

Corn Silage Digestibility - Separating the Grain from the Chaff

Joanne Siciliano-Jones, Ph.D., F.A.R.M.E. Institute, Inc., Homer, New York (607) 749-5747

Introduction

The digestibility of a given farm's forages is of critical importance in determining the profitability of milk production. This being said, we must recognize that the digestibility of a given forage crop is the result of the combined effect of environment, harvest and ensiling management and genetics. As in most aspects of dairy farming, good genetics alone will not ensure success, but a combination of excellent management and good genetics will stack the deck in your favor.

To properly evaluate corn silage digestibility rankings requires two things. The first is an understanding of the various methods used in determining silage digestibility and what this means to your farm and your cows. The second is how the growing season and your management decisions will affect the digestibility of the resulting crop. The following information was developed to put these issues into perspective.

Digestibility Testing Methods

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There are 3 major types of digestibility tests. These are 1) animal digestion trials where a test feed is fed to a number of animals and differences in digestion are measured, 2) *in vitro* digestibility testing where a test feed is finely ground and disappearance of dry matter or fiber is measured in a buffered solution of ruminal fluid contained in a glass (or plastic) vessel, and 3) *in situ* digestibility testing where a test feed (either ground or as fed) is placed in a porous cloth bag and disappearance of dry matter or fiber is measured in the rumen of a ruminant animal.

Animal digestion trials are the most accurate method for measuring forage digestibility. However, these studies require large numbers of animals (>20 per test feed), large amounts of test feed, and substantial amounts of time. As a result, this type of testing is not feasible for evaluation of large numbers of hybrids in many locations. *In vitro* and *in situ* tests were developed as a way to obtain the same types of digestibility information with a lower investment of time and money. Both *in vitro* and *in situ* digestion are correlated with animal production. Each method has certain advantages and disadvantages that must be taken into account when evaluating silage digestibility tests.

In vitro digestibility testing was the standard testing method for many years because of consistency of the results and small sample size requirements. Generally, *in vitro* procedures use a buffered solution of ruminal fluid. However, some procedures use purified fiber digesting enzymes such as cellulases. A drawback of *in vitro* testing is that it requires the use of very finely ground (1 or 2 mm) samples. It is well known that finely ground feedstuffs are digested differently than coarsely chopped materials. Recent research has shown that finely grinding feedstuffs may erase differences in digestibility. This problem is demonstrated in a comparison of corn silage harvested at dent and black layer stages which was recently conducted by researchers at Washington State University and the University of Idaho. While there is no doubt that corn silage harvested at dent will be more digestible and support a higher level of milk production than black layered corn silage, the following figure shows how drying and finely grinding both corn silages removes digestibility differences as measured with *in vitro* testing. Recent research at the University of Minnesota suggests that *in vitro* testing may reflect starch content more than actual digestion.

