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Cattle preference for hay from round bales with different wrap types

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ABSTRACT

Three different methods of wrapping and storing alfalfa hay in round bales were used to explore possible differences in preferential consumption. Large round bales of alfalfa were stored indoors, outdoors with conventional net wrap, or outdoors with a new wrap that incorporates a breathable film. This film is intended to better conserve hay in round bales by shedding precipitation but allowing internal moisture to exit the bale through microscopic pores. Five separate preference trials, each of 18-d duration with six 3-d periods, were conducted using beef cattle. In all 5 preference trials, hay wrapped with breathable film was preferred over net-wrapped hay stored outdoors. For instance, in trial 1 hay wrapped with breathable film was preferred over net-wrapped hay stored outdoors in all 18 pairings ($P < 0.001$), and consumption of the film-wrapped hay was significantly greater (78 vs. 28% of total hay offered, $P = 0.05$). Results suggest that when bales are stored outdoors, cattle will strongly prefer to consume hay from bales wrapped with breathable film compared with net-wrapped bales. Although in 2 trials hay wrapped with breathable film was preferred over hay stored indoors, when considered across all trials and pairings, preference of hay from breathable film bales did not differ from that stored indoors.

Key words: bale, hay, preference, net wrap, storage method

INTRODUCTION

Feed cost is the single largest variable influencing profitability of the cow–calf enterprise (Miller et al., 2001). The large round bale is the predominant method used to package hay for beef cows. Uncovered bales stored outdoors are subject to considerable losses and deterioration of nutrient composition because of weathering (Russell et al., 1990; Bledsoe and Bates, 1992; Harrigan and Rotz, 1994; Collins et al., 1995; Shinners et al., 2009).

Additional losses can occur during feeding. Feeding losses can be attributed to feeding method, feeder design, cattle behavior, hay particle size, and hay nutrient composition (Belyea et al., 1985; Fisher et al., 1999). Uncovered round bales stored outside had feeding losses of 25% of DM compared with 12% for bales stored indoors (Belyea et al., 1985). Much of the waste was due to animal aversion toward the weathered hay. The type of bale wrap, which influences nutrient retention in the bale outer layer (Shinners et al., 2009), could influence total feeding losses.

To protect round bales from weathering, producers sometimes use a separate operation to wrap plastic film around the bale circumference. Unfortunately, moisture condenses at the interface between the bale and plastic, causing mold and algae growth (Shinners et al., 2009). A new type of bale wrap has recently been introduced to overcome these deficiencies. This wrap is applied at baling and is designed to shed precipitation but allow water vapor inside the bale to escape through microscopic pores (Tietz, 2013). In a manner similar to material used as air and water intrusion barriers in home construction, the film allows water vapor, but not liquid water, to pass through a matrix of high-density polyethylene fibers. This breathable film has been shown to reduce DM loss during storage (Shinners et al., 2010) but also might better conserve the outer layer of the bale, thereby reducing animal rejection. The per-bale cost of the wrap with breathable film is about 3.5 times that of conventional net wrap, so in addition to better DM conservation, reduced feeding losses and improved animal intake would help offset these costs. Therefore, the objective of this research was to investigate beef-cattle preferential consumption when offered

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alfalfa hay stored in large round bales with different wrap types.

MATERIALS AND METHODS

Breathable Films

This work was conducted during the development of the breathable films, so there were a variety of films used (Table 1). However, the differences were subtle and were more related to material cost than to performance in conservation of hay value. Losses during storage in bales with the breathable film wrap averaged 2% of DM (Table 1) over a storage period that spanned from July to May (325 d). Storage DM losses were determined using a procedure described by Shinners et al. (2010) in which 12 bore samples strategically distributed around the bale were used to calculate a volume-adjusted aggregate DM content. The construction of the breathable film G described in Table 1 is most closely related to the B-Wrap brand breathable film currently commercially available (Ambraco Inc., Dubuque, IA; Anonymous, 2013).

