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Abstract
In the first of two alfalfa hay experiments, lambs fed small bale hays averaged 16% better gains and feed conversions than those fed large bale hays; Fresh Cut®-treated hay gave 9% better performance than untreated hays; and medium-moisture hays produced 12% faster and more efficient gains than low-moisture hays. In the second experiment, hay baled above 30% moisture had excessive heating, more discoloration and mold growth, higher storage losses, and lower dry matter and protein digestibilities compared with 15% moisture hay.

Keywords
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Effect of Moisture, Bale Type, and a Preservative on Alfalfa Hay Quality and Feeding Value[1,2]

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Summary

In the first of two alfalfa hay experiments, lambs fed small bale hays averaged 16% better gains and feed conversions than those fed large bale hays; Fresh Cut®-treated hay gave 9% better performance than untreated hays; and medium-moisture hays produced 12% faster and more efficient gains than low-moisture hays. In the second experiment, hay baled above 30% moisture had excessive heating, more discoloration and mold growth, higher storage losses, and lower dry matter and protein digestibilities compared with 15% moisture hay.

Introduction

In spite of new hay-making equipment and techniques, the process continues to be greatly affected by weather. Preservatives could minimize weather risk by allowing hay to be baled at higher moisture levels, thereby reducing the time from cutting to baling. This would decrease field losses, such as nutrients leached and leaves shattered, and increase the potential for higher quality hay.

The success or failure of a hay preservative will be influenced by many factors including, but not limited to, hay moisture, bale size, bale type, and bale density. The objectives of these experiments were to determine the effects of moisture levels at baling, conventional or large bale types, and commercial preservatives on alfalfa hay quality, chemical composition, and feeding value for growing lambs.

Experimental Procedures

The alfalfa for these experiments was obtained from farmers' fields near the Agricultural Science Center at Artesia, New Mexico.

Experiment 1. Single windrow alfalfa plots approximately 1280 feet long were swathed on July 19, 1984 using a 14-foot swather with a mower-conditioner-crimper, which facilitated uniform dry down of the crop. A Massey Ferguson Model 126 baler was used to produce 14 x 18 x 36 inch bales (small bales), and a model 4800 Hesston baler was used to produce 4 x 4 x 8 foot bales

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[1] These experiments were part of a cooperative project between the Agricultural Science Center at Artesia, New Mexico State University and the Animal Sciences and Industry Dept., Kansas State University.

[2] Partial financial assistance was provided by Kemin Industries, Inc., Des Moines, Iowa and International Stock Food, Inc., Waverly, N.Y.

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(large bales). For each bale type, the alfalfa was baled at two moisture levels: approximately 15% (low) or 17% (medium) for the small bales and approximately 12% (low) or 14% (medium) for the large bales. The medium moisture hay was baled on July 22, and the low moisture, on July 24. The initial moisture of the windrows at baling was determined arbitrarily. Ninety-six small bales were made at the medium moisture and 48 at the low moisture. Eight large bales were made at the medium moisture and four at the low moisture. One-half of the medium moisture, small and large bales were treated at the bale chamber with Fresh Cut®, a commercial hay preservative from Kemin Industries, Inc. Small bales received 4 lb (2 quarts) per ton and large bales 6 lb (3 quarts) per ton. Fresh Cut® is a non-corrosive, non-volatile chemical hay stabilizer, which contains 20% propionic acid.

The two balers ran simultaneously, side by side in adjacent windrows. As the small bales came out of the baler, they were identified, weighed, and randomly assigned within each treatment to the following: 1) initial, pre-storage core sampling, or 2) thermocoupling for temperature measurement and post-storage core sampling and feeding. As the large bales came out of the baler, they were randomly assigned within each treatment to the following: 1) initial, pre-storage core sampling, or 2) thermocoupling and post-storage core sampling and feeding. For temperature measurement, two thermocouple wires were inserted into each small bale and four into each large bale. Initial temperatures were recorded within 1 hour post-baling. Thereafter, temperatures were recorded twice daily for the first 7 days and then once daily for 1 month.

All pre-storage bales were core-sampled within 1 hour post-baling, using a Pennsylvania State University sampler. Post-storage bales were weighed and core-sampled after 5 months of storage under a roof. All samples were frozen immediately in liquid nitrogen until analyzed for moisture and chemical constituents. All thermocoupled and post-storage bales were transported from Artesia to Manhattan, where they were flaked and visually appraised for color, aroma, mold, mildew, and dust.