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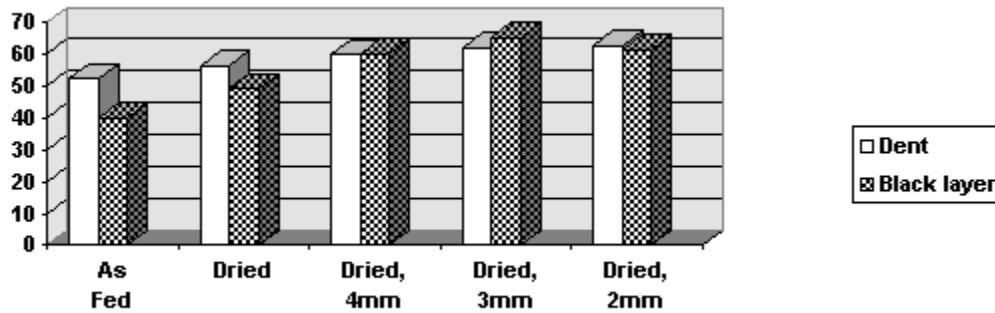
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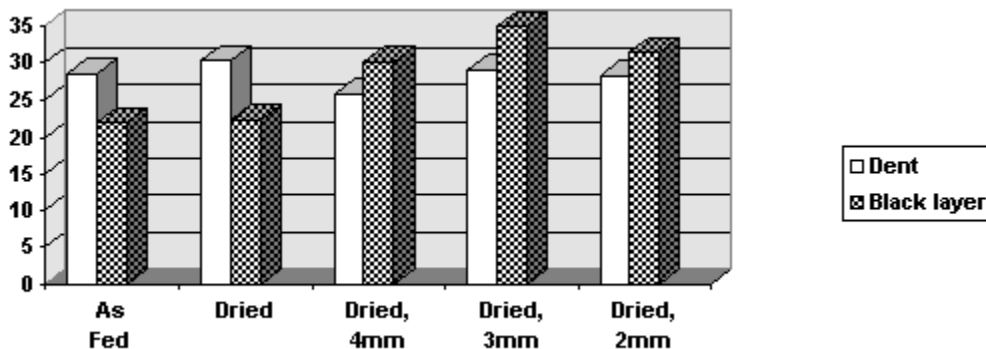
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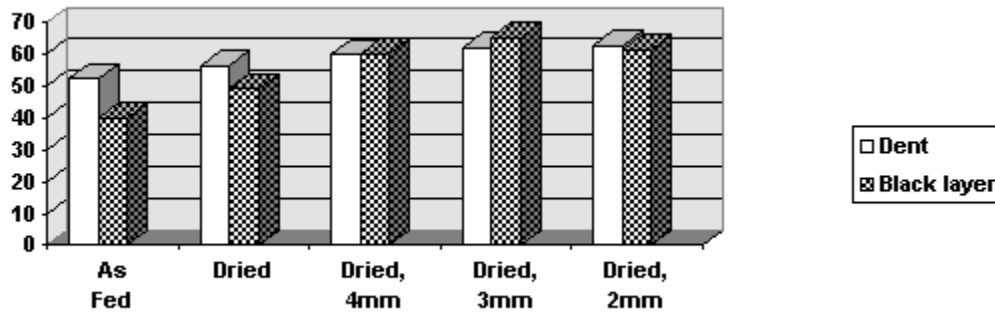
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Because of the problems in differentiating forage digestibility introduced by grinding forage samples, *in situ* digestibility evaluations using as fed forages are receiving more attention. The *in situ* technique requires more care in the laboratory than *in vitro* testing to ensure repeatable results; however, numerous University and private studies show that *in situ* results with as fed forages are a better method to predict animal performance. Some laboratories conduct *in situ* tests using finely ground forage samples to reduce sampling error. In this case, the same problems experienced with *in vitro* testing will be experienced. A potential drawback to *in situ* testing is that the testing should be done in the same type of animal that the results will be applied to. For instance, if silages are to be evaluated for feeding to lactating dairy cows, the *in situ* tests cannot be conducted in sheep or beef animals. In spite of the extra care required, several companies are evaluating *in situ* testing of silage hybrids to ensure that digestibility evaluations result in a real economic benefit to customers.

