Forages for Lactating Dairy Cows: Economic Significance

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Introduction

Forages comprise 35% to 70% of the dry matter (**DM**) in diets for lactating dairy cows. Forage quality impacts DM intake, diet energy density, dietary grain and protein supplementation, feed costs, and lactation performance. Undersander et al. (1993) presented a method for estimating milk per ton of forage DM as an index of forage quality based on energy content predicted from its ADF content and DM intake predicted from its NDF content. This index was used to evaluate the economic significance of corn silage and alfalfa for lactating dairy cows. Dairy producers that purchase their forage need to evaluate milk per ton of forage DM, while those that produce their own forage need to evaluate both milk per ton of forage DM and per acre.

Corn Silage

The primary contribution of corn silage (**CS**) to rations is energy, which makes prediction of its energy content important for diet formulation and economic evaluations. A published summative energy equation (Weiss, 1996), with crude protein (**CP**), fat, non-structural carbohydrate (**NSC**), and neutral detergent fiber (**NDF**) components and corresponding digestibility coefficients, was adapted for corn silage as follows: the CP and fat components were not altered, the NSC component with constant digestibility was replaced with starch and non-starch NSC components, the starch digestibility coefficient was varied in relationship to whole-plant DM content and kernel processing, and the NDF digestibility coefficient based on lignin content was replaced by an *in vitro* NDF digestibility (**IVNDFD**) measurement (Schwab and Shaver, 2001).

Regression equations were developed from literature data to predict total tract starch digestibility from whole-plant DM content for unprocessed and processed corn silage. Slopes of the unprocessed and processed CS starch digestibility regression equations indicate that DM content has a greater impact on the starch digestibility of unprocessed than processed CS. At 35% DM, predicted apparent total tract starch digestibility for unprocessed and processed CS were 86 and 91%, respectively. At lower DM contents the difference between processed and unprocessed silage was smaller and increased as DM content increased. The concentration of the non-starch NSC component of CS was approximated by subtracting percent starch from percent NSC, and a digestion coefficient of 98% was assigned to this component according to Weiss (1996). A 48-hour or maintenance intake IVNDFD measurement was used in the summative equation.

For the MILK2000 model (Schwab and Shaver, 2001; Schwab et al., 2001), we used our net energy for lactation estimates along with DM intake estimated from both NDF content and IVNDFD to estimate milk per ton of corn silage DM and per acre. In the spreadsheet, the cows' maintenance energy requirement (proportioned according to the percentage of corn silage in the diet DM) was then subtracted from energy intake to provide an estimate of the energy available from corn silage for conversion to milk (NRC, 1989).

Recent advances in CS production that can affect its nutritive value include, harvesting prior to black-layer stage of maturity (Bal et al., 1997), kernel processing (Bal et al., 2000b), high cutting (Satter et al., 2000), and high-oil (Drackley, 1997), brown midrib (***bm_3***; Oba and Allen, 1999) and leafy (Bal et al., 2000a) corn hybrids. The economics of these practices were evaluated using MILK2000 to estimate milk per ton of corn silage DM and per acre. Gross returns were then calculated using a milk price of $10.50 per cwt.

Harvest Timing

The estimated economic impact of harvesting corn silage at DM contents ranging from 25% to 45% is presented in Table 1. Milk (lb or $) per ton of corn silage DM and per acre were highest for 35% DM corn silage. Differences between 30% and 35% DM corn silage were minor. Harvesting corn silage at 25% DM or 40%-45% DM versus 30%-35% DM reduced milk (lb or $) per ton of corn silage DM and per acre. The estimated milk production loss incurred by harvesting corn silage too dry equates to a loss of $15,000 to $20,000 annually per 100 cows.

Table 1. Impact of corn silage harvest timing on estimated milk per ton and per acre[1].

DM %	Milk, lb/ton DM	Milk, $/ton DM[2]	Milk, lb/acre	Milk, $/acre[2]
25	3309	348	21510	2259
30	3435	361	24050	2525
35	3530	371	26472	2780
40	3122	328	23412	2458
45	2970	312	20791	2183

[1]From MILK2000 (Schwab and Shaver, 2001; Schwab et al., 2001).
[2]Calculated using a $10.50/cwt. milk price.

