in ADF with time were less dramatic than those in NDF. Among high moisture treatments, only conventional and laboratory-scale bales (density factor = 2.0) exhibited statistically significant ADF increases.

Acid detergent insoluble N responses were relatively consistent across the three methods of expressing artifact N. Particularly large ADIN increases occurred between 4 and 11 days of storage, a window of time when all bales were intensely generating heat. Artifact N levels usually changed little from 22 to 60 days. This suggests that degradation of nitrogen availability is essentially complete within the first month of storage.

It is unclear why NDF values increased with storage so much more than ADF. However, changes in both are thought to be due to losses of soluble or nonstructural components and not to changes in fiber components themselves.

Table 1. Description of Baling Treatments for High- and Low-Moisture Alfalfa Preserved in Laboratory-Scale (LAB) and Conventional (CONV) Bales

Moisture, %	Bale Type	Density Factor[a]	Bale Volume[b], ft^3	Fresh bale Weight[c], lb	Estimated Density, lb/ft^3
29.7	CONV	—	5.22	101.4	19.4
30.1	LAB	1.0	.0526	1.02	19.4
	LAB	1.5		1.53	29.1
	LAB	2.0		2.04	38.8
20.2	CONV	—	5.22	60.8	11.7
19.1	LAB	1.0	.0526	0.61	11.6
	LAB	1.5		0.92	17.5
	LAB	2.0		1.22	23.2

[a]Theoretical quotient of laboratory-scale bale density divided by conventional bale density.
[b]Laboratory-scale volume based on a predetermined average of .0526 ft^3.
[c]Excludes bale-wire weights for all laboratory-scale baling treatments.

Table 2. Comparison of Prestorage Alfalfa Quality Traits for Conventional (CONV) and Laboratory-Scale (LAB) Alfalfa Hay Baled at Two Moisture Levels

Bale Type	DM, %	ADIN-N, % of N	ADIN-DM %	N-ADF, % of ADF	NDF, %	ADF, %
High moisture						
CONV	70.3	3.12	.117	.419	32.6	27.8
LAB	69.9	3.10	.115	.403	34.2	28.5
Low moisture						
CONV	79.8	3.06	.109	.384	34.6	28.3
LAB	80.9	3.25	.113	.376	36.5	29.9
SE[1]	0.9	0.08	.005	.016	.6	.7

[1]Standard error of moisture × bale type interaction means.

Table 3. Mean Comparisons for Quality Responses over Time in Conventional (CONV) and Laboratory-Scale (LAB) High-Moisture Alfalfa Hay Bales

Bale Type	Density Factor[1]	Time, Days	NDF, %	ADF, %	ADIN-DM, %	ADIN-N, % of N	N-ADF, % of ADF
CONV	—	4	37.4	30.4	.125	3.32	.413
		11	44.5	32.2	.206	5.36	.635
		22	47.0	33.3	.225	5.60	.675
		60	48.4	35.6	.238	6.50	.666
LAB	1.0	4	37.6	27.9	.124	3.28	.444
		11	45.4	31.0	.167	4.43	.539
		22	44.0	29.2	.164	4.00	.560
		60	44.4	30.3	.171	4.75	.564
LAB	1.5	4	38.1	30.1	.136	3.56	.451
		11	44.6	31.4	.171	4.65	.545
		22	50.2	33.3	.203	5.49	.609
		60	47.3	32.3	.197	5.53	.610
LAB	2.0	4	38.6	29.0	.135	3.54	.468
		11	43.9	30.7	.185	4.97	.604
		22	47.8	32.4	.211	5.58	.652
		60	48.6	32.5	.217	6.07	.666
LSD[2]			3.6	3.3	.023	.61	.047

[1]Theoretical quotient of laboratory-scale bale density divided by conventional bale density.
[2]LSD ($P<.05$) for comparison of any two means, regardless of bale type or storage time.