

EVALUATING CORN SILAGE FOR FEED VALUE

Corn silage is the predominant forage used by the dairy industry in the United States, with more than 2.5 million hectares harvested in 2015 (USDA- NASS 2016). Plant fiber in corn silage and other forages is the foundation upon which nutritionally sound, economical and healthy dairy diets are built. In order to determine the quality and energy in corn silage, a representative sample is sent to a laboratory for wet chemistry analysis to measure nutrient levels and digestibility.

Moisture

The major factor affecting the quality of corn silage is stage of maturity at harvest. Moisture content is important for silage fermentation and can affect feed intake, palatability, and digestibility. The **goal for optimal corn silage whole plant dry matter is between 32-36%**. If corn silage is harvested too early, starch will be low, undesirable fermentation acids will be high, and there will be higher run-off of nutrients. If corn silage is harvested too late, starch and fiber digestibility will be compromised, there will be less production of desirable fermentation acids, which can inhibit yeast growth. Aerobic stability may be affected, as drier forage is harder to pack in the storage structure, resulting in more oxygen in the final product.

Nutrients and Digestibility

Corn silage is a very heterogeneous material consisting of fiber (stover) and starch (grain); both contribute to its value as an energy source. To measure the content of fiber in a corn silage sample, the lab uses a neutral detergent to dissolve the plant pectin, protein, sugars, and fats in the plant so what remains is the Neutral Detergent Fiber (NDF). The percent NDF of a forage measures most of the structural components in plant cells: the lignin, cellulose and hemicellulose. To measure the concentration of starch in a corn silage sample, the lab utilizes an acetate buffer and starch-specific enzymes to convert the starch component to glucose and measures what is liberated.

NDF Digestibility

Knowing the quantity of fiber and starch present in a forage sample reveals nothing about its digestibility, or quality. Forage quality impacts intake, milk production, as well as the health of the cow. If a silage has high NDF digestibility (NDFD) it allows for more dry matter intake potential and more inclusion in a dairy ration. Poorer quality forages fill up cows without providing as much energy. The NDFD of a forage crop can be variable for many reasons related to crop and silage management: plant species and variety, soil fertility, growing conditions, temperature or water stress at different stages of development, stage of maturity at cutting, primary or late-season growth, leaf loss, time in the storage structure, and protein degradation by excessive heating. In order to characterize the digestibility of a forage sample at the lab, *in vitro* Neutral Detergent Fiber Digestibility (IVNDFD) is measured, using rumen fluid. This is the percent of NDF digested after a certain time period, and kd, which is the rate (percent per hour) that the NDF is digested. Since 30 hours is about the ruminal retention time of a high-producing cow, this is the time point that is usually reported. In 2005, researchers made the observation that each 1-point increase in IVNDFD was associated with a 0.26 lb/day increase in DMI and a 0.47 lb/day increase in 4 percent fat-corrected milk. Ranges in the NDFD of corn silage samples are large, as referenced by samples submitted to Cumberland Valley Analytical Services in 2015.

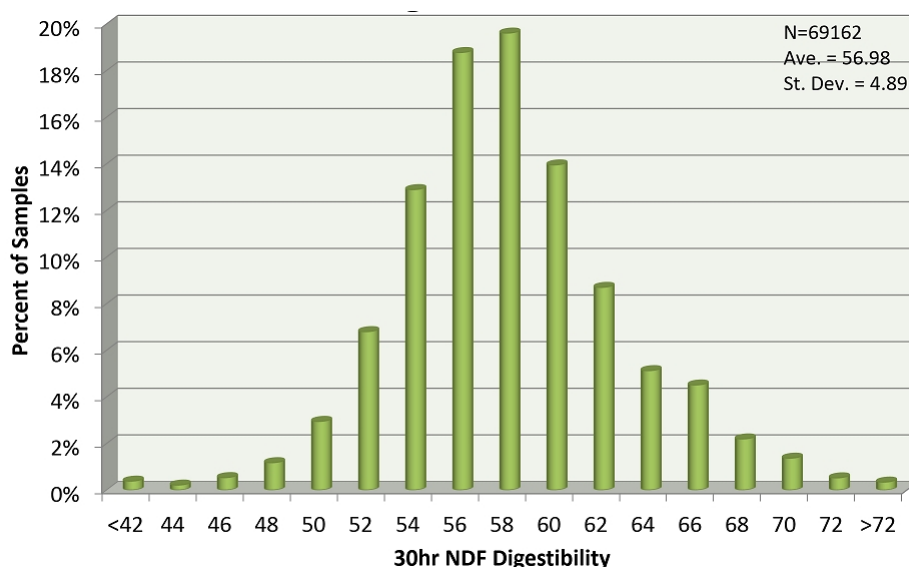


Figure 1. Distribution of 30 hr in vitro digestibility in corn silage. *Cumberland Valley Analytical Services, 2015.*

Conversely, the undigested portion of the NDF that never will be digested in the cow (uNDF) is the ballast that serves as an intake constraint. It is thought that the uNDF and the slower digesting NDF govern ruminal space available and therefore dry matter intake. Over a wide range of forages, the ratio of rumen to intake uNDF is constant at about 1.6.

