Efficient Use of Forages and Impact on Cost of Production

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Take Home Messages

- Feed costs can be lowered by maximizing the use of home grown forages and minimizing the purchase of concentrates.
- To maximize the use of home grown forages, it is important to produce high energy forages. The digestible energy content of the forage determines the amount of concentrate needed.
- Cutting alfalfa in the late-bud stage promotes low fiber content, high fiber digestibility, and high digestible energy content.
- For corn silage, grain development and high starch content maximizes digestible energy content.
- Barley silage should be harvested before it becomes over mature, with a final dry matter content of 30 to 40%.

Introduction

The nutritive value of home grown forages is crucial because it directly affects income over feed costs. Forages can be a valuable source of digestible energy for dairy cows. The greater the amount of digestible energy that the cow can consume from forages, the lower the amount of supplemental energy needed from concentrate feeds. In other words, the quantity of digestible energy provided to the cows through forages determines the amount and chemical composition of the concentrates that need to be purchased.

The amount of concentrate needed daily by the cow to maintain milk production directly affects income over feed costs. Admittedly, there is a cost of producing home grown forages and this cost can vary depending upon inputs and yields. However, once the forages are produced, the only way to lower total feed costs is to maximize the use of forages and minimize the purchase of off-farm concentrates. The less concentrate that is purchased, and the cheaper that the concentrate is per tonne, the lower the purchased feed costs.

The nutritive value of the forage determines entirely the quantity and composition of the concentrate needed to maintain the desired level of milk production. To maximize the use of home grown feeds and minimize the need for purchased concentrates, high quality forages are needed. That means the forages have to be well preserved to encourage high levels of intake, and they must be a source of highly digestible nutrients.

Digestible energy content (which determines Net Energy of Lactation, NE_L) is by far the single most important determinant of the nutritional value of forages. Energy content is far more important than protein content because the protein requirements of the cows can be provided through purchased feeds and from rumen microbial protein that is produced when energy rich feeds are fermented in the rumen. However, it is nearly impossible to fully compensate for low energy content of forages.

▪ Variability in the Composition and Nutritive Value of Forages in Western Canada

Dairy farms typically produce most of the forage they require, and there is tremendous variability in the chemical composition and nutritive value of these forages from year-to-year and from farm-to-farm (Table 1). This variability will affect the need for purchased concentrates.

Table 1. Variability in the composition of some forages grown in Canada 2010-2011 (data supplied by Cumberland Valley, Maugansville, MD; www.foragelab.com)

Feed		DM	pH	CP %DM	ADF %DM	NDF %DM	NDF-dig 30h %DM	Starch %DM	NE_L Mcal/kg	TDN %DM
Alfalfa silage	Mean	40.7	5.06	17.9	39.0	46.8	38.4	2.4	1.33	56
	STDEV	12.0	0.59	3.2	5.7	7.3	8.0	1.3	0.13	10
	No.	209	200	146	146	146	32	111	146	150
Alfalfa hay	Mean	88.5	6.70	19.5	32.9	41.7	39.3	2.6	1.41	61
	STDEV	2.7	1.72	3.5	4.8	6.7	6.5	0.5	0.10	4
	No.	442	2	427	427	427	37	370	427	427
Grass silage	Mean	38.9	5.34	16.4	35.8	60.8	66.6	1.1	1.43	62
	STDEV	16.6	0.93	4.2	4.1	5.5	4.0	0.6	0.10	4
	No.	47	29	43	43	43	2	19	43	43
Grass hay	Mean	87.6	6.27	10.4	38.2	64.5	59.6	1.9	1.35	59
	STDEV	4.7	0.00	4.1	5.0	5.1	9.6	0.4	0.07	3
	No.	72	2	72	72	72	12	58	72	72
Barley silage	Mean	36.7	4.60	11.5	34.0	53.4	50.6	12.3	1.45	62
	STDEV	9.2	0.87	2.4	5.9	7.1	9.5	7.2	0.12	5
	No.	272	265	265	265	265	63	205	265	265
Corn silage	Mean	35.9	4.09	8.4	28.1	46.3	63.1	24.5	1.63	70
	STDEV	18.5	0.66	1.0	4.0	6.3	6.4	8.1	0.10	4
	No.	373	344	313	312	313	86	310	312	313