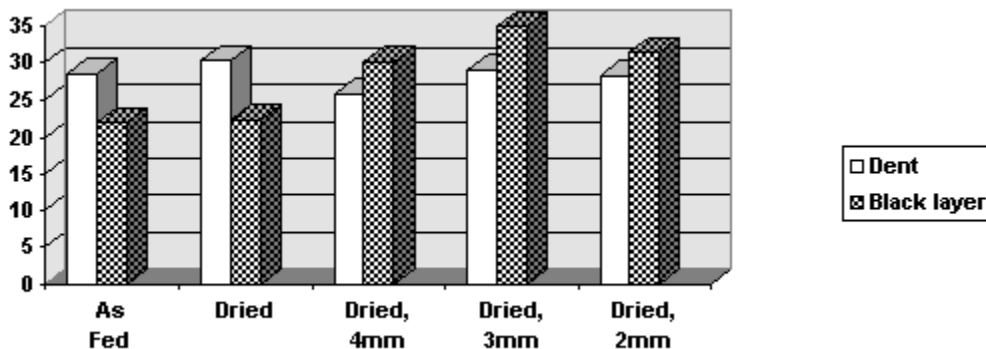
To improve speed and reduce costs, some companies predict digestibility (either *in vitro* or *in situ*) using near infrared reflectance (NIR). Put very simply, this technique detects particular chemical structures by the way in which a light beam is reflected off the sample. Patterns of light reflectance are then related to various levels of different nutrients. Nutrients with distinct chemical structures such as moisture and nitrogen are easier to predict than more complex structures like ADF and NDF. Because all nutrient levels are predicted from light reflectance which can vary with growing season and day length, NIR calibrations must be updated regularly to remove the influences of interfering factors such as pigments. With NIR, predicting digestion of finely ground materials has the same problems discussed for *in vitro* testing. In addition, there is no single "digestibility" molecule or compound, which makes prediction of digestibility with NIR technology more difficult than standard nutrient analysis predictions.

All of the methods discussed above can be conducted with variations on the basic procedure. One of the most common differences among labs is length of the digestion period. This can vary from 24 to 48 hours. Differences in digestibility methods and lengths of digestion result in different baselines for digestibility results making it virtually impossible to compare one company's digestibility results to those of another.



