Economic Returns and Risk Analysis of Forage Wrapping Technologies

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ABSTRACT

Using stochastic simulation, we evaluated the cost savings a cow-calf operation may experience by adopting high-moisture baleage with an in-line wrapper. The results of this analysis indicate the baleage technology is economically viable for high-quality forages such as winter annuals, alfalfa or legumes, especially at higher feed prices. Break-even herd size is between 50 and 150 cows, depending on a producer's current machinery complement. There is no apparent economic advantage to purchasing baleage equipment strictly based on reducing storage or feeding losses for beef cattle producers.

Introduction

Pasture, feed, and forage costs comprise the largest portion of operating expenses in a beef cow-calf operation. Strategies to reduce this category of expenses are commonly of interest to cow-calf producers and the focus of extension education and research efforts (e.g., Adams et al., 1996; May et al., 1999; Stockdale, 2010; Eisele et al., 2012). Recent weather extremes, such as drought followed by extended periods of rain, have spurred producer interest in technology that will not only lower per head costs of feeding but allow cattlemen to store high-quality feedstuffs in a timely manner. Baleage has the ability to meet both of these criteria by allowing harvesting of forages at higher levels of moisture, wrapping the bales in plastic, and reducing the need for additional supplementation costs.



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Baleage does not require the wait for the forage to reach a moisture level of 14 to 18 percent as commonly required for hay production. This reduces the weather risk producers commonly face while waiting for the forage to field cure and harvest. Harvesting the forage at higher moisture levels allows for the forage to more readily retain its nutritive value and digestibility compared to conventional hay (McDonald, 1981; McCormick, Cuomo, and Blouin, 1998; McCormick et al., 2011). However, the incorporation of baleage into a beef cow-calf operation is not inexpensive as there is a need to purchase a bale wrapper which is nearly equivalent to the cost of a new round baler. Additionally, conventional round balers may not be able to handle the higher moisture content of harvested forage which may require purchase of a round baler that is able to harvest forages at higher moisture levels. As the average herd size for Southeastern US cow-calf producers is less than fifty cows, this technology may not be cost effective for producers to purchase and incorporate into their operation.

The objective of this paper is to determine the economics of baleage versus conventional hay production for beef cattle producers in the Southeastern US. In this paper, we use stochastic models to evaluate three possibilities: savings from reduced hay storage and feeding losses; reduced purchased feed costs due to harvesting and feeding higher quality storage forage; and a combination of the previous two scenarios. We conducted this analysis for a range of herd sizes.

Previous Research

Baleage differs from hay production in that the forage is baled at higher moisture content than hay and then wrapped in plastic. The act of harvesting and wrapping the forage at higher moisture levels is similar to the harvesting of silage as the forage ferments once wrapped in plastic (Sauvé et al., 2010). Forage preserved as baleage reduces quality losses as leaves are less prone to shatter due to the higher moisture content (Hancock & Collins, 2006). Reduced quality losses associated with baleage results in improved nutritional value and animal preference compared to hay (McCormick, Cuomo, and Blouin, 1998; Han et al., 2004; Hancock & Collins, 2006).

Incorporation of baleage into a cattle operation also reduces forage yield losses associated with harvest. Part of the reduction in yield loss is associated with the forage being wrapped in plastic and not exposed to the elements (Collins et al., 1995; McCormick et al., 2011). Conserved forage in the central and Southeastern US is commonly stored as round hay bales without protection from the weather (Hancock & Collins, 2006). Leaving hay exposed to the elements reduces the amount of hay that is available and impacts animal consumption (Belyea, Martz, and Bell, 1985; Collins et al., 1995; Turner, Poore, and Benson, 2007; Stockdale, 2010).

In addition to the losses associated with lack of adequate storage facilities, harvested forage in the Southeastern US is also exposed to high humidity and frequent rainfall that reduces the ability of the producer to harvest the forage at its optimum time. The inability to harvest forage due to high humidity and rainfall can result in quality and storage losses above those that may occur elsewhere in the US (Nelson et al., 1983). These losses occur in large part because baling hay at too high of a moisture level can result in mold and/or fire. As a result, producers often wait for extended periods of time for hay to cure properly. Harvesting forages as baleage mitigates these concerns.

