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Applying corn condensed distillers solubles to hay windrows before baling: Effects on bale temperature, nutrient composition, and growing steer-calf performance[1]

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ABSTRACT

Three experiments were conducted to evaluate an alternative method of storing and feeding liquid ethanol coproducts while improving hay bale nutrient quality. In Exp. 1 and 2, corn condensed distillers solubles (CCDS) were applied to native grass windrows producing large, round bales. Inclusion levels (percentage of bale weight, DM) equaled 0 or 20% (Exp. 1) and 0, 16, or 32% (Exp. 2). Level did not affect internal temperature or DM, and 20% CCDS bales had increased ($P < 0.01$) CP and fat compared with 0% CCDS bales (Exp. 1). No effect of level was observed for DM in Exp. 2, and CP and fat linearly increased ($P = 0.02$). Bales from Exp. 2 were fed in an 84-d growing period (Exp. 3) with individually fed steers ($n = 60$, initial BW = 288 ± 11.6 kg) using a 2 × 3 factorial arrangement of treatments. Treatment factors included CCDS level (0, 15, or 30% of diet, DM) with or without supplemental metabolizable protein. Gain and ending BW linearly ($P \leq 0.01$) improved as CCDS inclusion increased. Feed efficiency improved linearly ($P \leq 0.01$) as CCDS increased but was also enhanced by supplemental metabolizable protein. Data suggest 32% CCDS can be applied to windrows with the methods used in this experiment without affecting internal bale heating or moisture retention. Nutrient analyses and cattle response to increasing CCDS validate that within-bale storage occurred and improved nutrient quality of the bale.

Key words: bale, beef cattle, distillers solubles, protein, storage

INTRODUCTION

In the Midwest, wet ethanol coproducts are excellent sources of protein and energy in beef cattle diets, and historically the price of these feedstuffs declines during late summer (Waterbury and Mark, 2008). Thus, an opportunity to purchase coproducts at lower prices may be provided to cow-calf, backgrounding, or both types of operations, but storage methods are needed until feeding in the fall or winter. Corn condensed distillers solubles (**CCDS**) is a nutrient-dense, wet (DM = 23–45%) ethanol coproduct often sold at a discount to distillers grains. Because CCDS is a liquid, storage in bulk tanks is ideal, but bagging (Peterson et al., 2009; Wilken et al., 2009) or bunkering (Warner et al., 2011) the product with low-quality forage has also been conducted. These storage techniques require investment in equipment and facilities for mixing, packing, and delivering the feed (Lardy, 2007), which may not be practical for producers in extensive production settings.

Hay production is often a necessary component of the cow-calf industry (Nayigihugu et al., 2007; Phillips et

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al., 2011). The chemical composition of harvested forage is frequently less than desired due to advanced plant maturity at harvest (Volesky et al., 2002) and harvesting conditions (Han et al., 2004). Therefore, a management strategy designed to store CCDS while concurrently improving bale nutrient content may be a better storage method when CCDS is less expensive (i.e., in the summer at hay harvest). In theory, the nutrient composition of hay bales could be improved such that additional supplementation of protein or energy may not be needed. Verifying within-bale storage of CCDS is necessary, and the performance of growing cattle fed CCDS-treated bales can indicate whether storage was successful. Our objectives of these 3 experiments were (1) to evaluate the ability to store CCDS in large, round bales by application to hay windrows before baling; (2) to determine the influence of CCDS on internal bale temperature after baling and hay nutrient composition; and (3) to evaluate the feeding value of hay bales previously treated with CCDS and thus determine the extent of within-bale storage.

MATERIALS AND METHODS

All procedures and facilities described in the following experiments were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee.

Exp. 1

Equipment and Treatments. This experiment was conducted at the University of Nebraska–Lincoln Dalbey-Halleck Research Unit located near Virginia in southeast Nebraska. In 2010 one 16.2-ha field of tallgrass prairie was swathed in late July. Predominant forage species included big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Hay was allowed to dry in windrows without raking for 3 d. Following drying, CCDS (Table 1) were sourced and delivered from a commercial ethanol plant (E-Energy Adams, Adams, NE), off-loaded into a 3,785-L liquid trailer, and applied directly to windrows before baling. The trailer was equipped with (1) an electric shut-off valve (Banjo Corp., Crawfordsville, IN); (2) a flow meter (Raven Industries, Sioux Falls, SD); and (3) a spray boom allowing the rate and total volume of CCDS applied to be measured and subsequently calibrated for correct application. Application of CCDS to windrows began in late morning and was completed by late afternoon the same day. Windrows were baled using a large, round baler once determined sufficiently dry by visual appraisal, and all hay regardless of treatment was baled within 24 h of CCDS application. Each bale was assigned an individual number and moved to the edge of the field. All bales were placed in rows, positioned end to end, and stored directly on the ground without covering.

Corn condensed distillers solubles were applied to windrows in 1 of 2 treatments: (1) 0% or (2) 20% CCDS of bale weight (DM basis), producing 0% (n = 45) or 20% (n = 36) bales, respectively. Treatments were applied to windrows in alternating fashion allowing for equal representation of treatments across the field. The percentage of CCDS inclusion (DM basis) was calculated for each individual bale. Inclusion rates were originally calculated based on assumed DM values for CCDS (35%) and control hay (90%), and then the actual inclusion rates were determined retrospectively after adjusting for the observed DM for CCDS (37.5%) and hay (90.4%).

Table 1. Nutrient analysis of corn condensed distillers solubles (CCDS) applied to grass hay windrows before baling in both Exp. 1 and Exp. 2 (DM basis)

Item	Exp. 1	Exp. 2
DM,[1] %	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]As-is basis.

Temperature Recordings, Core Sampling, and Nutrient Analyses. Internal bale temperatures were recorded at 2 and 3 wk after baling on a subset of 8 randomly selected bales within each treatment, and bales were rerandomized before each measurement. Temperature was measured using a 76-cm-long digital hay probe (AgraTronix, Streetsboro, OH) placed at 5 locations on the curved side of each bale. At each measurement, the probe was inserted horizontally at a point within the approximate mid-section of the bale. To allow for calibration between bales, 1 min was allowed to elapse before recording the temperature. For each bale, all 5 temperature measurements within collection date were averaged with the mean value used for analysis.

Core samples were collected at 0, 2, 3, and 24 wk after baling from a subset of 8 randomly selected bales within each treatment, and bales were again rerandomized before each sampling time point. The 0-wk time point occurred 3 to 4 h after baling. Samples were collected using a 91-cm-long, 1.3-cm-diameter drill-powered hay probe, with the probe positioned horizontally at a point within the approximate mid-section of each bale as approved by the National Forage Testing Association (2012). Two samples were collected from each bale, one from either curved side at opposite points, and were composited and frozen until analysis. Dry matter was determined by drying samples in a 60°C forced-air oven for 48 h (Buckner et al., 2011). Dried samples were then ground to pass through a 1-mm screen (Thomas Scientific, Swedesboro, NJ). Nitrogen content was measured by combustion method (AOAC, 1990; method 968.06; LECO Corporation, St. Joseph, MI), and CP was derived by multiplying N% by 6.25. Fat was evaluated using the gravimetric biphasic lipid extraction