The flaked hay from each treatment was ground, stored in boxes, and fed to 72 crossbred feeder lambs (three pens of four lambs per treatment) in a 46-day growing trial. The rations contained 90% of the appropriate hay and 10% supplement (Table 45.1). The lambs were fed twice daily and feed refusals were recorded weekly.

Experiment 2. Single windrow alfalfa plots approximately 600 feet long were swathed on August 25, 1984 using a 14-foot swather with a mower-conditioner-crimper. The following nine hay treatments (20 bales each) were made using a Massey Ferguson Model 126 baler: high and medium moisture, baled without preservative (control) and with Silo Guard II at .5 and 1.0 lb per ton; normal moisture, control and with Silo Guard II at .5 lb per ton; and low moisture control. Silo Guard II, a commercial hay preservative from International Stock Food, Inc., was applied at the bale chamber. For the .5 lb rate, 1 lb of preservative was mixed with 1 gallon of water and the solution applied at 2 quarts per ton. For the 1.0 lb rate, 2 lb of preservative was mixed with 1 gallon of water and the solution applied at 2 quarts per ton. The high-moisture hays were baled on August 26; the medium moisture, on August 27; the normal-moisture, on August 28; and the low-moisture, on August 29.

As the bales came out of the baler, they were identified, weighed, and assigned in a randomized block design within each treatment to four groups: 1) initial, pre-storage core sampling only; 2) thermocoupling for temperature measurement only; 3) thermocoupling, post-storage core sampling, and feeding; and 4) feeding only. Procedures for thermocouple wires, temperatures, core samples, storage, transport, and visual appraisal were similar to Expt. 1.

The flaked hay from treatments 1, 2, 3, 4, 5, and 7 (Table 45.5) was ground, stored in boxes, and fed to 24 crossbred wether lambs (four lambs per treatment) in a two-period voluntary intake and digestion trial. The lambs each received 15 grams of a mineral, vitamin, and aureomycin premix daily.

Results

Experiment 1. Shown in Table 45.2 are storage losses for the six alfalfa hay treatments. Small bales had an average DM weight loss of less than 1.0% during storage. The low-moisture, large bales lost slightly over 4.0% of the initial DM, but the control and Fresh Cut® medium-moisture, large bales gained DM weight during storage. A net gain in dry weight is impossible; a weighing or analytical error(s) must have been involved. For example, a 10 lb error in initial or final bale weight would give nearly a 1.0% change in storage loss. Underestimate of initial bale DM content and/or overestimate of final bale DM content from the core samples would also cause storage losses to be incorrect.

There was no heating in any of the hay and all bale temperatures declined from the initial, post-baling readings. Visual appraisals showed no evidence of mold growth or excessive dust in any of the bales. There were no signs of discoloration (or browning) in the hays, although all medium moisture bales were somewhat greener and less stemmy than the low moisture bales.

Shown in Table 45.3 is chemical composition of the six alfalfa hay treatments. Results for the post-baling samples showed that crude protein (CP) was slightly higher in the small than in the large bales and also slightly higher in the medium-moisture than in the low-moisture bales. Similar trends occurred for cell wall (CW) contents and acid detergent fiber (ADF). The data indicate that the small bales had somewhat higher initial quality than large bales and that medium-moisture bales had somewhat higher initial quality than low-moisture bales.

Performance by lambs fed the six alfalfa hay rations is presented in Table 45.4. Lambs receiving the low-moisture, large bale hay gained slower ($P<.05$) and less efficiently ($P<.05$) than lambs receiving any of the other five hays. These results are consistent with the chemical analyses data. In general, the three small bale hay rations supported faster gains and better feed conversions than their large bale counterparts.

The medium-moisture hays treated with Fresh Cut® were consumed in greater amounts and gave better lamb performance than medium-moisture, control hays. These differences were not statistically significant. On a percentage basis, the advantage to using Fresh Cut® was greater with small bales than with large bales.

Experiment 2. The intended hay moistures at baling were 12, 20, 28, and 35% for low, normal, medium, and high- moisture treatments, respectively. Core samples taken immediately post-baling showed actual moistures to be 8, 15, 33, and 39 percent.