As the average US beef cow-calf operation has approximately forty beef cows (USDA NASS, 2014), it is not surprising that 42 percent of operations reported some form of off-farm income (McBride & Matthews, 2011). Off-farm employment can make harvesting of forages at their optimum nutritional level more difficult in the Southeastern US due to the time available for producers to cut, rake, and bale hay. Moreover, size of the cow-calf operation is also important to consider in adoption of technologies as it was found to explain the adoption of ten of the twelve production and management practices analyzed in Pruitt et al. (2012). In that study, producers in the Southeastern US were less likely to adopt production and management practices compared to producers in the Midwestern and Western US. This was the case for Southeastern US cow-calf producers regardless of whether or not the practice allowed producers to exploit economies of size or scope.

Data and Methods

This study examines the economics of utilizing an in-line bale wrapper for baleage versus a conventional hay baler and conducted in the context of a beef cow-calf producer. Comparisons of direct costs between hay and baleage are made for three scenarios:

1. Reduced storage and feeding losses;
2. Savings from harvesting and feeding higher quality forages; and
3. A combination of scenarios 1 and 2.

Scenarios 2 and 3 compare conventional hay production to baleage production of two types of forages which are commonly used in the Southeastern beef cattle operations: Bermuda grass hay and winter annuals. These scenarios are of economic interest due to previous research focusing on the nutritional and storage benefits of baleage lacking estimates of cost differences between baleage and hay production. For purposes of this study, we assume that over a 120 day winter feeding period, a cow will consume two percent of body weight in forage daily. For a 1,200 pound cow that results in 1.8 tons of dry matter (DM) being harvested as either conventional hay or baleage.

Conventional hay production involves cutting, tedding, raking, and baling, while baleage production involves cutting, baling, and wrapping. Thus, baleage often eliminates the need for a hay tedder or rake.[1] Estimated forage and harvesting costs shown in Table 1 are adapted from the University of Georgia (UGA) Extension forage budgets. Difference in costs between conventional hay and baleage production costs reflect the fact that baleage bales will typically be smaller and contain less dry matter than conventional hay bales due to forage being converted into baleage at higher moisture levels (60 percent moisture versus 15 percent moisture for hay). Additional differences in baling cost are reflective of the usage of a high-moisture baler to produce baleage that is not needed to produce conventional hay.

Estimated fixed costs associated with operating each type of hay baler and in-line bale wrapper are shown in Table 2. The assumptions for the in-line bale wrapper were developed through contact with equipment dealers and faculty at the LSU AgCenter and UGA that routinely demonstrate bale wrapping machines. More information on cost assumptions associated with bale wrapping machines is available in Pruitt and Lacy (2013).

Simulation Methods and Data

Stochastic simulation for all three scenarios was performed using the Microsoft Excel Add-in program @Risk (Palisade Corporation). In each of the three scenarios, 500 iterations were run using triangular distributions. The triangular distribution was selected as it provides a flexible form due to the only required parameters needed are the minimum value, expected value, and maximum value. This allows for application of the parsimony principle and eliminates the issues that may arise from imposing normality when it is not warranted. Values for storage and feeding losses associated with hay and baleage production were obtained from previously published research (Belyea et al., 1985; Hancock & Collins, 2006; Rotz & Shinners, 2007) and provided in Table 3. We focused on storage and feeding losses for all three scenarios described below as increased losses result in need to harvest additional forage for the cow to maintain body weight during winter feeding periods. This results in additional costs to beef cattle producers as equipment is operated more frequently to harvest forage that accounts for anticipated needs and storage and feeding losses.

Savings from Reduced Storage and Feeding Losses (Scenario 1)

Once forage production is complete, the forage is susceptible to storage and feeding losses. Storage losses are a result of exposing the forage to the elements with additional losses occurring when feeding the hay to cattle due to lack of palatability and failure to use a hay ring which limits the herd's ability to waste hay. This results in additional costs to the producer as additional forage is needed to offset the expected losses. Incorporation of baleage into a cow-calf operation minimizes losses as forage is not exposed to elements that can result in storage losses. Palatability is also improved which results in lower feeding losses (Hancock & Collins, 2006). Storage and feeding losses for hay are expected to be 15 percent compared to 10 percent for baleage. These estimated losses are simulated using a triangular distribution (Table 3) to determine the direct production costs a producer can expect given a base production cost and additional storage and feeding losses which increase per cow costs.