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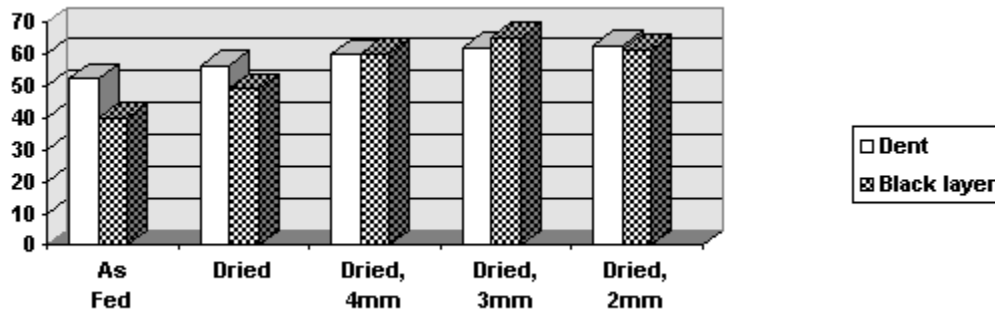
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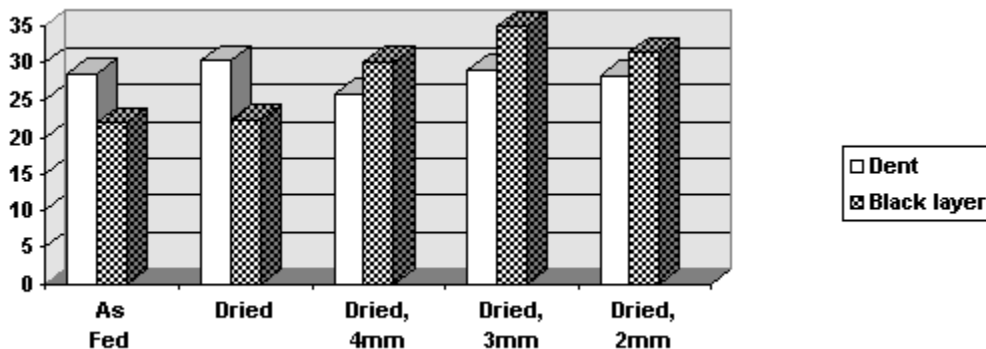
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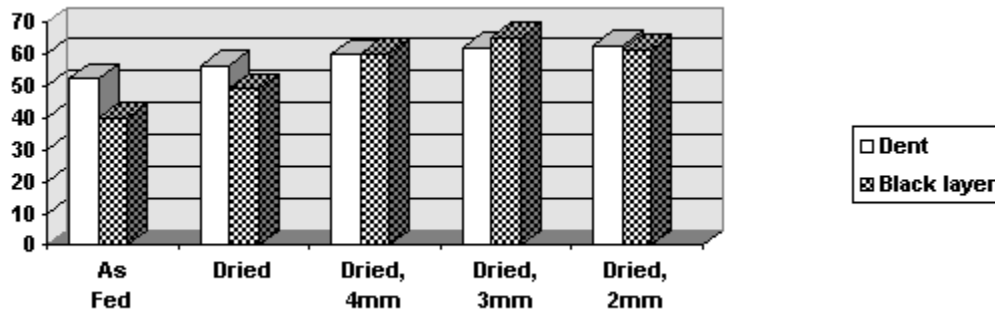
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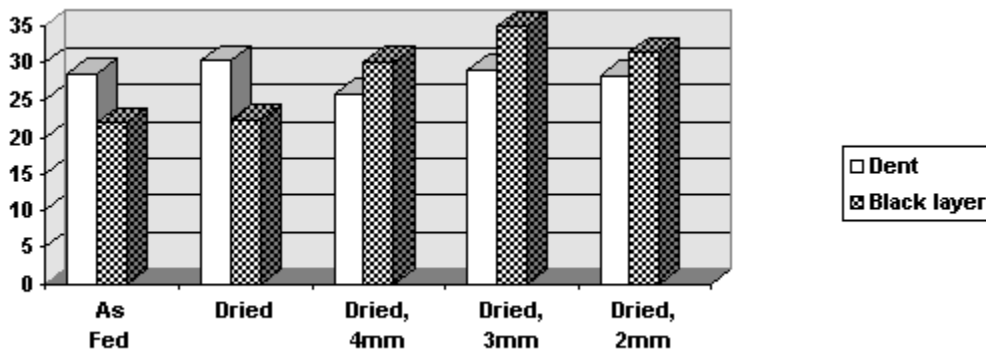
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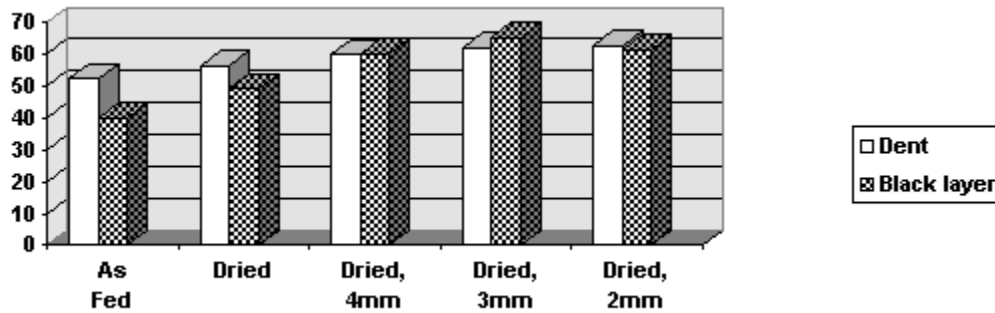
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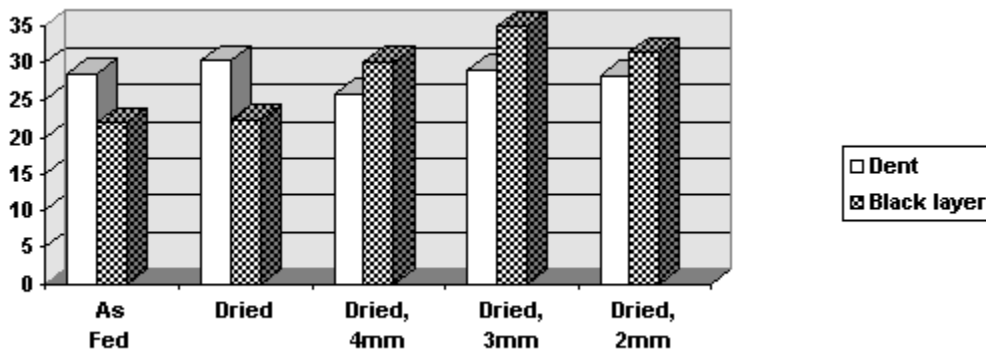
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Because of the problems in differentiating forage digestibility introduced by grinding forage samples, *in situ* digestibility evaluations using as fed forages are receiving more attention. The *in situ* technique requires more care in the laboratory than *in vitro* testing to ensure repeatable results; however, numerous University and private studies show that *in situ* results with as fed forages are a better method to predict animal performance. Some laboratories conduct *in situ* tests using finely ground forage samples to reduce sampling error. In this case, the same problems experienced with *in vitro* testing will be experienced. A potential drawback to *in situ* testing is that the testing should be done in the same type of animal that the results will be applied to. For instance, if silages are to be evaluated for feeding to lactating dairy cows, the *in situ* tests cannot be conducted in sheep or beef animals. In spite of the extra care required, several companies are evaluating *in situ* testing of silage hybrids to ensure that digestibility evaluations result in a real economic benefit to customers.