Starch Digestibility

Ruminal fermentability of the starch component of a corn silage is affected by the kernel texture (proportion of floury: vitreous in the endosperm), corn maturity at harvest (drier or wetter), level of kernel processing, conservation method, diet and animal factors, and length of time the corn has been fermented in the storage structure. Excessive ruminal fermentability can decrease fiber digestibility, efficiency of microbial protein production, and alter ruminal biohydrogenation, decreasing synthesis of milk fat and increase energy partitioned to body condition at the expense of milk. The concentration and ruminal fermentability of starch affects feed intake and energy partitioning of cows differently as they progress through lactation. Monitoring changes in starch digestibility due to the extent of fermentation in the corn silage is critical.

Starch digestibility (IVSD) is measured in the lab by incubating ground samples with buffered media *in vitro* and evaluating starch disappearance over seven hours. *In vivo* studies have shown that ruminal digestion of starch is affected by the enzymatic activity of the rumen fluid, which varies between cows, diets consumed and time of feeding, as well as particle size of the starch. The time of residence in the rumen varies between cows and starch sources. The 7-hour time-point is valuable to reflect relative rates of starch fermentation, however, comparisons should be made between the same sources and be done in the same *in vitro* run due to high variability. The coefficient of variation for 7- hour IVSD can be as high as 25% even after attempting to minimize variation by taking rumen fluid from several cows fed a specific diet at the same time of day relative to feeding.

Degradation of starch from corn by ruminal microbes is negatively related to the vitreous:floury ratio of the endosperm:kernels with a greater percentage of vitreous endosperm having decreased ruminal starch digestibility as compared with those with a higher percentage of floury endosperm, primarily because of the protein distribution within.

Total-tract-starch digestibility can be predicted accurately from concentration of starch in TMR (Total Mixed Ration) samples and on-farm collection of feces. Target levels for lactating dairy cows is 3% or less of fecal starch on a dry matter basis. At 4.5% fecal starch, the total-tract starch digestibility is 90%. If there is more than 5% starch in the feces, particle size of the starch sources and rate of starch digestion should be analyzed. Each 1% unit decrease in fecal starch supports an additional 1 lb more milk production.

Fiber Particle Size

Adequate forage particle size is necessary for proper rumen function, as coarse particles stimulate chewing activity and increase saliva production. Saliva is rich in sodium bicarbonate, which serves to keep the pH of the rumen in the normal range. In addition to chewing, rumination and stable rumen pH, particle size also has a role in feed intake, passage rate, digestive efficiency, milk production and composition.

The Penn State Particle Separator (**PSPS**) is a quick and effective method that can be used on-farm to measure the physically effective fiber (peNDF) of feeds. The peNDF can be estimated by adding the amount of feed on the top three sieves (all ≥ 4 mm) and multiplying by the NDF content of the feedstuff. Recommendations for particle size of forages are in Table 1.

Table 1. Forage and TMR particle size recommendations based on three experiments using early lactation cows fed either alfalfa haylage or corn silage with or without cottonseed hulls.					
Screen	Pore Size (inches)	Particle Size (inches)	Corn Silage	Haylage	TMR
Upper Sieve	0.75	> 0.75	3 to 8	10 to 20	2 to 8
Middle Sieve	0.31	0.31 to 0.75	45 to 65	45 to 75	30 to 50
Lower Sieve	0.05 ^a	0.07 to 0.31	30 to 40	20 to 30	30 to 50
Bottom Pan		< 0.07	< 5	< 5	≤ 20
^a Pores are square, so largest opening is the diagonal, which is 0.07 inches. This is the reason the largest particles that can pass through the Lower Sieve are 0.07 inches in length.					

Fermentation Profiles

The primary goal of making silage is to maximize the preservation of original nutrients in the forage crop for feeding at a later date. Oxygen is the enemy of silage and its preservation. Effective management practices exist surrounding silage harvest with the goal of quickly eliminating oxygen from the preserved forage toward achieving an excellent fermentation profile in the finished feedstuff. These include timing of silage chopping to coincide with proper dry matter, correct chop length and processing, using a silage inoculant, packing with heavy equipment, covering and lining bunkers with oxygen-barrier plastic, as well as allowing the silage to ferment at least three weeks prior to feeding. In addition, managing the exclusion of air after the beginning of feed-out is important to minimize spoilage.

Significant breakdowns in the management of the silage making process will show up as silage with less desirable fermentation characteristics. A fermentation analysis can illustrate the success or failure of efforts at harvest, long after harvest is complete. Lactic acid should be the predominant end-product of these fermentations. Fermentations that yield more lactic acid typically result in the lowest dry matter losses. Silages that have high levels of acetic, propionic, butyric or iso-butyric imply conditions where DM recovery from the silage making process may be poor. Generally, in well-preserved silage, at least 65-70% of the total acid will be lactic acid or 4-7% lactic acid (% DM). Acceptable silages generally contain < 3% acetic acid, < 0.1% butyric acid, and < 0.5% propionic acid. Final pH of the silage is not a

good measure of fermentation quality as it cannot provide information about the rate of change to arrive at a terminal pH.

Suggested Readings

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