Given the costs of production for the comparison of an in-line bale wrapper to the hay production at the simulated levels of storage and feed losses, we then determine breakeven herd size to purchase an in-line bale wrapper. The cost of ownership information in Table 2 is used to determine minimum cow herd size given the cost savings generated by incorporation of bale wrapping technology into a beef cow-calf operation. Since the intended audience of this research is beef cattle producers and potential custom operators, we chose to calculate annual fixed costs as a loan payment rather than depreciation plus interest on average investment costs. We did so because, in our experience, producers tend to relate more easily to a cost which is associated with a cash outlay as opposed to depreciation which is a non-cash expense.

Savings from Improved Forage Quality (Scenario 2)

Perhaps a more compelling reason for producers to consider utilizing baleage technology is to reduce feeding costs through improved forage quality. These improvements can usually occur by harvesting forage at shorter intervals. Numerous studies (e.g. Ethredge, Beaty, and Lawrence, 1973; Holt & Conrad, 1986; Michelangeli et al., 2010) have indicated that cutting hybrid Bermuda grasses at 28 day intervals optimize forage yield and quality. However, weather uncertainty can extend drying times or delay cuttings resulting in poor quality forage.

One particular advantage that baleage offers is the ability to harvest and store winter annuals (including ryegrass, oats, and cereal rye) in early to mid-spring at the proper growth stage. This task is virtually impossible in the Southeastern US with conventional hay production given the limited drying window provided during these times of year. When winter annuals are properly harvested, this forage type can routinely meet the nutritional requirements of lactating beef cows or growing steers and heifers without additional supplementation. This is not the case for Bermuda grass hay which needs additional supplementation to support lactating cows or growing animals.

Costs from feeding either Bermuda grass baleage or winter grass baleage were compared to feeding good, average, and poor quality hay. Default values from the UGA Basic Balancer (Stewart, Hancock, and Lacy, 2013) were utilized to develop rations to feed a 1,200 pound lactating cow for 120 days using the differences in forage quality. Available supplemental feeds available were whole cottonseed (WCS), corn, and a 50/50 mixture of corn gluten feed (CGF) and soy hulls. The rations and their assumed costs are presented below in Table 4. This scenario assumes that no storage or feeding losses occur for hay or baleage produced.

Combined Cost Differences from Reduced Storage and Feeding Losses and Lower Feed Savings (Scenario 3)

Data and assumptions from Scenarios 1 and 2 were combined to evaluate the summative implications of utilizing baleage technology in a beef cow-calf operation. Storage and feeding losses are the same as assumed in Scenario 1.

Results and Analysis

Scenario 1

Justifying in-line bale wrapper solely on the basis of reduced feeding costs does not appear to be economically viable. Based on the assumptions listed in Tables 1, 3, and 5, using an in-line bale wrapping system to reduce storage and feeding losses results in an estimated loss of $134 per cow per year. While the total pounds of DM fed are reduced, the lower DM pounds in a bale of baleage results in feeding more bales. With a higher cost per ton, and per bale, feeding baleage increases total feeding cost in this scenario. Even at the higher rates of losses with conventional hay feeding, baleage is still not economical at any time (Figure 1). As the cumulative density function (CDF) in Figure 1 indicates, there is a 90 percent chance of net savings being between $128/cow and -$90/cow. There is only a five percent chance of net savings being greater than $90/cow, suggesting that reduced hay feeding losses will not result in cost savings to the operation.

Scenario 2

While baleage cannot be justified for a cow-calf producer on the basis of reducing storage and feeding losses, it can be justified when considering improved forage quality from harvesting in a timelier manner. To evaluate the economics of utilizing baleage from improved forage quality, two alternatives were constructed: one where an in-line bale wrapper was used for harvesting Bermuda grass; and a second where winter annual forages were harvested (Table 1). Suggested feeding regimens based upon differences in hay quality (shown as a footnote to Table 4) were developed utilizing the UGA Basic Balance (Stewart, Hancock, and Lacy, 2013). Readers are reminded that this scenario considers only potential savings from improved forage quality and assumes zero percent storage and feeding losses.