Trial No. 1

Second-crop alfalfa at one-quarter bloom was cut on July 4, 2005, and baled in 150-cm-wide by 180-cm-diameter round bales on July 8 using a John Deere 567 (John Deere, Ottumwa, IA) round baler. No rain occurred

Table 1. Treatment identification and characteristics of each treatment for alfalfa hay bales made for the 5 preference trials[1]

		Bale moisture			% of DM					
Trial and treatment	Storage surface[2]	Initial (% wb)	Final[4] (% wb)	DM loss[3] (% of initial)	CP	ADF	NDF	TDN	DDM	RFV
Trial no. 1										
BFA	Sod	18.6	18.5	2.0	18.4	30.1^{a}	40.4^{a}	58.6^{b}	64.1^{b}	151^{c}
BFB	Sod	18.1	20.5	2.8	17.6	32.1^{b}	44.0^{b}	55.7^{a}	61.2^{a}	138^{ab}
NWO	Sod	18.5	20.9	7.3	17.9	31.0^{ab}	41.7^{ab}	56.1^{a}	61.6^{a}	145^{bc}
NWI	Concrete	14.2	15.6	1.0	17.8	32.3^{b}	44.5^{bc}	55.6^{a}	61.1^{a}	133^{a}
	LSD (P = 0.05)				1.2	1.7	2.6	1.9	1.9	10
Trial no. 2										
BFC	Rock	20.6	15.3	1.7	20.6^{b}	39.9^{a}	47.7^{a}	56.0^{b}	57.8^{b}	113^{b}
BFD	Rock	19.5	15.4	1.5	18.5^{a}	43.7^{b}	51.7^{b}	52.0^{a}	54.9^{a}	99^{a}
NWO	Rock	18.3	20.7	11.2	19.4^{ab}	43.1^{b}	52.1^{b}	52.6^{a}	55.3^{a}	99^{a}
NWI	Gravel	20.2	15.0	2.4	20.2^{ab}	40.6^{a}	49.2^{a}	53.6^{ab}	56.1^{ab}	102^{a}
	LSD (P = 0.05)				1.8	2.1	1.9	2.9	2.1	10
Trial no. 3										
BFE	Rock	15.1	15.7	2.1	19.7^{b}	41.0^{a}	48.1^{a}	54.8^{c}	57.0^{c}	110^{c}
BFF	Rock	18.6	15.5	1.0	17.4^{a}	42.5^{b}	51.8^{b}	51.6^{a}	54.6^{a}	95^{a}
NWO	Rock	18.1	16.9	5.4	18.0^{a}	42.8^{b}	52.3^{b}	52.9^{b}	55.5^{b}	99^{b}
NWI	Gravel	16.7	15.0	2.4	20.1^{b}	40.0^{a}	48.8^{a}	55.6^{c}	57.5^{c}	109^{c}
	LSD (P = 0.05)				1.2	1.4	1.6	0.9	0.6	3
Trial no. 4										
BFG	Rock	19.3	14.5	2.1	18.0^{a}	41.0^{ab}	49.7^{a}	54.8^{bc}	57.0^{bc}	107^{bc}
NWO	Rock	18.5	20.7	11.2	19.9^{b}	42.9^{b}	52.3^{b}	52.8^{b}	55.5^{b}	99^{ab}
NWO	Sod	19.1	24.9	12.4	17.3^{a}	45.3^{c}	55.6^{b}	50.3^{a}	53.6^{a}	90^{a}
NWI	Gravel	20.1	15.0	2.4	18.4^{a}	39.7^{a}	48.5^{a}	56.2^{c}	58.0^{c}	111^{c}
	LSD (P = 0.05)				1.4	2.0	3.5	2.3	1.7	9
Trial no. 5										
BFH	Rock	20.4	15.6	2.2	19.4^{c}	41.7^{b}	48.9^{a}	55.9^{c}	57.7^{c}	111^{c}
BFH	Sod	14.9	17.8	2.3	16.4^{a}	46.9d	56.4^{b}	49.1^{a}	52.8^{a}	86^{a}
NWO	Rock	19.7	24.9	12.4	17.7^{ab}	44.5^{c}	55.0^{b}	51.1^{b}	54.3^{b}	92^{b}
NWI	Gravel	15.7	15.0	2.4	18.7^{bc}	39.4^{a}	48.4^{a}	56.6^{c}	58.2^{c}	112^{c}
	LSD (P = 0.05)				1.6	2.2	3.2	0.8	0.6	3

[a–c]Different letters in the same column are statistically different.