▪ Energy Content of Forages Affects Purchased Feed Costs: Alfalfa Haylage Example

An example of the impact of the energy content of forages on ration formulation is given in Table 2. Three alfalfa haylages were compared: a high energy alfalfa containing 34% neutral detergent fiber (NDF), a medium energy haylage containing 40% NDF, and a low energy haylage containing 46% NDF (dry matter [DM] basis). Each haylage was used in a diet formulated with CPM Dairy (version 3.0.8.1) to meet the metabolizable energy requirements of a dairy cow producing 37 kg/day of milk containing 3.50% fat and 3.20% crude protein. The rations were also formulated to supply 95% of the metabolizable protein (MP) requirements, which resulted in relatively high rumen un-degradable protein and crude protein levels. If a lower MP requirement was used (as would be the case using the NRC model), the actual ration formations would have been different, but the lessons learned would have been the same. The prices used in these calculations were for Lethbridge in November 2011. Although ingredient prices fluctuate and alternative ingredients and ration formulations are certainly possible, the general principles hold true.

There are several key points that can be learned from Table 2. Firstly, the high quality forage provides a lot more flexibility in terms of ration formulation. The ration containing the high energy forage allowed us to use a much greater proportion of haylage in the diet, but instead we chose to limit the proportion of haylage to about 55% (same proportion as for the medium haylage). As a result, expected milk production on this ration was about 40 kg/day. Because of the highly digestible fiber in this haylage, it was necessary to add a small amount of straw to enhance effective fiber intake of the cows to avoid any possible problems associated with sub-acute rumen acidosis. Alternatively, we could have used a greater proportion of haylage and no straw, and simply formulated the ration to meet the energy requirements for 37 kg/day of milk.

Table 2. Impact of alfalfa haylage energy content on least cost ration formulation[1] and purchased feed costs (DM basis)

	Energy Content		
	High	Medium	Low
Forage:			
NDF content (%)	34	40	46
Crude protein (%)	23	20	17
NE_L (Mcal/kg)	1.69	1.44	1.26
Predicted milk (kg/d)[2]	**40.0**	37.0	37.0
Est. DM intake (kg/d)	21.5	21.5	21.5
Ration composition:			
NDF (%)	26.5	28.7	28.0
Forage NDF (%)	20.9	22.0	21.5
Crude protein (%)	21.1	20.4	18.9
RUP (%)	35.7	40.9	38.0
Starch (%)	23.0	23.0	28.0
NFC (%)	43.0	41.5	43.8
Ration formulation (%):			
Alfalfa silage	56.5	55.0	49.0
Straw	2.1	0.0	0.0
Corn grain	28.9	26.3	30.7
Corn DDG	0.00	7.48	6.66
Canola	2.62	2.09	0.00
Soybean meal	0	0	7.82
Blood meal	2.33	2.33	2.33
Meat bone meal	4.01	3.35	0.00
Mineral-vitamin premix	3.49	3.49	3.49
Concentrate cost:			
$/cow/day	3.59	3.73	4.08
$/100 kg milk	9.00	10.08	11.02
$/tonne (as fed)	363	347	335

[1]Rations balanced with CPM Dairy using feed costs as of Nov. 2011.
[2] Contains 3.50% fat and 3.20% crude protein. NDF = neutral detergent fiber; NFC = non-fiber carbohydrates; RUP = rumen undegradable protein.

Next, it is evident that as the NDF content of the haylage increases, the NE_L content of the forage decreases, and the proportion of haylage in the ration decreases. As a consequence, more concentrate needs to be fed each day, so the purchased feed costs increase. The other interesting point is that the cost per tonne of concentrate actually decreases with decreasing forage quality. That is because the higher feeding level of the concentrate means that some of the more expensive vitamins, minerals and other feed additives in the diet are spread across a larger quantity of concentrate and thus, a less expensive concentrate (per tonne) can be fed. Conversely, better quality forages can mean higher priced concentrates per tonne because the concentrate is fed in a lower amount. Relative to feeding a high energy haylage, purchased feed costs per 100 kg of milk increased 12% for the medium energy forage and by 22.4% for the lower energy forage. For a 100-cow dairy operation averaging 10,000 kg/cow/year of milk, this difference equates each year to an additional $10,800 for concentrates for the medium energy forage and $20,200 for the low energy forage.

