1980

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L.D. Kamastra

P.K. Turnquist

C.K. Krueger

C.E. Johnson

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Agricultural Experiment Station • South Dakota State University • Brookings, South Dakota 57007

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L.D. Kamstra, P.K. Turnquist, C.R. Krueger, C.E. Johnson, E.A. Dowding and **T.S. Chisholm**

Summary

During a 3-year period, 12 large hay packages (six alfalfa, six prairie hay) were made using either the Haybuster or Hesston process and stored from 8 to 29 months. Stacks were core sampled at periodic intervals for physical (moisture, density) and quality parameters (crude protein, neutral-detergent fiber, Crampton and Maynard cellulose, acid-detergent fiber, acid-detergent lignin, ash and *in vitro* dry matter digestibility). The hay package storage areas were located in north-central South Dakota.

Mean density for alfalfa hay packages varied from 75.2 to 96.7 kg/m^3 depending on process and storage time. Mean density for prairie hay packages varied from 34.0 to 44.5 kg/m^3. Dry matter losses averaged 0.52 and 0.63% per month for the alfalfa and prairie hay packages, respectively.

Most stacks lost moisture with storage time. Although significant changes in quality parameters occurred with storage time, the retention of quality was very good. The small decrease in dry matter digestibility was not considered to be of practical importance.

Large hay packaging systems were developed to provide a method of storing hay with minimum labor, low field losses, convenience, maximum speed of operation, and flexibility of forage utilization in farm feeding operations. Some of the time tested principles of good haymaking (such as low moisture content and maximum compaction) may have to be compromised to achieve all these objectives. For example, if hay is to be harvested and stored with little field curing, initial moisture levels could exceed 30%.

How important are these compromises at feeding time? How well do large hay packages retain initial forage quality during field storage? What changes take place in physical parameters?

Kamstra: Animal Science Department, SDSU, Brookings, SD; Turnquist: Agricultural Engineering Department, Auburn University, Auburn, AL; Krueger: Ohio Agricultural Research and Development Center, Wooster, OH; Johnson: Agricultural Engineering Department, Auburn University, Auburn, AL; Dowding: Agricultural Engineering Department, University of Idaho, Moscow, ID; Chisholm: Agricultural Engineering Department, SDSU, Brookings, SD.

Alfalfa and prairie hay, selected because they dominate hay production in the Northern Plains, were measured in large packages for crude protein, neutral-detergent fiber, cellulose, acid-detergent fiber, acid-detergent lignin, ash, and *in vitro* dry matter digestibility. Physical parameters measured were package density and moisture.

When the project began, machines producing two main types of big hay packages were in use: the round package and the rectangular package machines. Machine principles for forming the two geometrical shapes are different, and the Haybuster process (round) and the Hesston process (rectangular) were chosen.

Comparisons between machine types and between some types of conventional practice were ruled out because of the extremely large amount of land (up to 36 hectares) required to produce one package. Resources of this magnitude were not available for this study.

Experimental Procedure

Harvest and Storage

In 1973, three stacks of alfalfa (*Medicago sativa* L.) were made with a Haybuster 1800 at the Pasture Research Center, Norbeck, South Dakota, and field stored for 29 months. At the same time, three Hesston 30 alfalfa packages were made at the M. Richards farm near Ipswich, South Dakota, and field stored for 23 months. In 1974, three Haybuster 1600 prairie hay packages were made at Orient, South Dakota, and field stored for 22 months. In 1975, three additional Haybuster 1600 prairie hay packages were formed near Orient, South Dakota, and field stored for 8 months.

The composition of all prairie hay stacks was predominantly little bluestem (*Andropogon scoparius* Michx.) and green needlegrass (*Stipa viridula* Trin.)

A summary of package identifications, sampling dates, and storage times is given in Table 1. The storage areas were located in north-central South Dakota with the Ipswich and Orient areas being approximately 24 kilometers north and south, respectively, of the Pasture Research Center at Norbeck.

Initial weight, moisture content, and density (dry basis) of the packages are given in Table 2.

Long-term annual precipitation in the area averages 432 mm, with temperatures during the growing season averaging 29° C. Below average rainfall fell during the storage period (1972-76). A record of temperature and rainfall is shown in Table 3.