Kernel Processing

The estimated economic impact of corn silage kernel processing is presented in Table 2. The estimated milk production benefit from kernel processing equates to $6,000 of gross income annually per 100 cows. These calculations were done on 40% DM corn silage, and the estimated response to processing would be less on 30% DM corn silage and greater on 45% DM corn silage. Benefits of processing beyond starch digestibility of chopping at a longer length of cut with less sorting of cobs in the feed bunk were not considered in these calculations. To be considered excellent for degree of processing there should be more than 95% kernel breakage and no cobs should be greater than a 1/8th concentric ring.

Table 2. Impact of corn silage kernel processing on estimated milk per ton and per acre[1].

Degree of Processing	Milk, lb/ton DM[2]	Milk $/ton DM[3]	Milk lb/acre	Milk $/acre[3]
None	2872	301	20108	2111
Fair/Poor	2976	312	20835	2187
Excellent	3080	324	21563	2264

[1]From MILK2000 (Schwab and Shaver, 2001; Schwab et al., 2001).
[2]Calculations done assuming 40% DM corn silage.
[3]Calculated using a $10.50/cwt. milk price.

Height of Cutting

Increasing corn silage height of cutting by 14 inches reduced whole-plant NDF and ADF contents by 7%- and 4%-units, respectively (Satter et al., 2000). High cutting would also be expected to increase IVNDFD, because the more highly lignified portion of the stalk would be left in the field. Satter et al. (2000) projected the DM per acre yield loss associated with high cutting at 5% to 8%. The estimated economic impact of high cutting is presented in Table 3. The estimated milk production benefit from high cutting equates to $8,000 or $3,000 annually per 100 cows for milk $/ton DM or milk $/acre, respectively. Height of cutting offers some flexibility for manipulating the quality of corn silage. In some situations, potential benefits of high cutting for reducing nitrates, mycotoxins, and(or) soil erosion may have merit. High cutting increases whole-plant DM content (Satter et al., 2000), which may be a plus for custom operators hoping to get started early in the harvest season on immature corn silage.

Table 3. Impact of corn silage height of cutting on estimated milk per ton and per acre[1].

Height of Cutting	Milk lb/ton DM	Milk $/ton DM[2]	Milk lb/acre	Milk $/acre[2]
6”	3074	323	21520	2260
18”	3374	354	22251	2337

[1]From MILK2000 (Schwab and Shaver, 2001; Schwab et al., 2001).
[2]Calculated using a $10.50/cwt. milk price.

Hybrids

The estimated economic impact of various corn silage hybrids is presented in Table 4. Only bm_3 and nutri-dense hybrids show a significant positive deviation from the mean of all hybrids tested for milk per ton of corn silage DM. Milk per acre for the nutri-dense hybrids was similar to the average for all hybrids tested. Although milk per ton was highest for bm_3 of the hybrid categories compared, milk per acre for bm_3 was lowest of the hybrid categories compared and was $304 per acre lower than the average of all hybrids tested. Dairy producers buying corn silage from a grower and dairy producers growing their own corn silage may have a widely different view of bm_3 hybrids. There were no advantages to leafy hybrids. This observation agrees with the results of feeding trials with leafy hybrids (Bal et al., 2000a; Kuehn et al., 1999). High-oil and waxy hybrids were worse than the average of all hybrids tested for milk per ton and per acre (high-oil) and milk per acre (waxy).

Table 4. Impact of various corn silage hybrids on estimated milk per ton and per acre[1,2].

Hybrid	Milk lb/ton DM	Milk $/ton DM[3]	Milk lb/acre	Milk $/acre[3]
bm_3 (n=12)	3410	358	21500	2258
Bt (n=130)	3140	330	25000	2625
High Oil (n=12)	3040	319	22500	2363
Nutri-Dense (n=10)	3240	340	24300	2552
Leafy (n=70)	3110	327	24600	2583
Waxy (n=56)	3090	325	22600	2373
All Hybrids (n=2407)	3110	327	24400	2562

[1]From MILK2000 (Schwab and Shaver, 2001; Schwab et al., 2001).
[2]Source: J.G. Lauer, UW-Madison Agronomy, 1995-2000 UW Silage Trials.
[3]Calculated using a $10.50/cwt. milk price.

