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Evaluation of Storage Covers When Wet Distillers Byproducts Are Mixed and Stored with Forages

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Summary

Wet corn co-products were mixed with forage and stored in 55 gallon barrels with different covers mimicking bunker storage methods to determine shrink losses and spoilage. Three mix combinations and seven cover treatments were used to compare spoilage levels of covered co-product mixes vs. uncovered mixes. Spoilage and losses of the mix were effectively reduced with all covers, with losses reduced from 8 to 9% when uncovered, to 1 to 5% when different cover treatments were used.

Introduction

Wet distillers grains plus solubles (WDGS) have a relatively short shelf life and spoilage can occur within a few days depending on the extent of oxygen exposure and ambient air temperature. Also, WDGS is delivered in semi-truck load quantities, making it impractical for use on smaller livestock operations that cannot feed up large quantities within a few days. In addition, seasonality of feedlot cattle numbers affects the price of WDGS, thereby making it economical for both feedlots and cow-calf producers to purchase it in the summer and use it later in the year or in the winter. Previous research has focused on methods to "bulk" up WDGS or solubles for storage in either silo bags or bunkers. When bunker storage is used (likely the most predominant storage method), losses or shrink are important and likely minimized depending on how the bunker is covered. Therefore, the objective of the current study was to evaluate different covers for bunkers by determining spoilage and losses when distillers byproducts are mixed with forage and covered in different ways.

Procedure

Storage

To replicate a bunker storage environment, a combination of 70% WDGS and 30% ground cornstalks (DM basis) was mixed and packed in 55 gallon steel barrels at the University of Nebraska Research Feedlot near Mead, Neb. Stalks were ground using a tub grinder with a 5-inch screen. Each barrel was filled with approximately the same weight of mix and packed to a similar height. Weights (as-is) were recorded for each barrel and samples were collected for DM determination. The height by barrel also was recorded. Table 1 provides the composition of mixes tested and corresponding barrel cover treatments for the three experiments. Within each experiment, cover treatments were assigned randomly to each barrel. Barrels contained approximately 300 lb of as-is mix with 3.14 ft^2 of surface area exposed.

Cover Treatments

In Exp. 1, three covers were evaluated: an open, uncovered treatment (Control; Figure 1); a plastic cover (6 mil thickness) weighted with sand to mimic tires that would be used in commercial sized bunkers; and salt added as a cover at the rate of 1 lb per ft^2 of surface area (Figure 2). Barrels were housed indoors in temperature-controlled rooms and undisturbed for 57 days.

In Exp. 2, three cover treatments with two different mixes were evaluated. One of three cover treatments was assigned randomly to barrels

Table 1. Mixture composition (% DM basis) and corresponding cover treatments for three experiments in 55-gallon barrels to mimic storage bunkers.

Exp. 1			
WDGS	Corn Stalks		Cover
70	30		Open[1]
70	30		Plastic with sand[2]
70	30		Salt[3]
Exp. 2			
WDGS	Solubles	Straw	Cover
70	—	30	Open[1]
70	—	30	Solubles[4]
70	—	30	Solubles with salt[5]
—	70	30	Open[1]
—	70	30	Solubles[4]
Exp. 3			
WDGS		Straw	Cover
70		30	Open[1]
70		30	Open with H_2O[6]
70		30	Open (outside)[7]
70		30	Solubles with salt[5]
70		30	Solubles with salt and with H_2O[5,6]

[1]Open barrel has no cover and is considered control.
[2]Plastic with 6-mil thickness used as a cover and sealed on outside of the barrel with tape and weighted down with sand.
[3]Salt was added at a rate of 1.0 lb/ft^2.
[4]Solubles were added to simulate a 3-in cover equivalent, 45 lb (as-is); 16 lb of DM required in the barrel to provide 3 in.
[5]Salt was added to solubles at rate of 1.0 lb/ft^2.
[6]Water was applied to an uncovered barrel by hand 1 time per week equivalent to .6 in of rain.
[7]Barrels were stored outdoors uncovered and subjected to all environmental factors.

Figure 1. Picture of Control (uncovered) barrels depicting spoilage layer, fresh layer, and markings for determining the height of spoilage.