Table 1. Hay package identifications, sampling dates, and storage times.

Package	Location	Package type	Sampling date	Field storage time, months§
		Alfalfa hay		
1,2,& 3	Norbeck	Haybuster 1800	6-13-73†	0.0
			7-12-73	1.0
			10-19-73	4.2
			4-26-74	10.4
			11-18-74	17.2
			5-13-75	23.0
			11-11-75‡	29.0
4,5,& 6	Ipswich	Hesston 30	6-13-73†	0.0
			7-12-73	1.0
			10-19-73	4.2
			4-26-74	10.4
			11-18-74	17.2
			5-13-75	23.0
		Prairie hay		
7,8,& 9	Orient	Haybuster 1600	7-30-74†	0.0
			11-18-74	3.7
			5-13-75	9.6
			11-10-75	15.6
			4-28-76	20.9
			5-18-76‡	21.6
10,11, & 12	Orient	Haybuster 1600	8-22-75†	0.0
			11-10-75	2.7
			4-28-76	7.9

† Date packages were formed and initially sampled
‡ All packages were weighed in the field for determining dry matter loss
§ All packages were stored uncovered outside

Table 2. Hay package initial weights, moisture contents, and densities.

Package no.	Wet weight, kg	Moisture, %	Density, kg/m³'
		Alfalfa hay	
1	9818.8	26.2	108.4
2	8159.8	22.7	102.2
3	6484.1	23.1	88.5
4	3912.7	33.1	75.7
5	3797.5	33.4	73.6
6	3808.4	32.9	76.2
		Prairie hay†	
7	2697.5	<2.0	35.6
8	2466.7	<1.0	33.7
9	2652.6	<1.0	35.8
10	3943.8	16.0	45.1
11	4180.4	17.0	45.6
12	4109.8	15.7	42.8

† Very dry field conditions existed at the time of preparation of stacks 7, 8 and 9
' Density was standardized to 15% moisture content

Table 3. Average annual precipitation and temperature at hay package storage locations.

Year	Annual precipitation† mm	Annual temperature‡ °C
1972	388	5.3
1973	360	7.8
1974	381	7.3
1975	513	6.6
1976	250	6.6

† Average precipitation is 432 mm, annually
‡ Average temperature during growing season was 29° C

The dominant soil of this region is a Williams loam which is classified as a Typic Agriboroll, fine-loamy, mixed. None of the fields had received fertilizer or herbicide applications during the previous 5 years.

All alfalfa was cut at the first-flower stage of maturity. The cool-season prairie grasses were in the late-seed stage and the warm-season grasses were in the early-boot stage of maturity. The stacks of prairie hay were a mixture of cool and warm-season grasses with no selection attempted.

The Haybuster 1600 and 1800 package systems formed an approximately hemispherical stack, 4.9 and 5.3 m in diameter, respectively, of long hay. The stack was compacted by continuous pressure from a packer drum.

The Hesston 30 package system formed a 2.4 x 4.3 x 4.0 m rectangular stack of forage chopped in 5-15 cm segments. The density of this stack was equal to approximately one half that of conventionally baled hay. The operator had the option to control the number of compressions in making the stack. Generally no more than three or four compressions are recommended for greatest machine field efficiency.

Acceptable operating procedures were used by the experienced operators in making the 12 hay packages in this study.

Sampling and Analysis

The 12 hay packages were sampled with a power driven hay core sampler device (3) which extracted a core sample 5.4 cm in diameter and 76-140 cm in length.

The rectangular Hesston hay packages were conceptually partitioned into thirds from front to rear for sampling. Four cores were extracted from each third of the stack, one core each at 0.61 and 1.22 m above the ground on each side, for a total of 12 samples per stack on each of the sampling dates.

The round Haybuster stacks were conceptually partitioned for sampling into thirds around the circumference and sampled in a similar manner.

