Applying Corn Condensed Distillers Solubles to Hay Windrows Prior to Baling: I. Procedure and Effects on Bale Temperature and Nutrient Composition

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Summary

Two experiments investigated the effects of applying liquid corn condensed distillers solubles to grass-hay windrows prior to baling on storage, bale temperature, and nutrient composition. Application of the wet material did not impair the ability of hay to expel heat post-baling in either study. Increased CP and decreased NDF for hay treated with corn condensed distillers solubles indicated successful within-bale storage occurred. Results suggest application prior to baling is a feasible strategy for storing liquid co-products while improving forage quality.

Introduction

Previous research (*2009 Nebraska Beef Cattle Report,* pp. 11-12 and 30-32) demonstrated corn condensed distillers solubles (CCDS) can be ensiled in commercial silo bags by combining with low-quality forages. Although an effective method for storing liquid co-products, this technique requires equipment and facilities which may be inaccessible for some operations. In the summer, many Nebraska cow-calf producers harvest grass hay which can often be medium to low quality. A management strategy utilizing CCDS to improve hay quality while concurrently serving as a method of storage may be feasible. Therefore, our objectives were to: 1) evaluate the ability to store CCDS in large round bales by applying it to hay windrows prior to baling; 2) determine the influence of CCDS on internal bale temperature post-baling; and 3) characterize the effects of applied CCDS on hay nutrient composition.

Procedure

Both experiments described herein were conducted at the University of Nebraska–Lincoln Dalbey-Halleck Research Unit located near Virginia in southeast Nebraska.

Experiment 1

In 2010, one 40-acre field of native warm-season tallgrass prairie was windrowed in late July. Following a three-day drying period without raking, CCDS (Table 1) was applied directly to windrows prior to baling. Upon delivery, CCDS was off-loaded into a liquid fertilizer trailer equipped with a gasoline-powered engine. In order to apply CCDS to the windrows, the trailer was modified to include: 1) a ¾-inch diameter electric shut-off valve; 2) a 1½-inch diameter flow meter; and 3) and a 7 foot long by ¾-inch diameter spray boom. To the spray boom, ¼ -inch diameter drop holes were bored and spaced 1¼ inch apart. This boom was positioned at a 90 degree angle to the frame of the trailer and extended beyond the trailer's breadth, thereby allowing for a 3 foot spraying width to cover the windrow without applying CCDS directly on the ground (Figure 1).

A tractor, which was driven between windrows, was used to pull the trailer when applying CCDS. The shut-off valve and flow meter were wired to a 12-volt battery, which was positioned in the cab of the tractor, thus providing direct control of the flow and rate of CCDS applied by the operator. All windrows were baled using a large round baler within 24 hours of CCDS application. Bales were placed in rows, buffed end-to-end, and stored on the ground without covering.

Two levels of CCDS were applied to windrows: 1) 0 (0%); or 2) 20% (20%) CCDS of bale weight (DM basis), producing 0 (n = 45) or 20% (n = 36) bales, respectively. Application level was calculated using distance traveled to produce a large round bale, bale weight, driving speed, and CCDS

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Figure 1. Liquid trailer with modifications to apply CCDS to hay windrows.

Table 1. **Nutrient analysis of CCDS applied to grass hay windrows prior to baling.**

Item[1]	Experiment 1 (2010)	Experiment 2 (2011)
DM	37.5	39.3
CP	23.4	31.4
Fat	25.9	21.7
OM	89.9	90.2
S	1.1	1.2
P	1.9	1.9
pH	4.6	4.2

[1]% of DM.

Table 2. **Inclusion rates of CCDS treated bales by year[1].**

Year	n	Level[2]	Mean[3]	SD	Minimum	Maximum
2010	36	20	20.4	2.5	13.8	23.9
2011	31	16	16.1	2.5	10.7	21.4
	27	32	32.3	4.6	22.0	41.7

[1]% inclusion (DM basis) of bale weight.
[2]Projected inclusion level, %.
[3]Observed inclusion level, %.