To improve speed and reduce costs, some companies predict digestibility (either *in vitro* or *in situ*) using near infrared reflectance (NIR). Put very simply, this technique detects particular chemical structures by the way in which a light beam is reflected off the sample. Patterns of light reflectance are then related to various levels of different nutrients. Nutrients with distinct chemical structures such as moisture and nitrogen are easier to predict than more complex structures like ADF and NDF. Because all nutrient levels are predicted from light reflectance which can vary with growing season and day length, NIR calibrations must be updated regularly to remove the influences of interfering factors such as pigments. With NIR, predicting digestion of finely ground materials has the same problems discussed for *in vitro* testing. In addition, there is no single "digestibility" molecule or compound, which makes prediction of digestibility with NIR technology more difficult than standard nutrient analysis predictions.

All of the methods discussed above can be conducted with variations on the basic procedure. One of the most common differences among labs is length of the digestion period. This can vary from 24 to 48 hours. Differences in digestibility methods and lengths of digestion result in different baselines for digestibility results making it virtually impossible to compare one company's digestibility results to those of another.

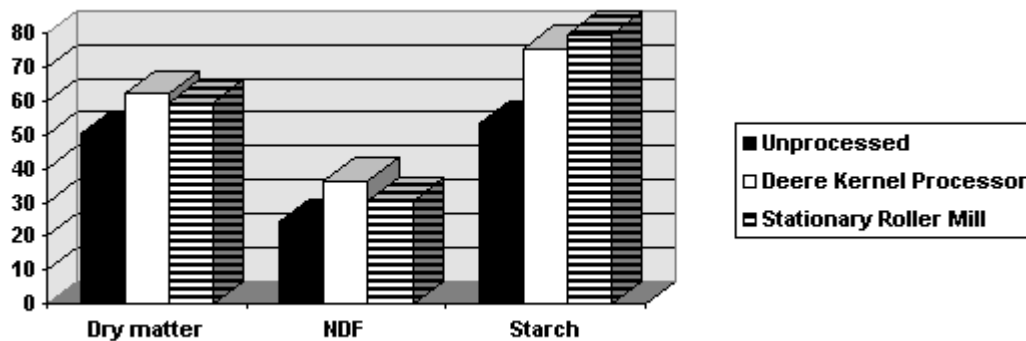
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Plant appropriate relative maturity hybrids to accommodate your harvest schedule. For many farms, this will mean using the traditional guidelines on planting early, mid season and full season hybrids (for your farm) to spread your workload at harvest. For bunker silos, harvest whole plant corn silage at 1/3 to 1/2 milkline or about 72 to 65% moisture to capture optimum yield and digestibility. Both the planting and harvest schedule must be managed in conjunction with the relative maturities of the corn silage hybrids to minimize the risk of harvesting overly mature corn silage with low digestibility. For instance, avoid planting all long season hybrids on your best fields early in the season and all short season varieties later on the poorer soils so that all the corn silage fields are not ready for harvest at the same time. It is equally important to place hybrids where they can be harvested. Planting a hybrid on poorly drained soils which will prevent timely harvest will result in a low digestibility silage.