During the experimental period, 720 core samples were extracted from the 12 packages of alfalfa and prairie hay. The four core samples from each third of a stack were combined into a single sample for analysis, resulting in three composite samples per

"One-man" operations such as with the Hesston (left) and Haybuster (right) allow harvesting alfalfa at higher moisture content, thus preventing much of the losses encountered with traditional harvesting methods. The Hesston chops hay into 5-15 cm segments and delivers a 2.7 metric ton stack with hay density half that of baled hay. The Haybuster compresses loose hay into a 7.2 metric ton hay package with hay density two thirds that of baled hay. The two machines were **not** compared; the object of the study was to determine if larger hay packages would retain acceptable forage quality after long-term storage in the field.

package per sampling date. The validity of this sampling and compositing method has been discussed by Turnquist et al (7).

These quality parameters were measured: crude protein (CP), neutral-detergent fiber (NDF), acid-detergent fiber (ADF), Crampton and Maynard cellulose (CMC), acid-detergent lignin (ADL), *in vitro* dry matter digestibility (IVDMD), and ash. Ash and CP were determined by procedures of the Association of Official Analytical Chemists (1), ADF and ADL were analyzed by the procedures described by Van Soest (8), NDF was analyzed by the method of Van Soest and Wine (9), CMC was determined by the method of Crampton and Maynard (2), and IVDMD was determined by the technique of Tilley and Terry (6). The physical parameters of moisture and density at time of sampling were determined by using core sample wet weights, volumes, and dry weights. Core samples were taken by the procedure of Johnson et al (3).

Samples were dried to constant weight in a forced-draft oven at 50 to 55° C, ground in a Wiley Mill through a 1-mm screen, and stored in glass bottles for later analysis. Statistical analyses were performed with analysis of variance procedures as outlined by Steel and Torrie (5).

Results and Discussion

Physical Parameters

Alfalfa hay packages. The dry matter loss values for the Haybuster 1800 packages (1, 2, and 3) field stored for 29 months are presented in Table 4. Average loss per month for the three stacks was 0.52% Since the stacks were weighed only at the beginning and end of the storage period, we cannot assume that equal increments of loss occurred each month.

Table 4. Dry matter loss in alfalfa packages 1, 2 and 3 (Haybuster 1800) for a 29-month storage period.

	Package no.		
	1	2	3
June 13, 1973, dry matter, kg	7246.24	6307.70	4986.04
Nov. 10, 1975, dry matter, kg	6061.95	5383.21	4276.01
Dry matter loss, kg	1184.29	924.49	710.03
Dry matter loss, %	16.34	14.66	14.24
Average dry matter loss per month, %/mo	0.56	0.51	0.49
Mean loss for 3 stacks, %/mo		0.52	

No attempt was made to determine the components of loss. For example, the losses due to wind and consumption by deer and other animals could not be measured but were assumed to be minimal.

The average field storage time on the Northern Plains is about 18 months. Therefore, we might expect about a 9% loss in dry matter. This type of loss could be used to partially judge whether it would be economical to provide some type of cover for the packages.

The core sampler, designed by Johnson, Dowding, and Turnquist, was driven by an electric drill. Cutting action was provided by relative motion between outside and inside tubes.

The analysis of variance of moisture content of alfalfa for the two package types is shown in Table 5. Differences in stacks and dates were found.

Differences between stacks in moisture content with increasing storage time were expected, because of considerable field variation and the large quantities of alfalfa that were required to make one package.

Mean values of moisture content are shown in Table 6. Moisture change patterns were similar in the two package types.

Mean density during 23 months of storage was 96.7 kg/m³ for the Haybuster 1800 packages and 75.2 kg/m³ for the Hesston 30 packages (Tables 7 and 8). Significant density increases occurred with increasing storage time, indicating settling.

Table 5. Analysis of variance of moisture content of alfalfa hay packages.

Factor	Haybuster 1800	Hesston 30
A (stacks)	*	**
B (dates)	**	**
C (horizontal)	**[1]	*[3]
D (vertical)[3]	N.S.[2]	*[2]
A X B	**	N.S.
A X C	N.S.	**
B X C	**	**
A X B X C	N.S.	N.S.
A X D	N.S.	*
B X D	*	N.S.
A X B X D	N.S.	N.S.
C X D	N.S.	N.S.
A X C X D	N.S.	N.S.
B X C X D	N.S.	**

[1] Horizontal sampling is "around" the stack in three segments
[2] Horizontal sampling is from "front to back" of rectangular stack
[3] Vertical sampling is 0.61 and 1.22 m above ground
N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level
**Statistically significant difference in means at 1% level

Table 6. Comparison of moisture content for alfalfa hay packages, means, %.