Table 3. **Effect of level of CCDS and sampling date on hay bale internal temperature in Experiment 1.**

	2 week		3 week			*P*-value		
Item	0	20	0	20	SEM	Level[2]	Date[3]	L x D[4]
Temperature, °F[1]	94.1[a,b]	96.1[a]	94.3[a]	92.0[b]	0.74	0.85	<0.01	<0.01

[1]Measured using a digital hay probe.
[2]Fixed effect of CCDS level.
[3]Fixed effect of sampling date.
[4]CCDS level x sampling date interaction.
[a,b]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

Table 4. **Effect of level of CCDS on hay bale nutrient composition in Experiment 1.**

	Treatment			
Item[1]	0	20	SEM	*P*-value
DM	90.4	90.1	1.09	0.58
CP	7.2[a]	9.8[b]	0.20	<0.0001
NDF	69.2[a]	60.0[b]	0.36	<0.0001
Fat	1.7[a]	4.7[b]	0.14	<0.0001
S	0.1[a]	0.3[b]	0.01	<0.0001

[1]% DM basis.
[a,b]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

flow rate. Windrow lengths to produce each treated bale were measured. Therefore, the percentage CCDS inclusion (DM basis) was calculated for each bale retrospectively.

Bale temperatures were recorded using a digital hay probe at 2 and 3 weeks post-baling on a subset of eight bales within treatments. Core samples were collected using a drill-powered hay probe at 0, 2, 3, and 24 weeks post-baling from a subset of eight bales within each treatment. Samples were frozen, dried (140°F, 48 hours) to determine DM, and ground for analysis of CP, S, fat, and NDF. At application, CCDS samples were collected and frozen prior to DM determination. Samples were then freeze-dried prior to analysis for CP, fat, S, OM, P, and pH.

All data were analyzed as a completely randomized design. Temperature data were analyzed as a 2 x 2 factorial arrangement of treatments. Model fixed effects included CCDS level, date, and the level x date interaction. Nutrient composition data were analyzed with date as a random effect. The model for all analyses included the fixed effect of CCDS level. Because treatments were applied on a bale basis, the experimental unit for all analyses was bale.

Experiment 2

In 2011, a second trial was conducted using the same field to evaluate applying increasing levels of CCDS to windrows prior to baling. Date of hay harvest, length of drying time prior to application, application timing relative to baling, equipment, bale management post-baling, and calculations used to determine application rate were as described in Experiment 1. Three levels of CCDS (Table 1) were applied to windrows: 1) 0 (0%); 2) 16 (16%); and 3) 32% (32%) CCDS of bale weight (DM basis), producing 0 (n = 30), 16 (n = 31), and 32% (n = 27) bales, respectively.

Bale temperature was measured on a subset of six bales within treatments at 0, 2, and 3 weeks post-baling. Core samples were collected at 0 and 3 weeks post-baling from a subset of three bales within treatment, and samples were composited within date and level. Samples were frozen, dried to determine DM, and ground for analysis. Corn condensed distillers solubles samples were collected, prepared, and analyzed as in Experiment 1.

All data were analyzed as a completely randomized design. Temperature data were analyzed as a 3 x 3 factorial arrangement of treatments with bale as the experimental unit. Model fixed effects included CCDS level, date, and the level x date interaction. Orthogonal contrasts were constructed to test linear and quadratic effects of increasing CCDS levels within sampling date because an interaction was observed. For nutrient composition data, the effect of sampling date was tested, and determined nonsignificant. Therefore, pooled means across sampling date

Table 5. Effect of level of CCDS and sampling date on hay bale internal temperature in Experiment 2.