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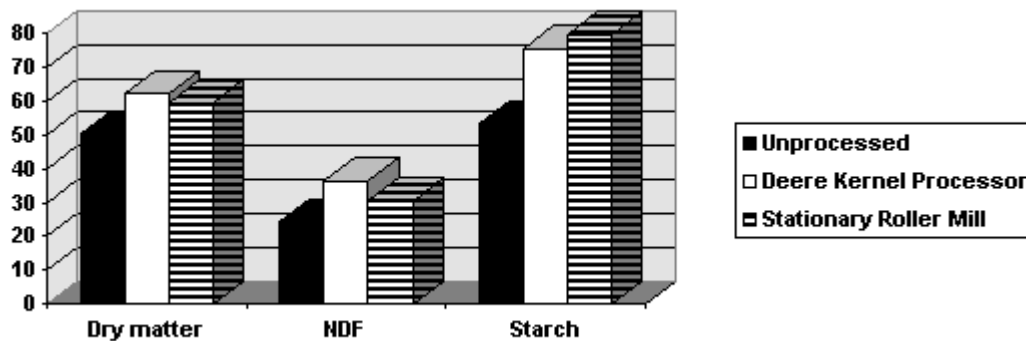
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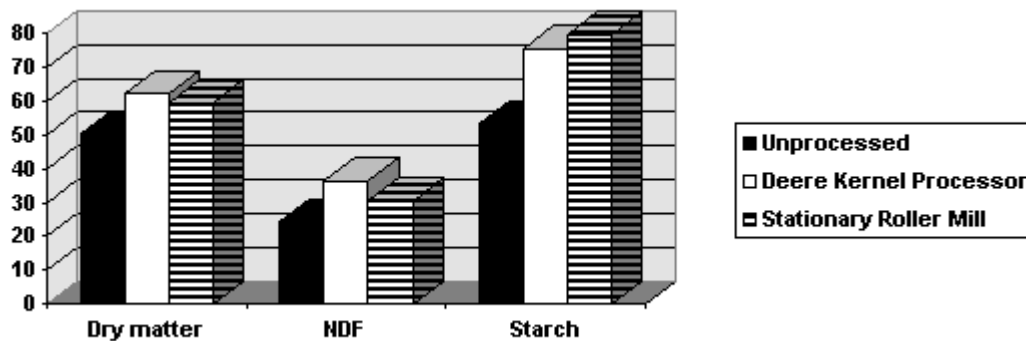
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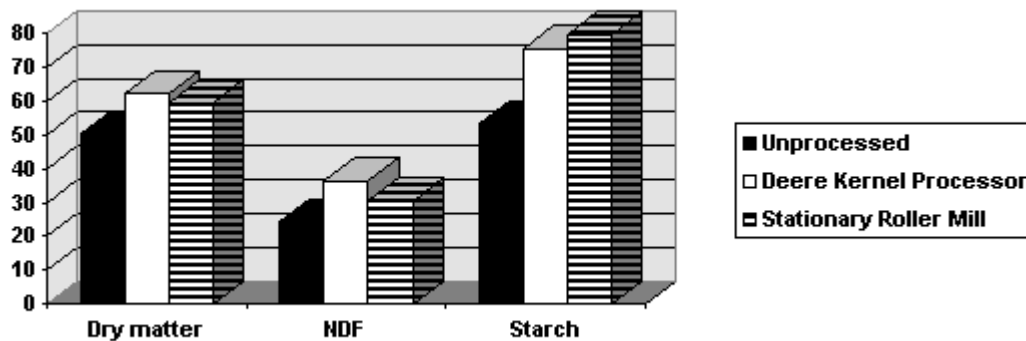
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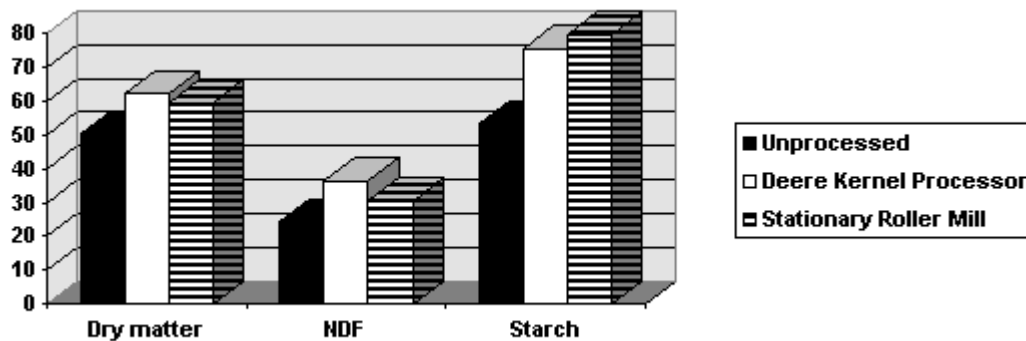
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First and foremost, you must select hybrids that can be grown and harvested at the appropriate stage of maturity on your farm. After this, forage inventories may dictate hybrid selection strategy. If corn silage supplies are generally tight, yield must be a primary consideration. If supplies are generally abundant, quality characteristics may be weighted more heavily. This must be a farm by farm decision. Growers are advised to use the following selection criteria (listed in approximate order of importance) in choosing suitable hybrids.