Figure 2. Salt cover illustrating amount of salt (1 lb/ft^2) added and change in height.

that contained a 70:30 ratio (DM basis) of WDGS:straw. Another mix containing a 70:30 ratio of distillers solubles and straw was used to evaluate only two cover treatments. The three cover treatments evaluated with WDGS:straw mixtures included no cover (Control), solubles added directly to the top as a cover (Solubles; Figure 3), and addition of solubles combined with salt (Sol+Salt). Solubles were added in quantity to provide a 3-inch thick cover which equated to 45 lb (as-is) or 16 lb of DM. For the Sol+Salt treatment, the same quantity (45 lb) of solubles was added; however, salt was mixed with solubles at the same rate of 1 lb per ft^2 of surface area (3.14 lb of salt). The two cover treatments evaluated with the solubles:straw mixture were a Control (no cover) and the Solubles cover treatment. The same sampling and process was used as for Exp. 1. Barrels were housed indoors in temperature controlled rooms and were undisturbed for 62 days.

In Exp. 3, five cover treatments were evaluated with a mixture ratio of 70% WDGS and 30% straw. The cover treatments included: a Control (no cover) and Sol+Salt cover (similar to that in Exp. 2), both stored indoors in temperature controlled rooms; an open barrel stored outdoors where temperature and moisture would fluctuate; an open barrel housed indoors with simulated rainfall of 0.6 in. of water once weekly; and a Sol+Salt treatment housed indoors, with simulated rainfall of 0.6 in. of water once weekly. Barrels were stored for 56 days from March 15 to May 15, 2009.

When each barrel within the three treatments was opened, total barrel weight and mix height measurements were taken to determine DM loss of the product. Surface spoilage content was measured for depth, removed, and weighed. On treatments with distillers solubles as a cover, depth measurements were taken, and the solubles were removed and weighed. The unspoiled portion of the mix also was measured for depth, then removed and weighed. Representative samples of spoiled material, unspoiled or "normal" material, and solubles (if present for that treatment) were taken from within each individual barrel to be used for analysis. Spoilage was based on visual appraisal (Figure 1).

Samples either were frozen or a subset was dried in a 60° C forced air oven for 48 hours to obtain DM. Frozen samples were freeze dried for subsequent quality analysis. Freeze-dried samples were ground through a Wiley Mill (1 mm screen) and analyzed for *in vitro* DM digestibility, determined by a 30-hour incubation of 0.3 g substrate in a 1:1 mixture of McDougall's buffer (1g Urea/L) and rumen fluid collected from steers fed a forage-based diet. Tubes were stoppered, flushed with CO_2, incubated at 39ºC, and swirled every 12 hours. After 30 hours, 6 mL of 20% HCl solution and 2 mL of 5% pepsin solution were added to each tube. Tubes were then incubated at 39ºC for 24 hours. Residue from the tubes was filtered and

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dried in a 60°C forced air oven for 24 hours.

The goal of this research was to evaluate covers for bunker storage using a barrel as a model and to allow for replication that is not possible with large, commercial size bunkers. Data were calculated for amount of spoilage and amount of DM that was not recovered for a barrel approximately 27 inches in height. A key assumption was that all spoilage and losses would occur from the top where stored material was exposed to oxygen. Therefore, the amount of DM that was spoiled or not accounted for (loss) was extrapolated to a barrel that was 10 ft in height to mimic a 10-ft bunker storage facility. Data are presented as both a barrel and a bunker; a bunker is defined as a 10-ft height that would contain the same density of weight extrapolated to that height. Data were analyzed as completely randomized design experiments in SAS (SAS Institute, Cary, N.C.) with barrel as the experimental unit. Data were analyzed separately by experiment and separately based on the mix of distillers solubles with straw or WDGS with straw in Exp. 2.