Parameter		Haybuster 1800	AOV	Hesston 30	AOV
Stack	1	14.01		13.45	
	2	12.75	*	13.17	**
	3	12.99		12.60	
Date	1	24.02		33.14	
	2	15.58		12.36	
	3	10.95	**	10.44	**
	4	12.81		9.60	
	5	7.27		6.24	
	6	8.87		6.67	
Horizontal	1	13.38		13.02	
	2	13.81	**	13.43	*
	3	13.56		12.77	
Vertical	1	13.25		13.32	
	2	13.25	N.S.	12.83	*

N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level.
** Statistically significant difference in means at 1% level.

Table 7. Analysis of variance, density of alfalfa hay packages.

Factor	Haybuster 1800	Hesston 30
A (stacks)	*	N.S.
B (dates)	**	**
C (horizontal)	N.S.[1]	**[3]
D (vertical)[3]	N.S.[2]	**[2]
A X B	N.S.	N.S.
A X C	N.S.	*
B X C	N.S.	**
A X B X C	N.S.	N.S.
A X D	N.S.	N.S.
B X D	**	*
A X B X D	N.S.	N.S.
C X D	N.S.	N.S.
A X C X D	N.S.	N.S.
B X C X D	N.S.	N.S.

[1] Horizontal sampling is "around" the stack in three segments.
[2] Horizontal sampling is from "front to back" of rectangular stack.
[3] Vertical sampling is 0.61 m and 1.22 m above ground.
N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level.
**Statistically significant difference in means at 1% level

Table 8. Comparison of density for alfalfa hay packages, means, kg/m³.

Parameter		Haybuster 1800	AOV	Hesston 30	AOV
Stack	1	108.40		75.74	
	2	102.15	*	73.65	N.S.
	3	88.54		76.22	
Date	1	77.34		59.72	
	2	100.55		75.09	
	3	94.95	**	83.42	**
	4	98.47		82.94	
	5	127.93		76.54	
	6	99.11		73.17	
Horizontal	1	106.00		75.41	
	2	94.31	N.S.	70.29	**
	3	98.79		79.74	
Vertical	1	96.87		67.09	
	2	102.63	N.S.	83.26	**

N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level.
** Statistically significant difference in means at 1% level

The Haybuster packages exhibited 28.6% greater density and greater uniformity in density within a stack than Hesston packages. Greater uniformity between Haybuster packages is exhibited by the analysis of variance since there were fewer statistically significant interactions between stacks, dates, and locations.

Advantages of increased density and uniformity are: (1) greater resistance to storm and mechanical damage, and (2) greater resistance to moisture penetration.

Prairie hay packages. The dry matter loss for the Haybuster 1600 packages (7, 8, and 9) field stored for 21.6 months is presented in Table 9. Average loss per month for the three packages was 0.63%. From a practical standpoint, this loss is comparable to the alfalfa dry matter loss of 0.52%.

Tables 10 and 11 give the analysis of variance and means of moisture content respectively, for the 1974 and 1975 prairie hay stacks. Comparisons of

Six Haybuster 1600 prairie hay packages were formed and field stored for up to 22 months. The 1974 prairie hay was extremely dry when harvested; moisture content of the stacks increased between harvest and first sampling date.

Density of **all** stacks increased with increasing storage time, as indicated by settling and shrinking. Losses due to winds and storms were regarded as minimal.

Newly formed Hesston hay packages were less dense and less uniform than Haybuster stacks, but moisture change patterns for both systems were similar during 23 months of field storage.

packages 7, 8, and 9 with 10, 11, and 12 can not be made since the only common factor was the same packaging machine. Hay packaged in 1974 was extremely dry due to overly mature plant material and very dry weather. (The moisture content of the 1974 harvested hay increased between harvest and the first sampling date following harvest.)

Table 9. Dry matter loss in prairie hay (Haybuster 1600) packages 7, 8, 9 for a 21.59 month storage period.