- **Relative maturity** - Should be appropriate for the growing environment, as well as the harvest management plan. The recommended spread of maturities should always be planted to avoid a small harvest window.
- **Yield** - Plant height and leafiness and grain:stover ratio are related traits which may also be evaluated. Maximizing yield of digestible nutrients is most desirable. However, depending on available corn ground and forage inventory requirements, economics may dictate that yield be of slightly more importance than digestibility or vice versa. Hybrids for silage production should be evaluated on whole plant dry down. Many times, hybrids with strong **stay-green** are too wet for ensiling at the appropriate stage of kernel development or have extremely hard kernels when moisture is optimal for ensiling.
- **Grain content** - High grain content is still desirable to help minimize off farm grain purchases and allow for harvest of corn grain if yields and market conditions are favorable. Provided that the grain is digestible, high grain yields will be closely related to nutritional quality. Soft kernel texture helps maximize grain digestion. A high grain yield is of no use if the grain ends up in the manure pit. This characteristic will be related to nutritional quality.
- **Adaptation to high plant population** - Selected hybrids should yield and stand well at high populations to maximize productivity of the corn growing enterprise.
- **Nutritional quality** - Potential for high digestibility must be accompanied by the above characteristics. Very few producers can afford to substantially sacrifice yield for high digestibility.

Unique Genetics are a special case. A number of companies market corn hybrids which are genetically very different from common commercial hybrids. The most important consideration in evaluating this type of hybrid is what information is available to demonstrate the hybrid's advantages. On farm trials, unless conducted with split pens, are notoriously difficult to evaluate. Just think how many events on your farm can cause your milk production to change. The best evidence is a controlled research test - either a lactating cow trial or digestibility comparisons.

Almost equally important is expected yield. In some cases, increased digestibility is accompanied by poor yields or standability. Make sure you know any downside risks associated with a particular hybrid. Three of the more common cases of unique genetics are discussed below.