[1]wb: wet basis; DDM: digestible DM; RFV: relative feed value; BFA–BFH: breathable film stored outdoors; NWO: net wrap stored outdoors; NWI: net wrap stored indoors; LSD: least significant difference.

[2]Rock surface consisted of a 10-cm layer of 3- to 6-cm-diameter rocks.

[3]Loss of DM during the storage period. See Shinners et al. (2010) for procedure.

[4]Aggregate moisture of whole bale at removal from storage. See Shinners et al. (2010) for procedure.

during field drying. Hay DM content at baling, determined using two 10-cm bore samples per bale to a depth of 55 cm that were oven dried at 103°C for 24 h, ranged from 81 to 86%. Four treatments of 4 bales each were prepared: net-wrapped bales to be stored both indoors and outdoors, and bales wrapped with 2 different breathable films (**BF**, BFA and BFB, Table 1). One bale each of the 4 treatments was baled in succession, and this pattern was repeated across the field until 4 bales of each treatment were formed. The outdoor-stored treatments were placed directly on grass sod with the bales tightly butted together in a row oriented roughly north to south on a gentle slope. The bales stored indoors were placed on a concrete surface in a completely enclosed shed.

Bales were removed from storage on May 24, 2006, and were generally well-conserved (Table 1). Although the color of the hay beneath BFA and BFB treatments was bleached, it had a pleasant odor and did not have the black, weathered appearance of the outdoor-stored, net-wrapped treatment (**NWO**). The net-wrapped, stored-indoors (**NWI**) bales had a good green color but had a slightly musty odor.

Only the outer rind (15–20 cm) of each bale was offered because nutritional analyses of samples from the bale cores were similar for all treatments. The base of the bale in contact with the ground was also not included because it was felt that including this spoiled material might have caused the animals to refuse all treatments because it would have been such a large fraction of the total hay offered when only the outer rind was offered. The outer rind of each bale was removed and collected on a tarp so fine material was not lost. This process was repeated using 4 bales per treatment, which resulted in approximately 350 kg of DM per treatment. The material was then processed through a Fox model 6244 forage harvester (Fox River Tractor Co., Appleton, WI; length of cut = 15 mm) to improve homogeneity and to reduce the chance for sorting. Fines were captured from underneath the machine and recombined with the chopped material.

The feeding trial was arranged into 6 periods that each lasted 3 d. The 4 treatments necessitated 6 different pairings, and with the 6 pairings, 6 different animals were used so every animal could be offered all treatments across the entire trial (balanced incomplete block design). Cattle were weighed at the start of the adaptation period, upon initiation of experimental period 1, and at the conclusion of period 6. Animal weights at the beginning of period 1 and end of period 6 and daily gains of yearling beef heifers (Angus and Simmental crosses) are presented in Table 2. The cattle were removed from pasture and were housed indoors for the trial in individual 6.4 m × 3 m pens bedded with sawdust. Prior to the start of the trial, each animal was topically treated with Ivomec (Merial Limited, Duluth, GA) at recommended levels for parasite control. Throughout the trial, the animals received free choice mineral from trace-mineral salt blocks. All animal care and experimental procedures were approved by the CALS Animal Care and Use Committee at the University of Wisconsin–Madison.

One-half of the animal's diet consisted of corn silage because there was limited hay available, and by incorporating corn silage the animal would not be forced to eat a full diet of hay if both treatments had low nutrient content. A 10-d adaptation period was used at the beginning of the trial, similar to Fisher et al. (1999). During the adaptation period, each of the 4 experimental treatments was offered for at least 2 d to all cattle. The corn silage averaged 39% DM, and the 4 hay treatments averaged 84% DM. For the first 3 periods, corn silage DM was offered at 1% of BW. At the end of the third period, the corn silage DM was increased to 1.25% because of an increase in body mass. The daily amount of each treatment of hay DM offered was always equal to that of the corn-silage DM offered.