	Package no.		
	7	8	9
June 30, 1974, dry matter, kg	2651.65	2466.67	2638.55
May 18, 1976, dry matter, kg	2276.73	2144.99	2269.35
Dry matter loss, kg	374.92	321.68	369.20
Dry matter loss, %	14.14	13.04	13.99
Average dry matter loss per mo, %/mo	0.65	0.60	0.65
Mean loss for 3 stacks, %/mo		0.63	

Table 10. Analysis of variance, moisture content of prairie hay packages.

	Haybuster 1600	
Factor	1974	1975
A (stacks)	N.S.	N.S.
B (dates)	**	**
C (horizontal)[1]	**	N.S.
D (vertical)[2]	N.S.	N.S.
A X B	N.S.	N.S.
A X C	N.S.	N.S.
B X C	*	N.S.
A X B X C	N.S.	N.S.
A X D	N.S.	N.S.
B X D	N.S.	N.S.
A X B X D	N.S.	*
C X D	N.S.	N.S.
A X C X D	N.S.	N.S.
B X C X D	N.S.	N.S.

[1] Horizontal sampling is "around" the stack in three segments
[2] Vertical sampling is 0.61 and 1.22 m above ground
N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level
** Statistically significant difference in means at 1% level

Table 11. Comparison of moisture content for prairie hay packages, means, %.

		Haybuster 1600			
Parameter		1974	AOV	1975	AOV
Stack	1	4.40		7.91	
	2	4.20	N.S.	8.14	N.S.
	3	4.03		7.77	
Date[1]	1	0.73		16.24	
	2	9.21		3.98	
	3	4.54	**	3.60	**
	4	3.49			
	5	3.09			
Horizontal	1	4.87		7.91	
	2	3.94	**	7.81	N.S.
	3	3.82		8.10	
Vertical	1	4.06		8.23	
	2	4.37	N.S.	7.65	N.S.

[1] Storage time for dates is not the same for the 2 years.
N.S. No statistically significant difference in means.
* Statistically significant difference in means at 5% level.
** Statistically significant difference in means at 1% level.

Significant differences were found in the horizontal sampling location in the 1974 packages. This may have been because the centers of the stacks had depressions allowing entry of snow and rain; on occasions during sampling, wet sections of hay were extracted. Since mean values were low, the differences are of little practical concern.

Mean density for the 1974 packages was 34.0 kg/m³ (21.6 months storage) versus 44.5 kg/m³ (7.9 months storage) for the 1975 packages (Tables 12 and 13). The higher density for the 1975 packages is most likely due to the higher initial moisture at harvest (16.2% in 1975 versus 0.73 in 1974) which aided packing. Generally, density increased and then leveled off with storage time.

We expected significant differences in density between package types due to settling. Significant differences in the vertical density were noted (greater at bottom). This was contrary to the findings for the round alfalfa packages.

As in the case of the alfalfa packages, no horizontal differences were found.

Table 12. Analysis of variance, density of prairie hay packages.

Factor	Haybuster 1600 1974	1975
A (stacks)	N.S.	N.S.
B (dates)	**	**
C (horizontal)[1]	N.S.	N.S.
D (vertical)[2]	**	**
A X B	N.S.	N.S.
A X C	N.S.	N.S.
B X C	N.S.	N.S.
A X B X C	N.S.	N.S.
A X D	N.S.	N.S.
B X D	N.S.	N.S.
A X B X D	N.S.	N.S.
C X D	N.S.	N.S.
A X C X D	N.S.	N.S.
B X C X D	N.S.	N.S.

[1] Horizontal sampling is "around" the stack in three segments
[2] Vertical sampling is 0 61 and 1 22 m above ground
N.S. No statistically significant difference in means
* Statistically significant difference in means at 5% level
** Statistically significant difference in means at 1% level

Table 13. Comparison of density for prairie hay packages, means, kg/m³.[1]

Parameter		Haybuster 1600 1974	AOV	1975	AOV
Stack	1	35.56		45.11	
	2	33.74	N.S.	45.56	N.S.
	3	35.75		42.82	
Date[2]	1	20.78		33.78	
	2	37.62		50.53	
	3	43.61	**	49.18	**
	4	35.54			
	5	37.53			
Horizontal	1	35.15		40.75	
	2	34.73	N.S.	45.38	N.S.
	3	35.17		47.36	
Vertical	1	29.79		40.64	
	2	40.25	**	48.36	**

[1] Density was standardized to 15% moisture content
[2] Storage time for dates is not the same for the 2 years
N.S. No statistically significant difference in means.
* Statistically significant difference in means at 5% level.
** Statistically significant difference in means at 1% level.