▪ Producing High Energy Alfalfa Forage

Given that digestible energy content (and NE_L) is the most important consideration when producing home grown forages, one may ask: What factors affect the digestible energy content of alfalfa?

Harvest maturity is the single most important factor affecting nutritive value of alfalfa. There is no lack of information on the optimum time to cut alfalfa, and more detailed information can be obtained on many web sites. In general, the optimum time of harvest is a balance between optimizing forage yield, quality, and stand persistence (Fig. 1). As the plant matures forage yield increases, but nutritive value declines because the rate of stem growth exceeds that of leaf growth. Leaf to stem ratio declines with maturity, and the fiber in the stems becomes more lignified thereby decreasing fiber digestibility.

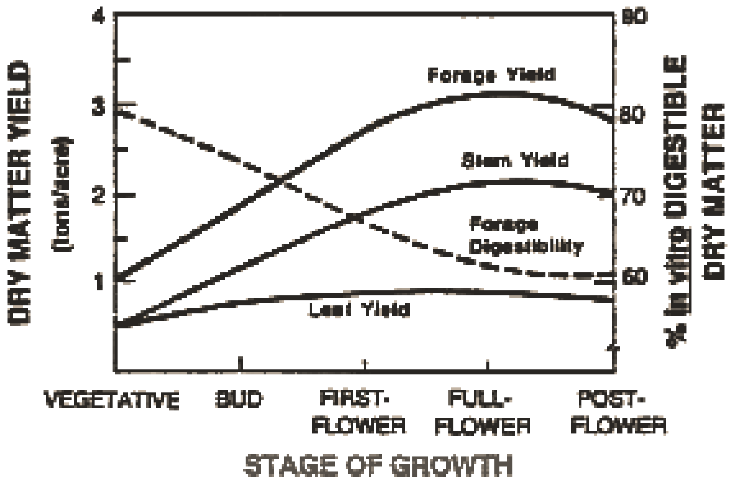

Figure 1. Changes in yield and quality with maturity for legume forages, such as alfalfa (from Minnesota Dept. of Agriculture).

Because energy content of forages is critical for dairy production, current recommendations are to harvest each cutting of alfalfa in the late-bud stage for dairy cows (Mahanna and Thomas, 2011). Timing of cutting is especially important for second cut material, because the long, hot days of summer can result in reduced fiber digestibility. An alfalfa stand will probably last longer under more conservative harvest management, but for second and third cuttings, this produces low-quality forage. The trend is to mow alfalfa at shorter stubble heights (2- to 3-inches) using disk mowers because alfalfa regrows from crown buds, not from the cut stems. Research at Miner Institute found that DM yields rose by 10% by mowing at 2-inch versus 4-inch stubble height, while quality fell by only 4%. However, the last harvest of the season needs to be cut higher (leave 4-6 inches) to catch and hold snow which insulates the alfalfa crowns.

Growing environment also affects forage digestibility, while alfalfa genetics plays a much smaller role (Mahanna, 2009). Most environmental factors that limit plant development (e.g., lack of water, cold weather, plant diseases) tend to promote higher quality because of their effect on increasing leaf:stem ratio. Growing conditions that promote high quality alfalfa include long day lengths, cool nights and moderately dry weather, thus alfalfa grown in western Canada tends to be higher in digestibility than that grown in the south. Warm, wet weather results in the poorest quality alfalfa.

In addition to the effects of growing and harvesting on alfalfa quality, the ensiling process is also very important. However, this topic has been dealt with by previous speakers (e.g., Kung, 2009) and is outside of the scope of the current topic.

▪ Energy Content of Forages Affects Purchased Feed Costs: Corn Silage Example

An example of the impact of the chemical composition of corn silage on purchased feed costs is shown in Table 2. Similar to alfalfa haylage, the main determinant of purchased feed costs when using corn silage is the energy content of the silage. However, unlike haylage, NE_L content of corn silage is determined mainly by its starch content and not digestible fiber content. Corn silage can be an excellent source of digestible energy in the dairy ration when it is well eared and contains high starch content.