It is apparent from this analysis that the real economic benefit of baleage technology lies in the ability to harvest high quality forages such as winter annuals, summer annuals, or legume crops such as alfalfa (Tables 6 and 7). It may be surprising to some readers that using baleage to harvest Bermuda grass does not appear to be economical. The reason for this is that even when harvested at the optimum growth stage, Bermuda grass still does not have the nutritional content of other high quality forages, especially when it comes to sustaining a lactating cow. Although the cost savings shown for the various herd sizes in Table 6 are negative, the cost savings are least negative when converting from poor quality Bermuda grass hay to Bermuda grass baleage. This highlights the improvement in forage quality that is possible by switching from conventional hay production to baleage.

Utilizing in-line baleage technology to harvest high-quality forages such as winter annuals, alfalfa, or perennial peanut seems economically rational given the results in Table 7. Even for small producers (less than 50 beef cows), the direct cost savings are positive. Cost savings are greater for average or poor quality hay producers switching from hay to baleage production compared to those already producing good quality hay. However, with an additional estimated annual fixed cost of approximately $7,000 to $15,000, depending on whether one already owns a high-moisture baler, the breakeven herd size to purchase the required baleage equipment is from 75 and 150 beef cows.[2]

Scenario 3

When the effects of improved feeding quality and reduced storage and feeding losses are combined, the economic feasibility of in-line bale wrappers becomes even more attractive (Table 8). In general, direct cost savings are increased by approximately $8 per cow per year for Bermuda grass baleage and approximately $100 per cow per year for winter annuals. When both storage and feeding losses and feeding costs are reduced, baleage can be a viable alternative for producers at between 50 and 75 beef cows if they have the opportunity to grow and harvest winter annuals.

Stochastic feed prices

To determine the impacts of higher feed prices on the economics of baleage, savings from utilizing baleage using simulated feed prices to reflect the range of prices in recent years. This analysis was conducted by simulating feed prices using a triangular distribution with a low feed price of $200 per ton, an expected price of $250 per ton, and a high feed price of $400 per ton. The triangular distribution was used to simulate prices. Results for this simulation are shown in Table 9.

As one would expect, higher supplemental feed prices increases the cost-effectiveness of an in-line bale wrapper. Using the simulated feed price values, winter annual scenarios yield cost savings 97.6 percent of the time compared to good quality hay, and 100 percent of the time for average and poor quality hay. Summary statistics for the six scenarios are presented in Table 9.

Implications and Conclusions

Using an in-line bale wrapper to store harvested forages appears to have economic merit for Southeastern US beef cow-calf producers. While there is not a conceivable scenario where reduced storage and feeding losses alone would justify purchasing the additional equipment to wrap and store forage, baleage can be economical for other reasons. Purchasing baleage equipment on the premise of putting up higher quality warm-season forages such as Bermuda grass does not seem to be warranted due to the relatively low nutritional value of these forages. Rather, the primary benefits result from the ability to harvest and preserve high quality forages such as annual forages or alfalfa. The economic benefits of utilizing baleage increases with feed prices. At supplemental feed prices above $300/ton, baleage can be a viable alternative for producers who typically feed poor quality hay.

When reduced storage and feeding losses and reduced feed costs due to forage quality are considered, the breakeven herd size appears to be slightly more than 50 beef cows. This analysis assumes a producer already owns a round-baler and other hay making equipment. If a producer does not already own this equipment, the breakeven threshold to make the additional investment is considerably higher.