	0 week			2 week			3 week				*P*-value		
Item	0	16	32	0	16	32	0	16	32	SEM	Level[2]	Date[3]	L x D[4]
Temp., °F[1,5]	98.5[b,c]	105.2[a]	101.2[b]	94.7[d,e]	95.5[c,d]	94.3[d,e]	82.2[g]	88.0[f]	91.8[e]	1.28	< 0.01	< 0.01	< 0.01

[1]Measured using a digital hay probe.
[2]Fixed effect of CCDS level.
[3]Fixed effect of sampling date.
[4]CCDS level x sampling date interaction.
[5]Quadratic effect of level within 0 week bales, and linear effect within 3 week bales ($P \leq 0.01$).
[a-g]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

are reported and the experimental unit tested was level within date.

Results

Experiment 1

Variation in windrow density across the field produced differences in linear windrow lengths necessary to make a large round bale. Therefore, a range of 10.1% units of CCDS was observed among 20% CCDS bales (Table 2); however, the mean inclusion level equaled approximately 20%. Internal temperature data are summarized in Table 3. A significant CCDS level x sampling date interaction was noted. Interestingly, temperature declined ($P \leq 0.05$) from 2 to 3 weeks post-baling for 20% bales but remained constant for 0% bales. Level of CCDS had no effect on bale temperature suggesting typical heat elimination occurred.

Consistent with the temperature data, DM was not different between treatments (Table 4). This implies adding CCDS to hay prior to baling has minimal impact on the drying process. Significant increases in CP, fat, and sulfur were observed for 20% bales. In addition, NDF, an indicator of fiber, was reduced 13.3% by adding CCDS.

Experiment 2

Variation in CCDS inclusion among bales was directly proportional to the level of CCDS applied (Table 2). The greatest inclusion amount for a bale in the 16% group was less than the minimum for a 32% bale. Thus, inclusion rates for individual bales did not overlap across treatments. As in Experiment 1, a significant CCDS level x sampling date interaction existed for temperature (Table 5). A significant quadratic response of temperature in relation to increasing CCDS levels was observed immediately after baling; however, temperatures were not different at 2 weeks post-baling. Temperature linearly ($P \leq 0.01$) increased with greater CCDS levels when measured at 3 weeks post-baling. Despite internal temperature being greatest for 32% bales at 3 weeks after baling, temperature declined for all treatments across time. Similar to Experiment 1, results suggest applying up to 32% CCDS to hay prior to baling does not interfere with heat elimination nor does it cause excessive heat production in treated bales.

Table 6. Effect of level of CCDS on hay bale nutrient composition in Experiment 2.

	Level				
Item[1]	0	16	32	SEM	*P*-value
DM	92.3	93.1	91.4	1.33	0.68
CP	6.9[a]	11.5[b]	12.8[b]	0.48	<0.01
NDF	74.6[a]	63.7[b]	56.2[c]	1.05	<0.01
Fat	1.8[a]	4.2[b]	5.4[b]	0.52	0.03

[1]% of DM.
[a-c]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

Level of CCDS did not impact DM indicating sufficient drying had occurred pre-baling (Table 6). Fat and CP content were increased significantly by adding CCDS when compared to bales that had no CCDS added, but CP and fat were not different between bales that had 16 or 32% CCDS added to the bales. Compared to bales that had no CCDS added, fiber was decreased ($P \leq 0.01$) by 14.6 and 24.7% for 16 and 32% bales, respectively. Therefore, successful within-bale storage occurred.

Issues associated with applying CCDS to hay were not encountered, but 32% windrows were more difficult to bale. We had no baling issues when CCDS was applied at 16% or 20% rates. Additional drying time beyond that allowed in the current study may be necessary when levels greater than 25% are applied. In both experiments, bales wrapped, handled, and kept adequately for several months post-baling. Applying CCDS to grass hay windrows before baling had no impact on DM or subsequent heat production. Improvement of nutrient values implies windrow application is an effective storage method. This strategy could be utilized to increase the quality of low to medium quality forages.

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