Results

In Exp. 1, approximately 124 lb of DM were added to barrels, and cover treatment affected ($P < 0.01$) spoilage and loss (Table 2). Barrels covered in plastic had the least amount ($P < 0.05$) of spoilage and loss compared to either Control or Salt covers. Salt was intermediate ($P < 0.05$) to Control and Plastic covers. Depth of surface spoilage of barrels was consistent among treatments and across experiments, ranging from about 8 to 10 in on average. When spoilage loss was calculated for a 10-ft bunker situation, DM losses ranged from 1.2 to 3.8% loss and were affected ($P < 0.01$) by cover treatment with the same statistics as the barrel measurements. Spoilage also was affected ($P < 0.01$), with only 0.6% spoilage in the Plastic cover treatment for a 10-ft bunker compared to 3.7% spoilage when the bunker was left

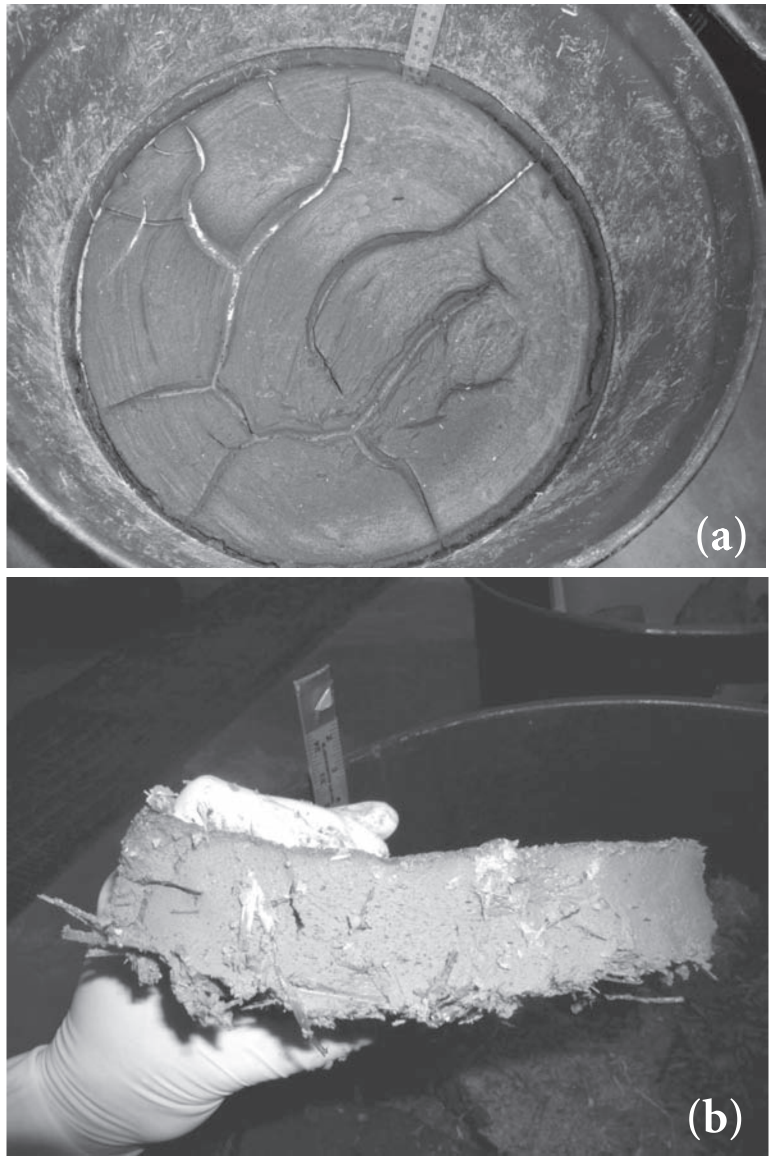

Figure 3. (a)Solubles as a cover and (b)solubles layer following approximately 60 days of storage illustrating loss of moisture and DM over time from the solubles as a cover.

Table 2. Effect of storage covers for storing 70% WDGS with 30% ground corn stalks on DM loss and spoilage in Exp. 1.

	Control	Plastic	Salt	F-test
Barrel				
DM added, lb	115.4	115.13	114.8	0.95
DM spoilage, lb	20.2^{a}	3.1^{b}	19.8^{a}	< 0.01
DM loss, lb	17.6^{a}	0.0^{c}	4.2^{b}	< 0.01
10 ft. Bunker[1]				
% DM loss[2]	3.4^{a}	0.0^{c}	$.82^{b}$	< 0.01
% Spoilage[3]	3.9^{a}	0.61^{b}	3.8^{a}	< 0.01
% DM spoilage & loss	7.4^{a}	$.57^{c}$	4.7^{b}	< 0.01

[1]Losses and spoilage extrapolated to a bunker storage facility with 10 ft height assuming all losses are from the surface and therefore the same whether a 27-in barrel or 10-ft bunker.
[2]% DM loss calculated based on the amount of loss as a percent of the total stored in a 10-ft tall bunker. The weight in a 10-ft bunker with 3 ft^2 surface area is calculated from DM density added to barrels.
[3]% Spoilage calculated similar to method for calculating % DM loss but with amount of spoilage DM.
[a,b,c]Means with different superscripts differ ($P < 0.05$).