In this example, three corn silages were compared; a high energy silage containing 37% starch, a medium energy silage containing 27% starch, and a low energy silage containing 17% starch (DM basis). The diets were formulated using similar conditions as those used in the alfalfa haylage example. As the starch content of the corn silage increased from 17 to 27 and then to 37% DM, forage content of the diet DM could be increased from 40 to 50 to 60%. As a result, less concentrate was needed to maintain the desired level of milk production. Relative to feeding the high energy corn silage, purchased feed costs per 100 kg of milk increased 11% for the medium energy silage and by 24% for the lower energy silage, demonstrating the importance of producing high energy corn silage.

Table 3. Impact of corn silage starch content on least cost ration formulation[1] and purchased feed costs (DM basis)

	Quality		
	High	Medium	Low
Corn silage:			
Starch content (%)	37	27	17
NDF content (%)	40	51	63
CP content (%)	9	9	9
Milk (kg/d)[2]	37.0	37.0	37.0
Dry matter intake (kg/d)	21.5	21.5	21.5
Ration composition:			
NDF (%)	30.6	33.7	36.2
Forage NDF (%)	23.8	25.7	25.2
Crude protein (%)	20.2	19.7	19.3
RUP (%)	37.2	38.5	37.4
Starch (%)	28.0	28.0	26.1
NFC (%)	38.9	37.6	35.6
Ration formulation (%):			
Corn silage	59.5	50.5	40.0
Corn grain	0	9.5	1.4
Corn DDG	17.2	20.9	20.9
Barley	0	0	22.1
Canola	5.1	3.9	0
Soybean meal	14.0	11.7	12.1
Tallow	0.8	0	0
Mineral-vitamin premix	3.5	3.5	3.5
Concentrate cost:			
$/cow/day	3.35	3.71	4.14
$/100 kg milk	9.05	10.04	11.19
$/tonne (as fed)	346	314	289

[1]Rations balanced with CPM Dairy using feed costs as of Nov. 2011.
[2] Contains 3.50% fat and 3.20% crude protein.

▪ Getting the Most Out of Corn Silage in Western Canada

Choose the Right Hybrid

Corn development and yield is very heat-dependent (Baron et al., 2001), so it is very important to select a short season hybrid that is suitable for the environment in which it is grown. The hybrid must have a good chance of developing well eared cobs before the first expected frost to maximize digestible energy yield. For more information on growing corn for silage in Western Canada, readers are encouraged to consult Dr. V. Baron's previous paper presented at the WCDS (Baron et al., 2008).

Harvest at the Right Stage

For both short and long season hybrids, DM content of the plant increases as the crop matures. Within the DM, the starch content increases due to development of the ears (Fig. 2). However, the starch also becomes less digestible as the kernels become harder. Thus, as the DM content of the silage increases, kernel processing to maximize digestibility of starch becomes more important. The increase in ear development dilutes out the stem and leaves, and thus NDF content decreases as the plant matures. In addition, the NDF becomes less digestible with maturity.

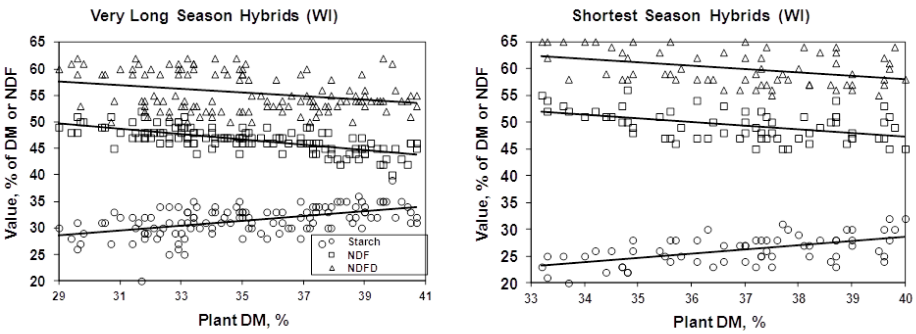

Figure 2. Changes in starch and NDF content, and digestibility of NDF (NDFD), with plant maturity for short and long season corn hybrids (courtesy of F. Owens, Pioneer Hi-Bred, Des Moines, Iowa).