Quality Parameters

Alfalfa hay packages. Of the quality components measured, only ash showed a significant difference due to geographical location (Table 14). The higher ash may be related to higher initial moisture content of the Hesston stacks. Ash can also be affected by the amount of soil contamination. Significant differences in all quality parameters are noted during the 23-month storage time.

The increase in the more stable quality components (ADF, CMC, ADL, ash) and decrease in soluble cell contents (NDF) indicate a loss of quality with storage time (Table 15). This fraction is the most likely to be lost during storage because of its soluble nature and nutrient composition. The loss would not be apparent if other dry matter component losses were even greater, thereby increasing the percentages of all remaining components.

It is doubtful that differences of this magnitude are of practical concern since IVDMD decreased only 2% after 23 months of storage. Quality retention, based on parameters measured, appeared to be very good.

Table 14. Analysis of variance, quality constituents in alfalfa hay packages (1 through 6).

	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
Location, L[a]	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.
Dates, D (storage time)	**	**	**	**	**	**	**
L X D	*	*	N.S.	N.S.	**	**	N.S.
Stack	N.S.	**	N.S.	**	**	**	N.S.
D X Stack	N.S.	**	*	N.S.	*	**	N.S.

[a] Location geographical
[1] Norbeck, 3 Haybuster 1800 Stacks
[2] Ipswich, 3 Hesston 30 Stacks
N.S. No statistically significant difference in means
* Significant at 5% level.
** Significant at 1% level.

Table 15. Means and standard errors of quality constituents in alfalfa hay packages (1 through 6) with increasing field storage time, Norbeck and Ipswich, 1973-75.

Field storage time months	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
	Quality parameters +						
0.0	17.4	31.0	53.2	26.0	7.7	11.4	63.9
1.0	17.6	35.7	53.9	25.4	9.8	13.4	59.4
4.2	17.3	33.9	52.6	26.3	7.8	12.0	61.5
10.4	18.0	31.9	41.1	24.7	6.4	11.4	60.0
17.2	22.0	36.5	51.2	27.8	9.6	12.3	61.4
23.0	18.1	33.9	49.2	27.7	6.6	12.6	61.8
Mean	18.4	33.8	50.2	26.3	8.0	12.2	61.3
S.E.	0.100	0.197	0.345	0.216	0.134	0.072	0.324

\+ Each value is the mean of 18 composite samples

Prairie hay packages. Significant differences in all quality parameters for packages 7, 8, and 9 were noted during the 21 months of storage time (Tables 16 and 17). However, the magnitude of the changes is not considered excessive, as reflected in the relatively small decrease in IVDMD with storage time.

The decrease in CP is of possible concern since it would indicate denaturation of protein, as well as loss of nitrogen. The Kjeldahl process used to analyze for CP measures only the presence of nitrogen; therefore the level of protein denaturation is not known. A decrease in protein means loss of nitrogen through gas loss or leaching. Leaching is not likely to occur when the moisture level is so low.

Significant differences in all quality parameters for packages 10, 11, and 12 were shown during the 8 months of storage (Tables 18 and 19). Digestibility (IVDMD) after 8 months of storage was greater than the initial value. Increasing values for ash, ADL, ADF, NDF, and CMC suggest that dry matter losses were occurring with storage; but the forage quality remained good.

It is interesting to note that Schrempp (4) suggested ADL, NDF, and IVDMD were the more important quality parameters in measuring quality changes in the alfalfa hay packages (1 through 6). Schrempp proposed a tentative quality index system using only these three parameters for measuring quality changes during storage. The index system was not consistent for all stored hay, however, and could not be applied to quality changes in the stored prairie hay packages (7 through 12).

Table 16. Analysis of variance, quality constituents in prairie hay pckages (7, 8, and 9).