Three feed bunks were hung on the outside of each pen, providing separate space for the corn silage and each treatment of the hay pair presented. The corn silage was always offered in the middle bunk and the hay treatments in the side bunks. To eliminate the possible effect of habit and learning, the hay treatments were not offered in the same feed bunk location each day (Fisher et al., 1999). Animals were penned individually because animals within a group may differ significantly from the mean in

Table 2. Beef cattle mass at beginning of period 1 and end of period 6 and daily gain during preference trials

	Preference trial no.				
Item	**1**	**2**	**3**	**4**	**5**
BW					
Initial (kg)	223	367	350	387	406
Final (kg)	250	388	370	416	432
Daily gain (kg/d)	1.49	1.14	1.11	1.59	1.41
Corn silage consumption[1] (% of DM)	92	92	87	87	95

[1]Fraction of the corn silage DM offered that was actually consumed.

feed preferences and nutrient tolerances, therefore masking the effect of preferences (Atwood et al., 2001).

Feeding occurred each morning at approximately 0700 h. Refusals from the previous day were first collected and weighed, and the bunks were cleaned. All refusals were discarded and not reused. The heifers were then presented with the corn silage about 30 min before the hay treatments. This gave the heifers time to consume a good portion of the corn silage and obtain some gut fill.

Hay samples from 3 periods were randomly selected for a basic near infrared analysis by Dairyland Labs (Arcadia, WI) to obtain ADF, NDF, and CP concentrations, and from these the DM digestibility, TDN, and relative feed value (**RFV**) were calculated from the constituent values.

Trials No. 2 to 5

Second-crop alfalfa was cut on July 3, 2008, and baled in 150-cm-wide by 180-cm-diameter round bales on July 6 using a John Deere 567 round baler. Baling and bore-sampling procedures were similar to those described above. No rain occurred during field drying. Hay DM content at baling ranged from 85 to 79%, with an average for all bales of 82%. The outdoor stored treatments were placed either on grass sod or on a rock pad consisting of a 10-cm layer of rocks of approximate 3- to 6-cm diameter. All bales were tightly butted together in a row oriented roughly north to south on a gentle slope. The bales stored indoors were placed on a gravel pad in an open-front hay shed.

Four trials were conducted, and in each trial 4 treatments were compared. In trials 2 and 3, animal preference for hay wrapped with different breathable films was compared with net-wrapped hay stored both indoors and outdoors (Table 1). In trial 4, animal preference for hay wrapped with a single breathable film was compared with hay stored indoors; and hay wrapped with net wrap stored outdoors either on a rock pad or directly on the soil (Table 1). In trial 5, the treatments consisted of bales wrapped with breathable film stored either on a rock pad or on soil, and net-wrapped bales stored outdoors or indoors.

Bales were removed from storage on May 24, 2009. Preservation of hay DM was excellent for all bales wrapped with breathable film (Table 1), and the hay had a pleasant order without the black, weathered appearance common of the NWO treatments. The indoor-stored hay had a pleasant odor typical of dry hay stored under cover in an open-front hay shed.

In the first preference trial, only the outer layer of the bale was offered, but in trials 2 to 5 the entire bale was offered. The treatments were again size reduced to improve homogeneity and to reduce the chance for sorting, but these bales were size reduced by processing in a conventional tub grinder (Haybuster model H-1100, Jamestown, ND) equipped with 75-mm screens. Hay was stored in 1,100-L open-top tote bags until it was fed.

The procedures used in trials 2 to 5 were generally similar to those used in trial 1. Hay-bore samples were collected at the time the bales were removed from storage and were analyzed for composition using the procedure described above. The second and third trials were conducted simultaneously as were the fourth and fifth trials using 2 separate groups of 6 yearling steers (Red Angus and Angus crosses). Two separate groups of steers allowed for similar initial body masses for trials 2 to 5. Both corn silage and the hay treatments were offered at 1.25% (dry basis) of BW in all 4 trials. Cattle were reweighed at the midpoint of the experiment, and dry-mass offered was adjusted to maintain the target of 1.25% of BW.