Endnotes

1. One reviewer pointed out that the type of disc mower used will determine whether or not the forage will need to be raked prior to being baled and converted to baleage. Experts familiar with baleage production indicate that disc-mower type is just one of several factors affecting the need for a rake. Other factors include forage species, forage production, and environmental conditions.
2. This $9,000 is in addition to the annual fixed payments for a conventional baler. The total estimated fixed payments for a conventional hay baler are $7,000 to $8,000 and for a high-moisture baler and in-line bale wrapper are between $15,000 and $16,000. However, an economic analysis of herd size required to justify a producer owning their own hay equipment is beyond the scope of this paper.
3. Some readers find illustrations such as a depiction of the cumulative density function (CDF) helpful when interpreting results from simulations similar to those conducted in this paper. The net savings on a dollars per cow ($/cow) basis from utilizing baleage are shown on the horizontal axis and the cumulative probability from achieving that value or less in depicted on the vertical axis. For instance, there is a 5 percent or less chance that one would lose more than $128.17 per cow by adopting the baleage technology. One could also read this figure to mean that there is 95 percent chance that losses from adopting baleage strictly based on lower hay losses will be will be $89.89 or worse. Combining these two outcomes indicates that there is a 90 percent chance the net savings will be between -$128/cow and -$90/cow suggesting just a 5 percent chance that savings will be greater than -$90/cow.

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Figure 1. Cumulative Density Function of Net Cost Savings from Using Baleage versus Conventional Hay Production under Varying Levels of Hay Feeding Losses[3]