Table 3. **Effect of storage covers for storing 70% WDGS with 30% straw on DM loss and spoilage in Exp. 2.**

	Control	Solubles[1]	Sol+Salt[1,2]	F-test
Barrel				
DM in, lb	94.9[a]	90.9[ab]	87.8[b]	0.04
DM spoilage, lb	22.1[a]	8.6[c]	11.6[b]	< 0.01
DM loss, lb	13.3[a]	.35[b]	1.55[b]	0.02
10-ft. Bunker[3]				
% DM loss[4]	2.9[a]	.07[b]	.37[b]	0.02
% Spoilage[5]	4.9[a]	2.0[b]	2.7[b]	< 0.01
% DM spoilage/loss	7.9[a]	2.1[b]	3.1[b]	< 0.01
Barrel – Solubles as Cover				
Solubles DM in		16.0	16.0	—
Solubles DM recovered[6]		8.1	10.3	< 0.01
Solubles DM loss % [7]		49.6	35.2	< 0.01

[1]Solubles were added to simulate a 3-in cover equivalent, 45 lb (as-is); 16 lb of DM required in the barrel to provide 3 in.
[2]Salt was added to soluble at rate of 1.0 lb/ft^2.
[3]Losses and spoilage extrapolated to a bunker storage facility with 10 ft height, assuming all losses are from the surface and therefore the same whether a 27-in barrel or 10-ft bunker.
[4]% DM loss calculated based on the amount of loss as a percent of the total stored in a bunker that is 10 ft tall. The weight in a 10-ft bunker with 3 ft^2 surface area is calculated from DM density added to barrels.
[5]% Spoilage calculated similar to method for calculating % DM loss but with amount of spoilage DM.
[6]lb of DM measured in solubles left after storage.
[7]Loss of DM from solubles expressed as a % of solubles added as a cover.
[a,b,c]Means with different superscripts differ ($P < 0.05$)

Table 4. **Effect of storage covers for storing 70% WDGS with 30% straw on DM loss and spoilage in Exp. 3.**

	Control[1]	Control[2]	Control[3]	SOL+Salt[4]	SOL+Salt [2,4]	F-test
Barrel						
DM in, lb	94.6	96.3	100.2	101.4	99.6	0.43
DM spoilage, lb	21.0[a]	16.9[a]	20.5[a]	9.4[b]	6.6[b]	< 0.01
DM loss, lb	11.7[b]	8.04[b]	20.2[a]	0.0[c]	0.0[c]	< 0.01
10-ft Bunker [5]						
% DM loss [6]	2.7[b]	1.8[b]	4.4[a]	0.0[c]	0.0[c]	< 0.01
% Spoilage [7]	4.9[a]	3.9[a]	4.5[a]	2.1[b]	1.5[b]	< 0.01
% DM spoilage/loss	7.7[ab]	5.7[b]	8.9[a]	1.4[c]	0.0[c]	< 0.01
Barrel – Solubles as Cover						
Solubles DM in				16.0	16.0	
Solubles DM recovered [8]			11.5	11.3	0.71	
Solubles DM loss % [9]				27.9	29.4	0.71

[1]Open barrel has no cover and is considered control.
[2]Water was applied to barrel by hand 1 time per week equivalent to .6 in of rain.
[3]Barrels were stored outdoors uncovered and subjected to all environmental factors.
[4]Solubles were added to simulate a 3-in. cover equivalent, 45 lb (as-is); 16 lb of DM required in the barrel to provide 3 in; in addition, salt was added at a rate of 1 lb/ft^2 of surface area.
[5]Losses and spoilage extrapolated to a bunker storage facility with 10 ft height assuming all losses are from the surface and therefore the same whether a 27-in barrel or 10-ft bunker.
[6]% DM loss calculated based on the amount of loss as a percent of the total stored in a bunker that is 10 ft tall. The weight in a 10-ft bunker with 3 ft^2 surface area is calculated from DM density added to barrels.
[7]% Spoilage calculated similar to method for calculating % DM loss but with amount of spoilage DM.
[8]lb of DM measured in solubles left after storage.
[9]loss of DM from solubles expressed as a % of solubles added as a cover.
[a,b,c]Means with different superscripts differ ($P < 0.05$)

uncovered. It is unclear whether spoilage and losses should be combined. Most producers would likely feed the spoiled material; however, when spoiled and lost amounts were added, there was 1.8% spoilage/loss from Plastic cover treatments compared to a 7.5% loss from uncovered treatments (Control), with Salt covering being intermediate.