Shown in Figure 45.1 are hay temperature changes post-baling for the nine hay treatments. Extensive heating occurred in the high and medium moisture bales. The high-moisture bale temperatures rose from a 92 F average initial to 143 F after 6 days of storage. Temperatures of the medium-moisture control and 1.0 lb Silo Guard II bales rose from a 93.8 F average initial reading to 121 F at 9 days post-baling, whereas the 2.0 lb Silo Guard II bales rose from an 89.7 F average initial to 124 F at 6 days post-baling. There was no heating above the average initial temperature in any of the normal and low-moisture hay.

Visual appraisals of the bales showed the following: 1) very extensive discoloration with heavy mold growth throughout all high-moisture bales; 2) extensive discoloration, moderate mold growth, and light dustiness throughout all medium-moisture bales; and 3) bright green color, pleasant aroma, and no mold or dust for the control and .5 lb Silo Guard II normal-moisture and control low-moisture bales. All normal moisture hay appeared to have better leaf retention than the low moisture hay. Although handling and processing (grinding) losses were not measured, the low-moisture bales were observed to have the highest leaf-shattering losses.

Shown in Table 45.5 are storage losses for the nine alfalfa hay treatments. The high-moisture bales had an average DM weight loss of 19.0% during storage, while medium-moisture bales lost an average of 3.4 percent. Although Silo Guard II did reduce losses by about 20% in the high-moisture hay, all of these bales were of unacceptable quality for livestock feed. The 2.1% DM loss in the low-moisture hay was likely the result of shattering losses, which occurred during handling and transport. Chemical composition of the six alfalfa hay treatments fed to the lambs is shown in Table 45.5. The heating that occurred in the high-and medium-moisture hays resulted in higher fiber constituents than in the normal-moisture hays. The low-moisture hay had the lowest CP, which was likely due to excessive leaf shatter during baling, handling, and processing.

Shown in Table 45.7 are voluntary intakes and digestibilities of the six alfalfa hay treatments. Normal-moisture, Silo Guard II hay had the highest ($P<.05$) intake and high-moisture control hay had the lowest ($P<.05$). Normal- and low-moisture hays had the highest ($P<.05$) dry matter and CP digestibilities. The lower dry matter and CP digestibilities for the medium- and high-moisture hays reflect the nutritive value damage that was caused by heating during storage. Silo Guard II did not affect dry matter or CP digestibilities in the medium- and normal-moisture hays. None of the hay treatments consistently affected CW or ADF digestibilities. These results show the negative effects on hay quality caused by baling alfalfa when it is too wet or too dry. It was unfortunate that intended and actual hay moistures were not in closer agreement. The preservative was not intended or recommended for 33 or 39% moisture hay. The poor quality hay obtained at these moisture levels certainly does not imply that the Silo Guard II would not have improved hay quality in 20 to 28% moisture hay.