So, what happens to energy content (NE_L) as the plant matures? Energy content of corn silage can be estimated from chemical composition and there are a number of different prediction equations that can be used. The estimated energy value will depend on the equation used. In general, if a kernel processer is not used, most equations predict that the NE_L content is maximized at about 32-34% DM, and if a kernel processor is used, then NE_L is maximized at about 37-41% DM. However, results from recent feeding studies tend to suggest that these prediction equations may underestimate the NE_L content of more mature silages, especially if kernel processing is used. Silage has more starch (and value) today than 15 years ago when most of these equations were developed, and starch digestibility increases during fermentation (F. Owens, Pioneer Hi-Bred, Des Moines, Iowa Pioneer; personal communication).

With more mature corn silage, NDF content declines, plus digestibility of both NDF and starch decline. So, one might ask, why doesn't energy content decline. The reason for this is that starch content increases, which more than compensates for the decline in NDF digestibility. Thus, the most important factor affecting the energy content of corn silage is how well eared the corn is (i.e., starch content), once again stressing the importance of choosing a hybrid that will yield high starch content before frost.

Corn silage should be harvested at a maximum of 40% DM if a kernel processer is used, and at a maximum of 34% when a kernel processer is not used. The benefits of increased maturity at harvest are more DM harvested, greater starch and grain yield, and greater yield of NE_L per hectare. However, the limitations of increased maturity at harvest are reduced starch digestion, if silage is not processed, reduced digestibility of NDF, and the increased difficulty of ensiling. It should be noted that corn silage DM values refer to the moisture content of the plant at the end of its growth cycle (i.e., harvesting and/or frost), not to be confused with any change in DM content due to dry-down that occurs between frost and harvest. Drier silage at harvest increases the difficulty of packing and can lead to greater penetration of oxygen, with the risk of more heating and DM loss during feedout. Producers must weigh the potential benefits of delayed harvest against the risks.

▪ Optimizing Barley Silage Nutritive Value

Aspects of optimizing yield and quality of cereal silage in western Canada have also been covered previously at this conference (Baron et al., 2001). In general, the same concepts discussed above for corn silage apply to cereal silage, with some exceptions. Like corn silage, cereal silage is produced as a source of digestible energy and starch content increases while NDF content and digestibility of starch and NDF decrease as the plant matures. However, unlike corn, the decrease in starch digestibility that occurs with kernel ripening cannot be overcome using kernel processing, because it is not possible to set the rollers tight enough to break the kernels. Therefore, it is essential to harvest cereal silage before it becomes over mature, with the ideal stage corresponding to a silage DM content in the range of 30 to 40% DM.

A complete discussion of the optimum timing of harvest of barley for silage can be found in Baron et al. (2001), with the key points given below. For barley grown in central Alberta, 30% DM is attained about 17 days after heading. Barley plants continue to dry at about 1 percentage unit per day under average temperature conditions in central Alberta. However, drying can occur at a faster or slower rate depending on temperatures, with hotter temperatures speeding up the drying process. Thus, the DM content of barley can change from 30 to 40% in less than 10 days. Some drying will occur between cutting and when it enters the silo, so producers should allow more time than indicated by the dry down rate or cut earlier to avoid over-dry silage. Thus, the harvest window is short for barley, so it is important to begin the harvest such that silage making is complete before the silage becomes over-mature.

Baron et al. (2001) also explains that whole-plant yield of barley is about 85% of maximum at the point where silage harvest should occur. By the time 40% DM is attained, whole-plant yield is at about 95% of maximum. Thus, in achieving an optimum DM content, yield loss ranges from 5 to 15%.

▪ Conclusion

The cost of feeding is expected to increase as grain prices continue to increase, thus it is extremely important to maximize the use of home grown forages to minimize the purchase of off-farm concentrates. The digestible energy content of forage determines concentrate needs, so it is critical to produce high energy forages.

To maximize digestible energy content, harvest alfalfa forage in the late-bud stage to promote low fiber content and high fiber digestibility. With corn and barley silage, grain development and high starch content maximizes digestible energy content. However, barley needs to be harvested before it becomes over mature, because kernel processing cannot be used to increase starch digestibility of hardened kernels, unlike in the case of corn silage.

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