SILAGE QUALITY: HOW IS IT DEFINED AND MEASURED?

Karl Nestor Jr.[1]

INTRODUCTION

Corn silage is a palatable high energy, low protein forage that is used in most dairy rations across the US. The usage of corn silage has grown over the last decade. Seed companies have focused breeding activities on corn silage hybrids resulting in corn silage hybrid differences that rival other species in nutritional differences. When making decisions about the quality of corn silage, dairy producers needs can vary tremendously. If land base is limited, then total tonnage yield is extremely important or if disease pressure is high, then traits are important etc. There are many factors that affect the quality of corn silage such as chop length, packing density, etc. but the purpose of this paper is to discuss some of the nutritional quality differences of corn silage that the dairy producer should consider when making hybrid decisions and to answer some frequently asked questions about corn silage quality. Table 1 lists typical values for corn silage and includes alfalfa parameters as well for a point of comparison.

From a nutritional standpoint, the issue with corn silage is that it's a very heterogeneous material consisting of starch (grain) and fiber (fodder). Each of these should be considered when deciding about nutritional quality of corn silage however, there has been more progress on the fiber digestibility component than the starch component to date and more about fiber digestibility will be discussed. This is not to minimize the importance of dry matter as it is a key when making good silage but the purpose of this paper will be to focus on fiber and starch.

FIBER

The forage component of corn silage is made up of many different fiber types such as hemi-cellulose, cellulose, and lignin. Fiber is digested or fermented by rumen micro-organisms in the rumen of the dairy cow and are converted to useable volatile fatty acids such as acetic and propionic acids. These are then absorbed through the rumen wall and can be utilized by the dairy cow for energy or milk fat production. Acetic acid is one of the major components in milk fat production and is one reason why forages are so important in the dairy ration to help maintain milk fat production. Lignin is the indigestible portion of the plant and helps give it structural strength. Increasing the maturity of the plant increases the lignin content and is one reason why mature plants aren't very digestible. Corn silage hybrids with high lignin have lowered fiber digestibility. Corn silage hybrids with lower levels of lignin such as brown mid-rib (bmr) are available on the market today and can be a good option to increase fiber digestibility.

One of the key factors you should consider when considering corn silage is fiber digestion measured as neutral detergent fiber (NDF) digestibility. The NDF measurement lumps together several of the fiber components of a plant . Not that many years ago, most corn silages were very

---

[1] K.E. Nestor Jr. (kenstorjr@dow.com), Senior Nutritionist, Mycogen Seeds, 1236 Point of View Dr. Wooster, OH 44691 IN Proceedings, 2010 California Alfalfa & Forage Symposium and Corn/Cereal Silage Mini-Symposium, Visalia, CA, 1-2 December, 2010. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa symposium Proceedings)

similar in their nutrient content, including fiber digestibility but plant breeders have placed a lot of focus on improving the quality of corn silage and one way this has been done is by improving the NDF digestibility. Ranges of NDF digestibility measurements in the lab have ranged from 30% to 74.3% (4).

Why is this important? In a research review, Michigan State University reported that increasing NDF digestibility increases dry matter intake resulting in an increase in milk production (8). The relationship they reported was that for every percentage increase in NDF digestibility, milk production is increased 0.55 lb. per cow per day. This indicates the NDF digestibility should be a key consideration in your forage selection as it can directly effect the performance of your dairy cows.

Those of you that are raising or contracting alfalfa have been focusing on fiber digestibility indirectly as crude protein is directly related to fiber digestibility in alfalfa. A higher protein alfalfa tends to "feed better" than a lower protein alfalfa and the reason is the increased fiber digestibility. Now, with the differences in corn silage hybrids, the same focus can be put on fiber digestibility in your corn silage. When contracting corn silage, most of the emphasis is placed on the overall tonnage but a bonus could be added to the contract (similar to alfalfa contracts) to reflect differences in NDF digestibility.

When deciding on a corn silage hybrid based on NDF digestibility, you should pick one that is at least 4-5 percentage units different than your reference hybrid. Differences smaller than this may not be statistically different and may simply be due to lab variation. In addition, the small increase in milk production resulting from a small difference in NDF digestibility may not be observed because of the day to day variability in total milk production. Some corn silage hybrid such as bmr hybrids can have up to 12 percentage units increased NDF digestibility over typical corn silages.