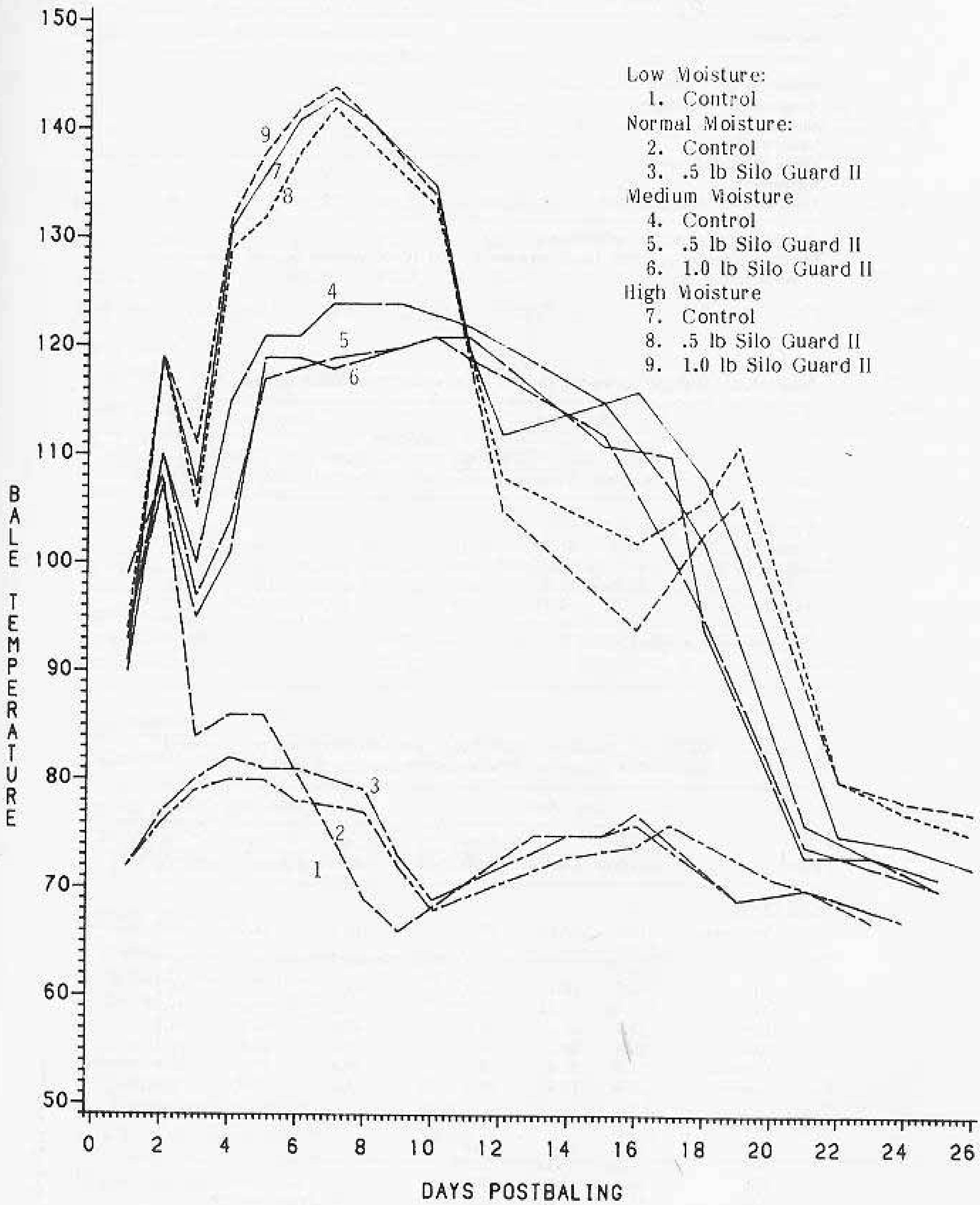

Figure 45.1. Temperature Changes for the Nine Alfalfa Hay Treatments in Expt. 2.

Table 45.1. Composition of the Supplement Fed to the Lambs in Expt. 1

Ingredient	% (as-mixed basis)
Rolled Sorghum Grain	88.2
Monosodium Phosphate	6.7
Salt	2.5
Cane Molasses	2.0
Trace Mineral Premix	.5
Aureomycin	*
Vitamin A, D, and E Premix	**

*Added to provide 20 mg/lamb/day.
**Added to provide 3,000 IU of vitamin A, 300 IU of vitamin D, and vitamin E per lamb per day.

Table 45.2. Storage Losses for the Six Alfalfa Hay Treatments in Expt. 1

	Small Bale			Large Bale		
	Moisture					
	Low	Medium		Low	Medium	
Item	Control	Control	Fresh Cut®	Control	Control	Fresh Cut®
Avg. Initial Bale Wt., lb[1]	66.1	52.1	54.2	1607	1360	1331
Avg. Final Bale Wt., lb[1]	65.8	51.5	53.9	1540	1376	1359
Wt. Change, %	-.45	-1.15	-.55	-4.18	+1.18	+2.10

[1] 100% dry matter basis.

Table 45.3. Effect of Moisture, Bale Type, and Preservative on Chemical Composition of the Six Alfalfa Hay Treatments in Expt. 1

	Small Bale			Large Bale		
	Moisture					
	Low	Medium		Low	Medium	
Item[1]	Control	Control	Fresh Cut®	Control	Control	Fresh Cut®
Post-baling:						
Moisture, %	15.1	16.8	17.1	12.2	14.1	14.4
	% of the hay DM					
CP	16.2	16.4	16.8	15.9	15.9	16.2
ADIN	.16	.14	.15	.18	.18	.17
CW	43.9	42.4	38.9	47.9	46.0	44.3
ADF	37.4	36.3	34.5	39.5	38.9	37.3
Cellulose	27.0	25.0	23.7	29.9	29.8	27.4
Lignin	9.6	10.8	10.4	8.0	7.0	7.9
Post-storage:						
CP	16.1	16.6	16.4	Analyses are not completed		
ADIN	.20	.15	.16			
CW	46.2	45.2	46.5			
ADF	36.7	35.0	36.5			
Cellulose	24.2	25.4	24.5			
Lignin	12.4	10.8	11.6			

[1] CP = crude protein, ADIN = acid detergent insoluble nitrogen, CW = cell wall contents, and ADF = acid detergent fiber.