In Exp. 2, cover treatment affected both spoilage ($P < 0.01$) and loss ($P = 0.02$), with Solubles or Sol+Salt covers resulting in less spoilage and loss ($P < 0.05$) compared to uncovered barrels (Control; Table 3). The same trend was observed for bunker storage with total spoilage and loss cut in half for Solubles or Sol+Salt (4.6 or 5.4%) compared to Control (uncovered) bunkers (9.3%). However, when solubles were used as a cover, it was necessary to account for the amount of solubles lost. Approximately 50% of the solubles' DM was lost when added as a 3-in cover; this loss was reduced ($P < 0.01$) to 35% when 1 lb/ft^2 of salt was mixed with solubles prior to covering. Therefore, not all of the solubles were retained when used as a cover treatment for bunkers.

In Exp. 3, when water was added by simulating a 0.6 in rainfall once a week, spoilage and losses were not decreased in barrels, but they were decreased when data were extrapolated to a bunker situation (Table 4). When barrels were stored outside and exposed to both precipitation and temperature fluctuations, then DM losses were greater in a bunker situation than when water was added to barrels stored indoors with no fluctuation in temperature. It is unclear why temperature fluctuation may increase losses. Within the same experiment, adding solubles and salt, either with simulated rainfall (0.6 in per week) or without added water, dramatically decreased ($P < 0.05$) spoilage and losses in the barrels and when extrapolated to a bunker. Similar to Exp. 2, 28 to 29% of the solubles' DM was lost when used as a cover, but appeared to be effective at reducing spoilage and losses of the stored WDGS:straw mix.

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In Exp. 2, a mix of 70% distillers solubles and 30% straw also was tested. The Control treatment showed a loss of 2.3% in a 10-ft bunker, but this loss was numerically reduced when solubles alone were added as a cover (Table 5). However, no difference was observed between the Control or solubles coverings for distillers solubles mixed with straw for total spoilage and losses in a bunker. Again, 36.8% of the 3-in covering of solubles was lost.

Results from the *in vitro* DM disappearance suggest little difference between spoiled material and non-spoiled material (data not shown; Exp. 1 and Exp. 2 only). The *in vitro* DM digestibility averaged 51.8% for spoiled material and 51.5% for non-spoiled material. Solubles used as a cover averaged 62.3% digestible; however, this is not compared to fresh solubles. Clearly, it is expected that spoiled and non-spoiled material would have different feeding value. These data suggest that the spoiled material is not markedly different when compared to the non-spoiled material and therefore could be fed to livestock.

Table 5. Effect of storage covers for storing 70% distillers solubles with 30% straw on DM loss and spoilage in Exp. 2.

	Control	Solubles	F-test
Barrel			
DM in, lb	96.9	87.2	0.02
DM spoilage, lb	12.1	11.6	.33
DM loss, lb	10.3	1.55	< 0.01
10-ft Bunker			
% DM loss	1.6	.36	< 0.01
% Spoilage	1.9	2.7	< 0.01
% DM spoilage & loss	3.5	3.1	0.22
Barrel – Solubles as Cover			
Solubles DM in		16.0	
Solubles DM recovered		10.1	
Solubles DM loss %		36.8	

Based on barrel storage, leaving a mix of WDGS and forage (70:30 ratio, DM basis) uncovered results in DM losses ranging from 3.5 to 5.0% in a 10-ft bunker. If spoilage is included as a loss, then the percentages range from 7.5 to 9.3% of DM. Plastic appears to be the most effective cover for reducing losses and spoilage, followed by solubles, salt, or combinations of the two. If solubles are used as a cover, one should expect that 25 to 50% of the solubles themselves will be lost as they dry during storage.

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