The measurement of NDF digestibility is a key issue in making your decision on corn silage hybrids based on fiber digestibility. Most commercial labs will measure NDF digestibility. There are two basic methods used to measure NDF digestibility - in vitro (or wet chemistry) and NIR (near infrared reflectance). The in vitro method is a direct method of measurement while NIR estimates NDF digestibility. In vitro is costly while NIR is relatively cheap. At this point in time, I believe that in vitro measurements give you a better measurement of NDF digestibility than the NIR measurement but the NIR process could be used when you are attempting to simply rank hybrids. One issue with NIR is that the differences between hybrids in NDF digestibility tends to be less as compared to the wet chemistry measurement. Knowing the true difference in NDF digestibility between hybrids could be very important when deciding between two hybrids. However, if your goal is to simply rank the hybrids in order of NDF digestibility, NIR can be a valuable tool.

Another consideration when analyzing NDF digestibility is the time points that are used for the measurement. Time points reflect the length of time that the forage in incubated before the NDF disappearance in measured. Standard time points are 30 hr. (which is reflective of the time forage spends in the rumen of the cow) and 48 hr. Other time points becoming popular are 24 hr. and even 12 hr. The shorter the time point used, the higher the variability will be in your samples.

Also, the NDF digestibility will be higher with longer incubation time so you can't compare a hybrid that was measured at 30 hour to a hybrid measured at 48 hr. A key point is to pick a lab you are comfortable with, and stick with that lab. Different labs have inherent internal variations in measurements so it is important to stay with the same lab for your analyses. Also, pick a time point and stay consistent with that time point. This allows you to make comparisons of hybrids without worrying about lab variation or time variation.

When feeding a high NDF digestible corn silage, care should be taken. First, maximize the amount of forage in the diet to make use of the increased NDF digestibility. It doesn't make sense to raise a corn silage with high NDF digestibility and then feed a limited amount which is essentially diluting the effect of increased digestibility. In addition, the higher NDF digestibility results in a higher energy forage (NDF is actually an energy source) and so high NDF digestible corn silage can replace a limited amount of corn or starch sources in the ration. These changes will result in a higher NDF in the overall ration but remember that you are focusing on a higher NDF digestibility so the higher NDF will not limit dry matter intake. Consult with your nutritionist before making any ration adjustments.

STARCH

The grain component will make up approximately 40% of the total silage. Approximately 75 to 80% of the kernel is starch. Starch on it's own is a very digestible high energy component and can be rapidly fermented within the rumen environment to volatile fatty acids which are then absorbed through the rumen wall and utilized as energy by the dairy cow. However, the starch in the corn kernel is protected by the outer pericarp layer and this must be broken before the starch can be digested. Factors that affect the availability of the starch in the rumen include dry matter of the forage, particle size as a result of kernel processing, and endosperm type.

Anything that can be done to break down the pericarp will increase starch digestibility. Higher moisture will soften the pericarp and allow better starch digestibility. Maturity and dry matter of the corn plant at cutting will affect starch digestibility. Studies have shown that increasing maturity of the corn plant (and increased dry matter) decreased starch digestion and reduced milk production (2). These results have been confirmed in other studies as well (5). When the plant becomes too mature, or harvest is delayed, it results in very hard corn kernel that have the tendency to pass completely through the digestive tract of the cow and is excreted in the feces.

Silage processing has become popular in the last decade to try to alleviate some of these types of problems. Silage processing helps to reduce the particle size of the kernel by breaking the pericarp barrier allowing rumen microflora access to the starch. When feeding grain, it is very desirable to reduce the particle size as much as possible through grinding but this can't be done with silage. The goal of silage processing is to break the kernel allowing for better starch digestion.

A third factor to consider for starch digestibility in corn silage is the type of endosperm. There are basically two types of endosperm in use in silages, one is a flinty or vitreous endosperm and the other is a floury or non-vitreous endosperm. The more vitreous the endosperm, the lower the overall starch digestibility (3). Vitreous endosperm is a very hard starch while a floury endosperm is relatively soft. One reason why grain hybrids can make somewhat poor choices for silages is that they can contain a lot vitreous or flinty type endosperm which allows for the grain to be handled (loaded, unloaded, etc.) without damage to the kernel. Kernel processing can help alleviate some of the vitreous issues but the vitreous starch itself is not as digestible as floury type starch.

Starch analysis in the lab is tricky at best because the starch itself is very digestible. Lab processes usually include grinding of the sample which make the starch much more available than what is probably accurate for the cow. The same considerations about lab choice discussed under fiber are relevant for starch. Each lab has their own starch degradability measurement and you should find a process and lab that you are comfortable with and stay with that lab.