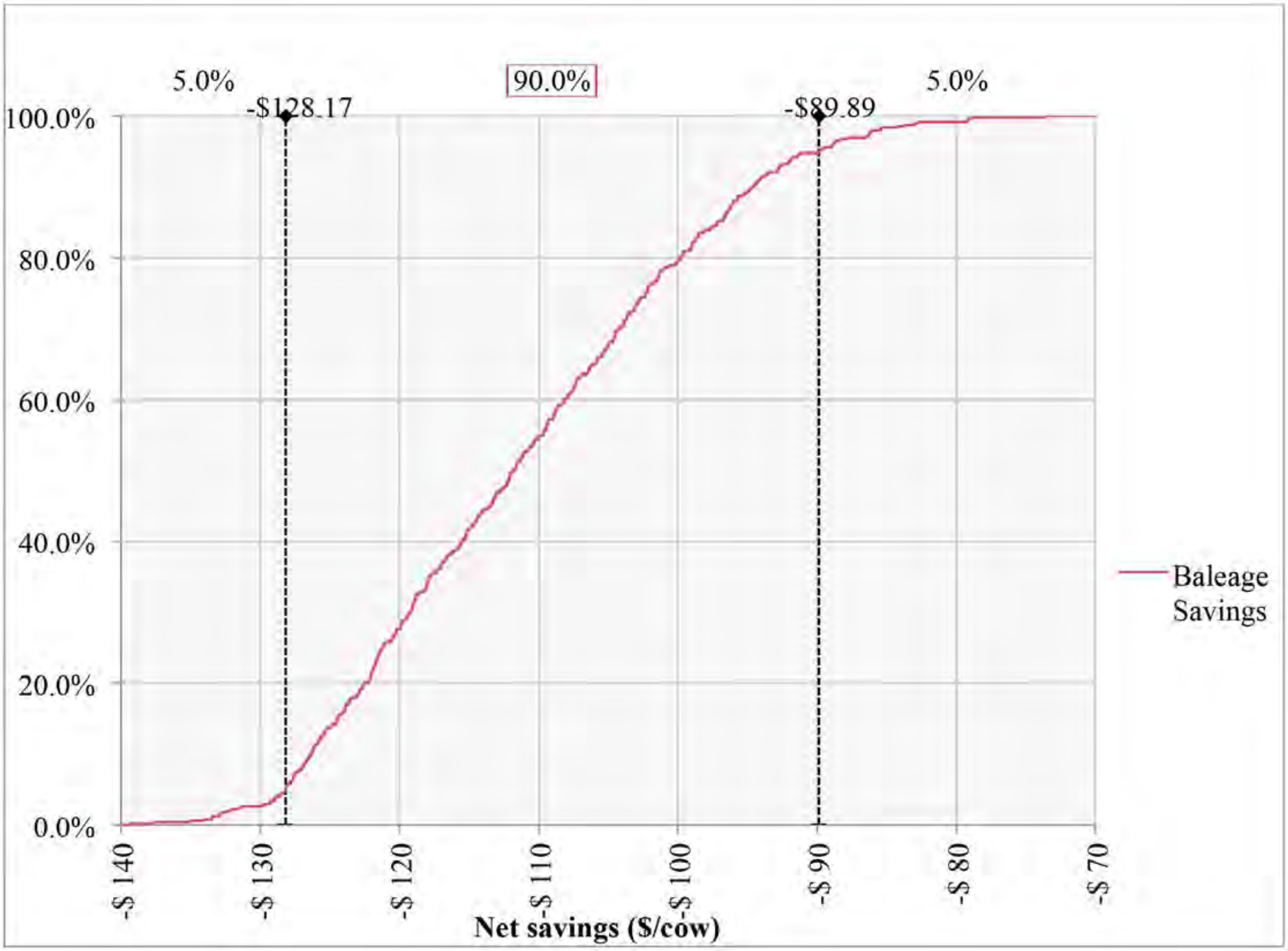

Table 1. Estimated Forage and Harvesting Costs for Conventional Hay and Baleage using an In-Line Bale Wrapper

	Conventional Hay	Bermuda grass Baleage	Winter Annual grass Baleage
1st cutting forage costs	$155.00	$155.00	$200.00
Cutting costs	$17.09	$7.26	$7.26
1st cutting tons DM basis	1.50	1.50	2.00
DM pounds per bale	850	600	600
Number of bales 1st cutting	3.50	5.00	6.67
Baling & wrapping cost per bale	$10.15	$15.55	$15.55
1st harvest cost	$52.91	$85.01	$110.93
1st harvest total cost	$207.91	$240.01	$310.93
Additional cuttings	2.00	3.00	2.00
DM tons per cutting	2.25	1.50	2.00
DM pounds per bale	850	600	600
Number of bales in subsequent cuttings	10.59	15.00	13.33
Forage cost per cutting	$50.00	$50.00	$50.00
Cutting cost per cutting ($/acre)	$17.09	$7.26	$7.26
Harvesting cost per cutting ($/acre)	$107.47	$233.25	$207.33
Total cost additional cuttings	$314.94	$849.75	$514.67
Total annual cost	$522.85	$1,089.76	$825.59
Prorated establishment cost ($/acre)	$50.00	$50.00	$0.00
Total cost per acre	$572.85	$1,139.76	$825.59
Total DM tons per acre	6.00	6.00	6.00
Cost/ton – DM	$95.48	$189.96	$137.60
Cost/bale – DM	$40.58	$56.99	$41.28

Table 2. Equipment and Labor Assumptions for Conventional and High-Moisture Round Baler and In-Line Bale Wrapper

	Conventional Round Baler	High Moisture Round Baler	In-Line Wrapper
Purchase Price	$31,500	$36,500	$30,000
Estimated Useful Life	8 Years	8 Years	15 Years
Estimated Annual Usage	200 Hours	200 Hours	48 Hours
Repair and Maintenance Rate	90.00%	90.00%	5.00%
Bales Wrapped in 1 Hour	N/A	N/A	48 Bales
Bales Wrapped per Plastic Roll	N/A	N/A	35 Bales
Length of Loan	5 Years	5 Years	5 Years
Interest Rate	5.25%	5.25%	5.25%
Annual Loan Payment	$7,326.06	$8,488.93	$6,977.20

Table 3. Estimated Dry Matter Storage and Feeding Losses for Hay and Baleage

	Hay	Baleage
Best	5.00%	3.00%
Expected	15.00%	10.00%
Worst	40.00%	15.00%

Adapted from: Belyea et al. (1985), Hancock and Collins (2006), and Rotz and Shinners (2007)

Table 4. Nutritional Composition and Total Feeding Costs from Various Qualities of Hay and Baleage