Statistical Analysis

A Chi-squared test was conducted to determine statistical differences between the number of times one treatment in a pairing was preferred over another and to analyze the treatment pairing using the percentage of the material consumed within each pairing. The trials were also analyzed as a balanced incomplete block design because each pairing occurred the same number of times in the trial, with each daily pairing could be considered as a separate block. Analyzing in this fashion ensured that period, day, and animal effects were included in the analysis. Analyses were performed using JMP 9 statistical software (SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

Acceptable animal growth occurred in all trials (Table 2). Daily gains for the groups of yearling heifers or steers ranged from 1.11 to 1.59 kg.

The hay from the outer rind of bales wrapped with breathable film BFA generally had a more favorable nutritional composition among the 4 treatments in trial 1 (Table 1). The remaining 3 treatments had similar nutritional composition. All 3 statistical methods of analyzing the data indicated that the cattle preferred the hay from bales wrapped in breathable film and consumed 2 to 3 times as much of this hay compared with hay from net-wrapped bales (Table 3). Cattle consumed a statistically greater fraction of the BFA hay offered compared with the BFB offered, likely because of the differences in nutritional composition. Hay from bales stored indoors was not statistically preferred in any pairings, perhaps for 2 reasons. First, the RFV of this material was statistically less than for the BFA and NWO treatments. Second, although the NWI hay had a good green color and was well conserved (Table 1), it had a slightly musty odor, and this odor evidently was objectionable to the cattle. In this trial only the outer rind of the bale was offered, so the degree of preferential consumption in this trial could be expected to be greater compared with trials 2 to 5.

In trial 2, the BFC and NWI treatments had statistically lower ADF and NDF content than the BFD and NWO treatments (Table 1). The material in trials 2 to 5 was derived

Table 3. Consumption preference of alfalfa hay in 5 separate trials using different round bale wrap and storage treatments and analyzed using 3 different statistical approaches[1]

		Number of periods first treatment preferred[2] over second (18 total periods)		Fraction of treatment consumed within pairing (% of DM offered)		Total amount of each treatment consumed	
First treatment	Second treatment	no.	*P*-value	First	Second	Treatment	% of DM offered
Trial no. 1							
BFA	BFB	12	0.157	67[b]	47[a]	BFA	78[d]
BFA	NWO	18	<0.001	84[b]	15[a]	BFB	70[d]
BFA	NWI	18	<0.001	83[b]	22[a]	NWO	28[c]
BFB	NWO	18	<0.001	80[b]	23[a]	NWI	26[c]
BFB	NWI	18	<0.001	85[b]	10[a]	LSD (*P* = 0.05)	10
NWO	NWI	8	0.637	47	46		
Trial no. 2							
BFC	NWO	18	<0.001	88[b]	31[a]	BFC	78[e]
BFC	BFD	16	0.001	73[b]	46[a]	BFD	54[d]
BFC	NWI	16	0.003	73[b]	51[a]	NWO	34[c]
BFD	NWO	11	0.346	60	44	NWI	61[d]
BFD	NWI	10	0.637	55	59	LSD (*P* = 0.05)	7
NWI	NWO	16	0.001	73[b]	28[a]		
Trial no. 3							
BFE	NWO	15	0.005	37[b]	23[a]	BFE	42[e]
BFE	BFF	14	0.018	49[b]	24[a]	BFF	32[cd]
BFE	NWI	9	1.000	40	33	NWO	26[c]
BFF	NWO	11	0.346	39[b]	24[a]	NWI	35[de]
BFF	NWI	11	0.346	34	39	LSD (*P* = 0.05)	6
NWI	NWO	11	0.346	33	31		
Trial no. 4							
BFGr	NWOr	17	<0.001	81[b]	52[a]	BFGr	81[e]
BFGr	NWOs	17	<0.001	83[b]	45[a]	NWOr	55[d]
BFGr	NWI	10	0.637	79	66	NWOs	44[c]
NWOr	NWOs	13	0.059	58	49	NWI	75[e]
NWI	NWOs	18	<0.001	88[b]	38[a]	LSD (*P* = 0.05)	10
NWI	NWOr	10	0.637	72[b]	56[a]		
Trial no. 5							
BFHr	BFHs	11	0.346	43	42	BFHr	38[d]
BFHr	NWO	15	0.005	49[b]	25[a]	BFHs	36[d]
BFHr	NWI	1	0.000	23[a]	63[b]	NWOs	23[c]
BFHs	NWO	13	0.029	46[b]	25[a]	NWI	65[e]
BFHs	NWI	0	<0.001	20[a]	72[b]	LSD (*P* = 0.05)	9
NWI	NWO	13	0.005	59[b]	24[a]		

[a,b]Means in rows with different superscripts are different with 95% confidence based on analysis using chi test.