CONCLUSION

While all of the issues with starch are important, none will necessarily maximize production in the dairy cow. Poor starch digestion in corn silage is detrimental but can be overcome somewhat by addition of external energy sources in the ration. The dairy ration will consist of roughly 50% forage and will be high in fiber and so emphasis should be placed on the quality of the fiber in the forage. There isn't much you can do to overcome poor fiber digestion in a silo full of forage. Corn hybrid choices are extremely robust and you can tailor the silage to fit the needs of your farm.

Two tools for corn silage comparisons developed by the University of Wisconsin for use in hybrid evaluations is their MILK2000 and MILK2006 spreadsheets (9). These spreadsheets calculate an energy value of corn silage based on both starch and NDF digestibility and deliver a value of milk per ton and milk per acre. Milk per ton is an estimate of the milk production from a ton of silage and milk per acre simply multiplies the milk per ton by the yield per acre. These terms, while helpful in making hybrid comparisons should not be your only factor and can be somewhat misleading. A good discussion of these factors can be found at (1). For example, a hybrid that yields very well but is poor nutritionally can have a very good milk per acre value but then you are stuck with a lot of bad silage. Also, a very poor yielding hybrid can have a very good milk per ton value but would be undesirable because it won't fill your silo. Both of these should be considered in your choice and you should try to maximize both with your hybrid selection.

It may be the time to start focusing on your corn silage hybrid selection and treating corn silage hybrids like alfalfa and focus on other factors other than just tonnage yield. Using NDF digestibility as one of your major criteria in picking a silage hybrid should become important if your goal is to maximize forage usage on your farm.

REFERENCES

1). Allen, M. 2005. Milk per Acre: Right for Some, Wrong for Many. http://dairyteam.msu.edu/articles/mdr/mdr_milkperacre.pdf

2). Bal M.A., J.G. Coors, and R.D. Shaver. 1997. Impact of the Maturity of Corn for Use as a Silage in the Diets of Dairy Cows on Intake, Digestion and Milk Production. J. Dairy Sci. 80:2497-2503.

3). Correa, C.E.S. R.D Shaver, M.N Pereira, J.G. Lauer, and K. Kohn. 2002. Relationship between corn vitreousness and ruminal in situ starch degradability. J. Dairy Sci. 85:3008-3012.

4). Hoffman, P.C. 2002. New developments in analytical evaluation of forages. Proc. Four State Professional Dairy Management Seminar pg. 1-12.

5). Johnson, L. J.H. Harrison, C. Hunt, K Shinners, C.G. Doggert, and D. Sapienza. 1999. Nutritive value of corn silage as affected by maturity and mechanical processing: A contemporary review. J. Dairy Sci. 82:2813-2825.

6). Nestor, K.E. Jr., P. Krueger, J. Anderson, J. Brouillette, and K. Emery. 2010. Fermentation Profile Over Nine Months of Storage of Brown Midrib and Non-Brown Midrib Hybrid Corn Silage.

7). NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy of Science, Washington DC.

8). Oba, M, and M.S. Allen. 1999. Evaluation of the importance of the digestibility of neutral detergent fiber from forage: effects on dry matter intake and milk yield of dairy cows. J. Dairy Sci. 82:589-596.

9). Shaver, R. Corn Silage Evaluation: Milk2000 Challenges and Opportunities with Milk2006. http://www.foragelab.com/pdf/FeedReports/milk2006weblinkslides.pdf

Table 1. Typical nutrient values for non brown mid rib (bmr) corn silage, bmr corn silage and alfalfa haylage and hay. (5,6) All values are in dry matter unless otherwise noted.

Parameter	Corn Silage	BMR	Alfalfa Silage	Alfalfa Hay
Dry Matter, %	32-38	32-38	38-40	85-92
Crude Protein, %	8.1	8.4	18-24	18-24
Soluble Protein, % of CP	50.4	49.3	50	25
NeL, Mcal/lb.	0.76	0.77	0.62	0.62
ADF, %	25.8	24.6	31-35	31-35
NDF, %	41.3	40.1	38-42	38-42
Lignin, %	3.1	2.5	7.3	7.3
Starch, %	31.6	31.0	20	17
pH	3.9	3.8	4-4.5	
30 hr dNDF, % of NDF	57.2	69.3		
Lactic, %	4.83	5.06		
Acetic	1.92	2.21		
Total VFA	6.79	7.39		

Please note that these values are typical and your results can vary.