Table 45.4. Performance by Lambs Fed the Six Alfalfa Hay Rations in Expt. 1

	Small Bale			Large Bale		
	Moisture					
	Low	Medium		Low	Medium	
Item	Control	Control	Fresh Cut®	Control	Control	Fresh Cut®
Hay DM, %	88.8	89.1	87.5	89.0	88.5	88.8
No. of Lambs	12	12	12	12	12	12
Initial Wt., lb	61.4	62.4	59.8	61.8	65.1	62.7
Avg. Daily Gain, lb	.298[a]	.288[a]	.337[a]	.213[b]	.276[a]	.298[a]
Daily Feed Intake, lb[1]	2.80	2.62	2.82	2.55	2.66	2.77
Feed/lb of Gain, lb[1]	9.46[a]	9.27[a]	8.37[a]	12.54[b]	9.75[a]	9.49[a]

[a,b]Values with different superscripts differ ($P<.05$).

[1]100% dry matter basis.

Table 45.5. Storage Losses for the Nine Alfalfa Hay Treatments in Expt. 2

Moisture, Treatment No., and Preservative	Avg. Intial Bale Wt., lb[1]	Avg. Final Bale Wt., lb[1]	Wt Change, %
Low Moisture:			
1. Control	28.4	27.9	-2.1
Normal Moisture:			
2. Control	62.5	63.0	+.8
3. .5 lb of Silo Guard II	61.4	61.2	-.3
Medium Moisture:			
4. Control	58.5	56.4	-3.6
5. .5 lb of Silo Guard II	58.6	56.7	-3.2
6. 1.0 lb of Silo Guard II	59.4	57.4	-3.4
High Moisture:			
7. Control	60.7	47.2	-22.2
8. .5 lb of Silo Guard II	57.0	47.6	-16.5
9. 1.0 lb of Silo Guard II	54.9	44.9	-18.2

[1]100% dry matter basis.

Table 45.6. Chemical Composition of the Six Alfalfa Hay Treatments in Expt. 2

Item[2,3]	Moisture and Preservative[1]					
		Normal		Medium		
	Low Control	Control	.5 lb of SG II	Control	.5 lb of SG II	High Control
Post-baling:						
Moisture, %	8.1	15.6	14.8	33.4	32.8	39.3
Post-storage:						
Moisture, %	10.3	11.6	12.1	13.9	14.3	16.7
	% of the Hay DM					
CP	22.1	23.5	23.4	23.4	23.9	23.7
CW	38.4	34.2	38.3	43.4	43.7	45.4
ADF	33.0	27.4	27.6	34.7	32.2	36.7
Cellulose	23.6	19.4	21.5	25.8	24.0	25.7
Lignin	8.0	7.0	7.4	8.7	7.8	8.5

[1]SG II means Silo Guard II.

[2]Post-baling analyses are not completed.

[3]CP = crude protein, CW = cell wall contents, and ADF = acid detergent fiber.

Table 45.7. Voluntary Intakes and Apparent Digestibilities of the Six Alalfa Hay Treatments Fed to the Lambs in Expt. 2

Item[2]	Moisture and Preservative[1]					
		Normal		Medium		
	Low Control	Control	.5 lb of SG II	Control	.5 lb of SG II	High Control
Voluntary Intake, lb of DM/Day	2.42^{ab}	2.39^{ab}	2.63^{a}	2.45^{ab}	2.45^{ab}	2.29^{b}
	Digestibility, %					
DM	64.4^{b}	67.7^{a}	66.2^{ab}	60.0^{c}	60.1^{c}	54.7^{d}
CP	77.2^{a}	76.8^{a}	78.4^{a}	69.3^{b}	70.7^{b}	52.5^{c}
CW	45.9^{bc}	47.5^{b}	51.3^{abc}	53.8^{a}	51.3^{abc}	53.9^{a}
ADF	51.4^{b}	50.1^{c}	50.7^{bc}	54.9^{a}	48.8^{c}	53.6^{a}

[1]SG II means Silo Guard II.

[2]CP = crude protein, CW = cell wall contents, and ADF = acid detergent fiber.

[a,b,c,d]Values with different superscripts differ (P<.05).