Alfalfa

Milk production decline with diminishing alfalfa quality (increasing ADF and NDF contents and decreasing RFV) is well established (Nelson and Satter, 1990). The MILK95 spreadsheet (Undersander et al., 1995) was used to assess the impact of alfalfa quality on estimated milk per ton of DM and per acre (Undersander et al., 1993). The spreadsheet estimated the energy content of alfalfa from its ADF content and alfalfa DM intake from its NDF content. In the spreadsheet, the cows' maintenance energy requirement (proportioned according to the percentage of alfalfa in the diet DM) was then subtracted from energy intake to provide an estimate of the energy available from alfalfa for conversion to milk (NRC, 1989). Gross returns were then calculated using a milk price of $10.50 per cwt. Grain and CP supplementation at varying qualities of alfalfa for 1350 lb cows producing 70 lb of milk per day were also determined by the spreadsheet.

Milk Production

The estimated economic impact of alfalfa quality is presented in Table 5. The estimated milk per ton benefit for alfalfa with a relative feed value (**RFV**) of 175 over alfalfa with an RFV of 125 equates to $15,000 annually per 100 cows. Because of reduced yield for the immature alfalfa, the estimated milk per acre benefit for 175 RFV alfalfa over 125 RFV alfalfa equates to $6,000 annually per 100 cows. Data from WI quality-tested hay auctions show that dairy producers pay $0.90 per point of RFV above the RFV of a base quality alfalfa (Undersander, 2001). So, 175 RFV alfalfa would sell for $45 more than 125 RFV alfalfa. Based on the estimated milk per ton, 175 RFV alfalfa was worth $65 more than 125 RFV alfalfa. Because of the premium price paid for high-quality alfalfa, it needs to be targeted to high producing cows with the potential for a production response from the high quality. Average-quality alfalfa can be targeted to low-producing cows and replacement heifers.

Table 5. Impact of alfalfa quality on estimated milk per ton and per acre[1].

Alfalfa (%CP, %NDF, RFV)	**Milk lb/ton DM**	**Milk $/ton DM[2]**	**Milk lb/acre**	**Milk $/acre[2]**
(22, 40, 175)	3371	355	15170	1593
(19, 45, 150)	3007	316	14283	1500
(16, 50, 125)	2758	290	13790	1448
(14, 53, 100)	1981	208	10400	1092

[1]From adaptation of MILK95 (Undersander et al., 1995; Undersander et al., 1993).
[2]Calculated using a $10.50/cwt. milk price.

Feed Costs

The impact of alfalfa quality on the cost of grain ($2.00/bu corn) and CP supplement (44% CP; $180/ton) as estimated by the MILK95 spreadsheet is presented in Table 6. The cost difference for RFV 175 minus RFV 125 alfalfa in purchased grain and CP supplement was $0.47 per cow per day.

Silage Quality

Bolsen et al. (1999) compared preservation and utilization efficiencies of silage harvested with or without the application of microbial inoculants and determined that inoculants increased net income by $27.45/cow/year and $58.86/cow/year for corn silage and alfalfa silage, respectively. Bolton and Holmes (2000) used average DM losses in covered and uncovered bunker silos of 9% and 18%, respectively, to calculate that after subtracting the cost of the plastic and tires a dairy producer could pay someone $63 per hour to cover a bunker and still come out ahead. Whitlock et al. (2000) fed corn silage diets to steers comprised of 0%, 25%, 50%, or 75% surface-spoiled silage and found large negative associative effects of the addition of surface-spoiled silage on DM intake and total-tract DM and NDF digestion. Extrapolation of these results to lactating dairy cows indicates that the mixing of surface-spoiled silage into their ration could reduce milk production by 5 lb/cow/day.

Table 6. Impact of alfalfa quality on cost of feed supplementation[1].

Alfalfa (%CP, %NDF, RFV)	Cost of Grain & CP Supplement $ per cow per day[2]
(22, 40, 175)	$0.59
(19, 45, 150)	$0.85
(16, 50, 125)	$1.06
(14, 53, 100)	$1.22

[1]From adaptation of MILK95 (Undersander et al., 1995; Undersander et al., 1993).
[2]Corn at $2.00/bu. and 44% CP supplement at $180/ton.

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