	Good Hay[§]	Average Hay	Poor Hay	Bermuda grass Baleage	Winter annuals Baleage
Amount of DM pounds fed	3,540	3,072	2,292	3,540	3,696
Feeding losses DM basis	0%	0%	0%	0%	0%
Total pounds DM needed	3,540	3,072	2,292	3,540	3,696
Bale DM weight (pounds)	850	850	850	600	600
Bales needed	4.2	3.6	2.7	5.9	6.2
Costs/bale	$40.58	$40.58	$40.58	$56.99	$41.28
Total hay/baleage costs	$168.99	$146.65	$109.42	$336.23	$254.28
Supplemental feed (tons)	0.40	0.62	0.98	0.40	0.00
Supplemental feed (price/ton)	$215.00	$240.00	$255.00	$215.00	$0.00
Total supplement cost	$86.43	$148.32	$249.39	$86.43	$0.00
Total feeding cost per cow	$255.42	$294.47	$358.81	$422.66	$254.28

[§]Good hay is defined as 12 percent crude protein (CP), 58 percent total digestible nutrients (TDN), average hay is defined as 12 CP, 53 TDN, and poor hay is defined as 6 CP, 45 TDN.

Table 5. Assumptions and Savings from Utilizing Baleage Technology to Reduce Feeding Losses

Production Assumptions	Cow	Hay	Baleage
Average weight (lbs):	1,200		
Cow consumption per day (percent of body weight)	2%		
Days in winter feeding period	120		
Total DM pounds needed for winter feeding period	2,880	2,880	2,880
Simulated storage and feeding losses		20%	9%
Total pounds DM needed		3,456	3,149
Bale weight (pounds DM basis)		850	600
Variable cost per bale (DM basis)		$40.58	$56.99
Total feeding costs		$164.98	$299.07
Savings from feeding baleage			($134.09)

Table 6. Direct Cost Savings due to Improved Nutritional Quality of Bermuda Grass Baleage

Number of Beef Cows	Good Hay	Average Hay	Poor Hay
25	($4,180.93)	($3,192.21)	($1,596.35)
50	($8,361.85)	($6,384.42)	($3,192.70)
100	($16,723.71)	($12,768.84)	($6,385.40)
250	($41,809.27)	($31,922.10)	($15,963.49)
500	($83,618.53)	($63,844.20)	($31,926.98)

Table 7. Total Direct Cost Savings due to Improved Nutritional Quality of Winter Annual Baleage

Number of Beef Cows	Good Hay	Average Hay	Poor Hay
25	$28.48	$1,017.20	$2,490.81
50	$56.97	$2,034.40	$4,981.63
100	$113.94	$4,068.81	$9,963.25
250	$284.85	$10,172.01	$24,908.13
500	$569.70	$20,344.03	$49,816.25

Table 8. Direct Cost Savings ($/cow) Winter Annual versus Bermuda Grass Baleage at Different Levels of Hay Quality Simulation

	Bermuda Grass Baleage			Winter Annuals		
Statistic	Good Hay	Average Hay	Poor Hay	Good Hay	Average Hay	Poor Hay
Mean	($167.70)	($120.83)	($56.65)	$5.32	$52.19	$116.37
Minimum	($192.45)	($146.18)	($85.10)	($12.66)	429.11	$92.58
Maximum	($147.03)	($93.40)	($27.41)	$22.92	$79.21	$146.55
Standard deviation	$8.13	$10.39	$11.60	$7.20	$9.59	$11.27
Percent chance of positive savings from baleage	0.00%	0.00%	0.00%	75.00%	81.00%	100.00%

Note 500 iterations were used in this simulation.

Table 9. Direct Cost Savings ($/cow) for Winter Annual versus Bermuda Grass Baleage at Different Levels of Hay Quality Simulation and Incorporating Stochastic Feed Price Simulation

	Bermuda Grass Baleage			Winter Annuals		
Statistic	Good Hay	Average Hay	Poor Hay	Good Hay	Average Hay	Poor Hay
Mean	($167.70)	($121.53)	($56.41)	$32.79	$78.97	$144.08
Minimum	($192.39)	($157.55)	($114.83)	($12.46)	$19.70	$47.73
Maximum	($144.24)	($86.23)	$14.90	$81.60	$151.71	$253.57
Standard deviation	$8.43	$13.15	$27.09	$18.23	$27.22	$43.11
Percent chance of positive savings from baleage	0.00%	0.00%	2.60%	97.60%	100.00%	100.00%

Note 500 iterations were used in this simulation.