	Quality parmeters						
	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
Dates, D (storage time)	**	**	**	**	**	**	**
Stacks, S	**	**	**	**	*	**	*
D X S	N.S.	**	**	**	**	**	N.S.

N.S. No statistically significant difference in means
* Significant at 5% level
** Significant at 1% level

Table 17. Means and standard errors of quality constituents in prairie hay packages (7, 8, and 9) with increasing field storage time, Orient, 1974-76.

Field storage time	Quality parameters +						
months	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
0.0	11.4	43.8	65.8	34.4	5.0	8.7	56.5
3.7	10.6	48.6	73.1	38.5	6.7	9.5	47.6
9.6	6.6	48.0	73.7	36.8	5.9	9.9	53.7
15.6	5.7	46.9	70.2	41.1	6.2	9.7	51.9
20.9	6.7	51.3	72.8	36.6	8.8	10.9	47.9
Mean	8.2	47.7	71.1	37.5	6.5	9.7	51.5
S.E.	0.122	0.118	0.324	0.124	0.168	0.122	0.324

\+ Each value is the mean of 9 composite samples

Table 18. Analysis of variance, quality constituents in prairie hay packages (10, 11, and 12).

	Quality parameters						
	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
Dates, D (storage time)	**	**	**	**	**	**	**
Stacks, S	**	*	**	N.S.	N.S.	N.S.	**
D X S	**	*	*	N.S.	*	N.S.	N.S.

N.S. No statistically significant difference in means
* Significant at 5% level
** Significant at 1% level

Table 19. Means and standard errors of quality constituents in prairie hay packages (10, 11, and 12) with increasing field storage time, Orient 1975-76.

Field storage time	Quality parameters +						
months	CP	ADF	NDF	CMC	ADL	Ash	IVDMD
0.0	5.8	43.0	61.9	34.2	7.7	7.2	46.4
2.7	6.0	42.1	61.1	39.5	7.0	7.4	53.5
7.9	6.8	44.7	63.1	34.8	9.7	11.8	51.1
Mean	6.2	43.3	62.0	36.2	8.1	8.8	50.3
S.E.	0.117	0.118	0.163	0.267	0.526	0.964	0.567

\+ Each value is the mean of 9 composite samples

Conclusions

Moisture and Density

1. Average dry matter loss per month for three Haybuster 1800 alfalfa packages was 0.52% during 29 months of field storage on the Northern Plains.
2. Moisture change patterns for three Haybuster 1800 alfalfa packages and three Hesston 30 alfalfa packages were similar during 23 months of field storage.
3. Haybuster 1800 alfalfa packages (mean density during storage, 96.7 kg/m³) were 28.6% more dense than Hesston 30 alfalfa packages (mean density during storage, 75.2 kg/m³).
4. Haybuster 1800 alfalfa packages were more uniform in density than Hesston 30 alfalfa packages.
5. Average dry matter loss per month for three Haybuster 1600 prairie hay packages was 0.63% during 21.6 months of field storage on the Northern Plains.
6. Mean density of prairie hay stacks increased 80.6% during 21.6 months of storage in 1974-1975 and 45.6% during 7.9 months of storage in 1975-1976.

Hay Quality Parameters

1. Except for prairie hay stacks 7, 8, and 9, crude protein (CP) percentages increased with storage.
2. Fibrous components (ADF and CMC) generally increased during hay storage.
3. Neutral-detergent fiber (NDF), which can be used as an indirect measure of the more soluble

plant material, varied somewhat with storage. Since no severe changes in this fraction were noted with any of the stacks with storage, the quality of the hay was judged high.

4. With few exceptions, acid-detergent lignin (ADL) showed a gradual percentage increase with storage time as other components were lost.

5. Even though highly significant statistical differences were found in *in vitro* digestibility (IVDMD) forage quality was not markedly affected from a practical standpoint by storage time.

In conclusion, although quality differences were statistically significant, they were not of the magnitude to be of practical importance to the farmer or rancher. Small losses in dry matter can be expected in any harvesting operation, regardless of method.

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Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly Dakota Territory establishing the Dakota Agriculture College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University
File 1 3-2—1,000 printed at estimated 62 cents each—7-80mb—5144A