Changes in Starch Digestibility with Storage Time

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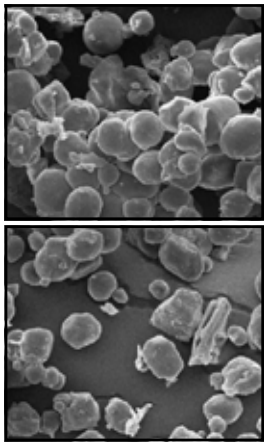
As days warm and ground thaws, we all start to think about forage production. However, you also want to think about forages you have in storage and how they may still be changing. This is especially true for corn silage (and high-moisture corn) which continues to change up to a year in storage.

Electron micrograph pictures at harvest and at 240 days of storage.



Starch is a main source of energy, with most Midwestern dairy cow diets containing 20-30%. However, starch digestibility varies greatly, having a major impact on lactation performance. Along with changes during storage, several factors affect starch digestibility (e.g., kernel maturity, endosperm type – vitreous vs floury, moisture, kernel processing). In the past 10 years, researchers recognized starch chemistry changes as corn silage is stored longer, leading to greater starch digestibility. Corn kernels contain starch in packets or granules which are encased in proteins called prolamins that protect kernel starch, but also restrict starch digestibility. These prolamins form around starch as kernels mature, which causes lower starch digestibility with progressing maturity. After active fermentation stages in the first 2-4 weeks of storage, bacterial processes are still occurring, including proteolysis (breaking down of proteins). Bacteria continue to break down prolamins, which then allows access to starch and greater digestibility. Also, as prolamins are broken down, the kernel structure becomes softer and reduces size of starch particles. Electron microscope pictures from Pat Hoffman (UW-Madison Emeritus Dairy Science Faculty) show starch granule structure of high-moisture corn at harvest and after 240 days in storage. Granules at harvest are more tightly packed while granules at 240 days are broken apart and will be easier to digest.

How much does starch digestibility increase in storage? Significantly, especially within the first 3-4 months with smaller subsequent increases. Table 1 shows data from recent studies with increases of 5-10% within 45 days and 8-17% within 120 days. Extending storage further provides some benefit with increases of 10-22% up to 270 days of storage. Temperature can also affect changes in starch digestibility. Colder temperatures in the silo (more likely to occur with silage bags or upright silos and not bunkers or piles) limit bacterial activity during winter. This is likely the case when harvesting frozen corn for silage or high-moisture corn. Once temperatures warm and silage thaws, bacterial enzymes are more active and can cause increased starch digestibility. Moisture is an important factor with wetter silages or high-moisture corn, having greater increases in starch digestibility over time.

Table 1. Ensiling effect on ruminal *in vitro* corn silage starch digestibility (%).

Study	Days Ensiled								
	0	30	45	90	120	150	180	240	270
Der Bedrosian et al, 2012	69	-	75	77	-	-	79	-	82
Ferraretto et al, 2014	62	72	-	-	79	-	-	84	-
Windle et al, 2014	54	-	59	63	-	68	-	-	-

Table from UW-Extension Forage Team article "Influence of Ensiling on the Digestibility of Whole-Plant Corn Silage" by L. Ferraretto, R. Shaver, and J. Lauer.

Increases in starch digestibility lead to better starch use, improved lactation performance, and less starch in manure. Also, it can decrease amount of other starch sources needed to get similar digestible starch in the diet. Improving starch digestibility generally has a positive outcome as it improves milk production, however, it can cause problems if not monitored. Monitoring starch digestibility is important to prevent issues with highly digestible starch that can cause rumen acidosis. As starch digestibility increases, rumen fermentation increases and creates greater amounts of volatile fatty acids and potentially acidosis if other diet (e.g., effective NDF, particle size) and management factors (e.g., stocking density, consistent feeding) are not in check. Herd monitoring for acidosis indicators including low milk fat test, loose manure, and sore feet/lameness is helpful, but the problem already exists if you see these symptoms. Working with your nutritionist to evaluate starch digestibility over time will help to make needed diet adjustments.

To evaluate changes in starch digestibility, have silage analyzed at a commercial lab using *in vitro* or *in situ* starch digestibility. Suggested analysis intervals would be when a new lot of silage is opened or every 1-2 months, especially if you are feeding new corn silage right away. Sampling for other nutrients is often done on a more regular schedule (every 1-2 weeks). To reduce costs, these could also be analyzed for starch digestibility using NIRS. Silage ammonia levels can also indicate starch digestibility since it increases as the prolamin proteins are broken down to ammonia, but this relationship is not as defined as with high-moisture corn since some of the ammonia will be from the silage stover fraction. Most labs offer these analyses using NIRS or wet chemistry techniques. It is suggested to use the same lab since variation may exist due to different procedures. When evaluating dry or high-moisture corn, the lab can use the UW-Feed Grain Evaluation System that analyzes the grain particle size, ammonia (for HMC), or the prolamin (dry corn) content to estimate starch digestibility. To evaluate starch digestibility of the entire diet, you can measure fecal starch content. As fecal starch increases, it indicates starch is not being efficiently digested. It is recommended fecal starch be less than 5%, which would be about 90% total starch digestibility. Wisconsin surveys have shown most farms are under 5%, but about 25% of samples were higher, having room to improve starch digestion (e.g., better kernel processing, lower DM at harvest).

To allow corn silage to stay in storage for 4 months requires storage availability and additional corn silage to be harvested the first year. Farmers can use silage bags or piles which are more flexible options for storing 2-3 additional months of feed. This also allows farmers to completely empty previous year's bunkers or piles instead of adding new silage to the previous year's silage. If using bunkers, extending bunker walls is also an option to increase storage space. It is not advised to increase storage by overfilling existing bunkers or piles leading to dangerously high silage faces, steep-sloped piles, and difficult-to-manage inventories.

Understanding how starch digestibility changes with storage time can be helpful to maintain lactation performance throughout the year and minimize acidosis potential. Monitoring changes allows you and your nutritionist to better manage the cow's diet, improve lactation performance, and minimize potential acidosis issues.