Starch variants (waxy corn, high sugar corns). A number of starch variants have been found in corn; many are used in human products. No conclusive research is available with these plants. In evaluating this type of hybrid, consider 3 issues. First, will you be feeding enough starch from corn silage that you will make a meaningful change in the types of starch/sugars reaching the rumen. If you currently feed more than 8-10 lbs. of corn meal and less than 25% of ration DM comes from corn silage, the answer is likely to be no. Second, don't forget the stover. An improved starch package in the grain cannot make up for low fiber digestibility in the stover. Third, determine what will happen to the starch or sugars during ensiling. Will ensiling remove or reduce the unique starch characteristics provided by the hybrid.

High oil corn. High oil corn can be grown as a hybrid or using the DuPont TopCross^R system. TopCross^R produces a

because of grain development. Further along in the maturation process, increases in GDD decrease digestibility. This loss in digestibility is due to drying and hardening of the grain, as well as maturation and lignification of the plant fiber. Losses in corn silage digestibility with increasing GDD can be avoided by selecting hybrids with above average digestibility rankings and harvesting the crop on time.

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Brown midrib corn. Brown midrib corn has a mutation which prevents complete lignification. This mutation has been studied for many years. Increases in digestibility and animal performance are well documented. Older hybrids were plagued by poor agronomic performance; less information is available on new hybrids. This is one case where documentation of the digestibility information is of less importance than documentation of agronomic performance.

Evaluating Digestibility Evaluations

Since there is no standard method for determining corn silage digestibility, hybrid digestibility tests must be approached with care. Various testing procedures can result in biases for certain types of hybrids. Four major areas are of importance.

- Magnitude of hybrid differences - every testing method has a degree of variability associated with it. Make sure that different hybrid rankings translate into measurable differences in digestibility from both a statistical and biological standpoint. My rule of thumb: if the difference between hybrids is less than 5% of their digestibility values, its probably not a real difference.
- Finely grinding silage samples (most *in vitro* and some *in situ* tests) will overemphasize the importance of grain yield (starch). This will be a big problem with hybrids that have rapid kernel maturation relative to the rest of the plant or those producing a hard kernel.
- Relative maturities of the hybrids being compared. This is not usually a problem within a given company's ranking system. Problems occur when single site strip trials are evaluated without segmenting hybrids by degree of maturation. This problem can also occur when digestibility data developed for another purpose, such as a management trial, is used to compare hybrids of differing maturities. Comparing one hybrid harvested at 1/3 milklime to another harvested at 2/3 milklime is useless.
- Design of the digestibility comparison. Most digestibility comparisons are conducted in strip or small plots. Others are conducted in matched fields. Either approach is acceptable, provided conditions are consistent for all hybrids. The need for comparing hybrids of similar maturity has already been discussed. In addition, it is critical that soil type and drainage, fertilization and pest control, and plant populations be consistent across the test. Otherwise, digestibility comparisons will be suspect at best.

Putting It To Work On Your Farm

Before deciding to include nutritional quality as one of the criteria to be used in hybrid selection, each farm operation should be thoroughly evaluated. The evaluation should cover the following areas:

- Forage inventories - can yield be sacrificed for improved quality? If so, to what extent?
- Storage facilities - is silage stored in bunkers, uprights, or bags? Is harvest moisture appropriate for the structure. Are facilities big enough to store all required silage? Is storage flexible enough to allow segmentation of the corn silage inventory based on nutritional quality?
- Maturity window for the farm - this includes not only average growing seasons but also individual farm factors such as machinery and labor availability and proximity of the fields to the silo(s). The important question here is; will harvest cover 1 week or 1 month? Overly mature hybrids may not hold their improved digestibility characteristics. In addition, some "high-quality" hybrids currently on the market do not exhibit adequate standability if harvest is delayed past optimum.
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