[c–e]Means in a column with different superscripts are different with 95% confidence using an ANOVA in a balanced incomplete block design.

[1]BFA–BFH: breathable film stored outdoors; NWO: net wrap stored outdoors; NWI: net wrap stored indoors. Nutrient composition provided in Table 1. Lowercase r and s indicate stored on rock or soil. LSD: least significant difference.

[2]Analysis using Chi-squared test to determine whether preference for first over second treatment was significant with 95% confidence ($P < 0.05$).

by tub grinding whole bales, so differences in hay quality in the outer rind were diluted by the greater mass of well-conserved hay in the bale core. Nonetheless, all 3 statistical methods indicated that the cattle preferred the hay from bales wrapped with the BFC breathable film in all pairings (Table 3). Despite overall good conservation (Table 1), the hay under the BFD material was observed to have a more weathered appearance than BFC-wrapped hay, and BFD had significantly lower TDN, digestible DM (**DDM**), and RFV, which likely accounted for the lack of preferential consumption of the BFD treatment. Indoor-stored hay was preferred ($P =$

0.001) over net-wrapped hay stored outdoors.

In trial 3, there was no statistical difference in DDM, TDN, or RFV between the BFE and NWI treatments (Table 1). The BFF and NWO treatments had significantly lower DDM, TDN, and RFV than did the other 2 treatments. Hay from bales wrapped with BFE was preferred ($P = 0.018$) over hay from the BFF and NWO treatments, but these were the only pairings that resulted in preferential consumption (Table 3). Hay consumption was less than in previous trials, averaging only 34% of DM offered, which might account for the lack of preferential consumption.

In trial 4, there was no statistical difference in DDM, TDN, or RFV between the BFG and NWI treatments (Table 1). The 2 NWO treatments had significantly lower DDM, TDN, and RFV than did the NWI treatment. Net-wrapped bales stored on a rock surface had significantly greater TDN and DDM than did net-wrapped bales stored on sod, but there was no difference in TDN or DDM compared with the BFG treatment. The film-wrapped bales were strongly preferred ($P < 0.001$) over NWO bales stored on either surface (Table 3). In 2 of the statistical analyses, hay from bales stored indoors was preferred ($P = 0.05$) over net-wrapped bales stored outdoors on either surface but was not different from film-wrapped hay. There was a trend for cattle to prefer net-wrapped hay stored on a rock pad compared with sod, but this was statistically significant only when considering total consumption.

In trial 5, there was no statistical difference in DDM, TDN, or RFV between the BFH and NWI treatments (Table 1). The BFH treatments had significantly lower TDN, DDM, and RFV than did the other treatments. Cattle strongly preferred hay from bales stored indoors using all 3 statistical analyses (Table 3). Both BFH treatments were preferred ($P = 0.005$, $P = 0.029$) over the NWO treatment. Despite the differences in nutritional composition of the film-wrapped bale stored on a rock surface, the hay from these bales was not preferred over film-wrapped bales stored on sod.

IMPLICATIONS

This experiment explored the preferential consumption of hay from large round bales stored indoors with conventional net wrap, outdoors with conventional net wrap, or outdoors with a new wrap that incorporated a breathable film. This film is intended to shed precipitation but allow internal moisture to exit the bale through microscopic pores. In all 5 preference trials, hay wrapped with breathable film was preferred over net-wrapped hay stored outdoors and in 2 trials was preferred over hay stored indoors. Across all trials, average consumption was 57, 35, and 52% of hay DM offered from BF, NWO, and NWI treatments, respectively. Results suggest that when bales are stored outdoors, cattle will strongly prefer to consume hay from bales wrapped with breathable film compared with net-wrapped bales. Hay from breathable film bales may have similar preference to that stored indoors.

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