DAIRY

Fermentation of Frozen & Thawed Corn Silage

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Corn silage and high-moisture corn harvest in fall of 2019 was difficult for many Midwest farmers due to excessive rainfall and wet soils preventing harvest at optimal moisture content. Also, some corn did not reach maturity to dry down due to late planting. For many, this situation delayed harvest until late fall, resulting in corn being taken off in cold or possibly freezing temperatures. Harvesting during freezing conditions directly impacts fermentation and likely nutritional quality. This was of interest in 2014 and 2015 when similar delays in harvest occurred and was a focus of research at UW-Madison (Ferraretto et al, 2017).

Harvesting corn (silage or high-moisture grain) at freezing temperatures will result in a forage/grain staying cold in the silo with limited or no fermentation until thawed and temperatures reach at least a few degrees above freezing. With limited plant respiration or aerobic fermentation typically increasing forage mass temperature, forage temperature does not increase when frozen or at low temperatures. During this research, samples were initially placed in a freezer for several months to see how this affected the ability of silage to ferment after freezing (if enough bacteria survive to enable fermentation). No inoculant was used before or after freezing to determine if adequate epiphytic bacteria (present on the plant at harvest) can survive to allow for fermentation. After thawing, silage was sealed in mini-silo vacuum bags and fermented at room temperature (68˚F) for ½-28 days. Silage fermented quickly with fermentation acids increasing (lactic and acetic acid) and pH decreasing from pH 5.5 on day 0 to pH 3.9 by day 14. This shows fermentation can take place in warm temperatures even after an extended time in a frozen state. However, forage mass will likely thaw slowly and have limited fermentation. In another test, high-moisture corn was frozen for several months, then thawed and kept at 37˚F (in a refrigerator) or 68˚F. Similar to corn silage, high-moisture corn kept at a warm temperature fermented quickly and pH decreased to 4.7 within 30 days. Corn held at 37˚F did not ferment and had no change in lactic acid or pH.

In a similar study using sorghum-sudangrass silage, samples were also kept at cold or warm temperatures and fermented for ≤60 days. The sorghum-sudangrass was harvested in early December and frozen prior to chopping. Fermentation was normal at a warm temperature with a pH drop to 4.0 within 15 days. However, silage kept at a cold temperature was still at pH 5.7. After 30 days of fermentation, cold silage pH dropped to 4.5 and at 60 days it was pH 4.3. Initial fermentation was likely slow due to limited bacterial activity, but once enough bacteria growth occurred the fermentation progressed quickly. It would be expected that silo temperatures would increase from the outside with fermentation following this pattern and likely taking several weeks due to the slow change in silo temperature.

When feeding unfermented cold/frozen silages, sugars that would have been converted to acid are still present and can lead to issues when silage is exposed to air. Once silos are opened, aerobic bacteria and yeast will feed on sugars and cause heating and spoilage in exposed silage or any unused silage each day. Sugars in frozen corn silages are highly nutritious to cattle and offset some reduction in starch digestibility, but can lead to aerobic stability problems. In a recent study of corn silage stored in small bunkers (10' wide by 18' long), we started harvesting in the morning (~30˚F) and observed little increase in silage temperature (Figure 1) over a two month period of storage. When the bunker was opened, silage had marginal signs of fermentation (pH 4.6) and heated within a day when exposed to air. In the same study, corn silage harvested later in the day (~50˚F) showed signs of significant fermentation (normal fermentation temperature pattern, acidic smell, and pH 3.8) and less heating issues when exposed to air for a few days (Figure 2). For those managing unfermented corn silage, a faster feedout may be needed to maintain feed quality and minimize air entry into the silo.

Figure 1. Graph of storage temperature for corn silage harvested at 30°F.

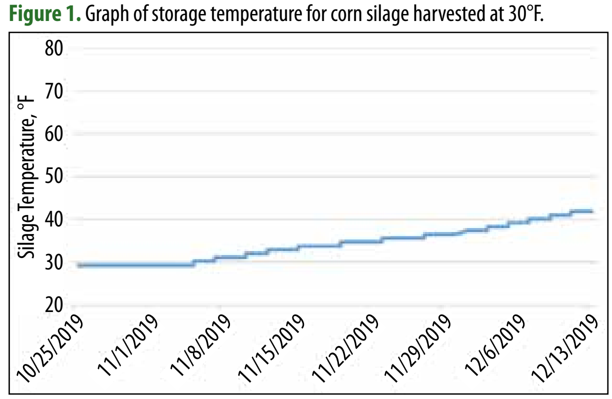
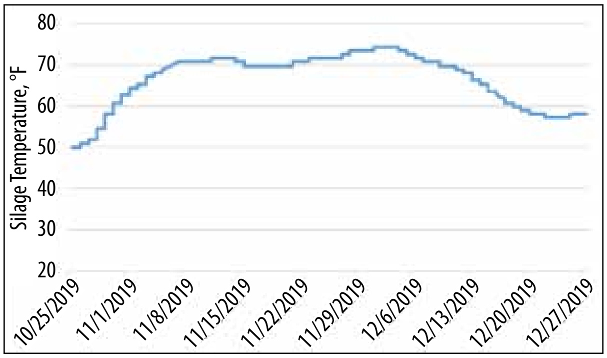


Figure 2. Graph of storage temperature for corn silage harvested at 50°F.



Nutritional quality will likely be affected by delayed fermentation, especially starch digestibility. Due to the lack of fermentation and bacterial breakdown of the protein-matrix protecting starch in corn kernels, frozen corn silage starch digestibility will likely not increase to levels normally found in fermented silage. To address this, farmers may allocate a silo with frozen silage to summer feeding to allow for greater fermentation and an increase in starch digestibility. This should keep nutrient digestibility closer to levels found in previously fed corn silage which had normal fermentation. Due to silage pile or bunker mass, it can take weeks or months for silage mass to thaw to temperatures necessary for adequate fermentation. This may not be the case if only a portion of silage mass (such as a pile or bunker) was frozen at harvest due to heat produced from the fermentation of the rest of the silage pile.

In an experiment studying frozen fall-grown oat baleage, silage bags or bales were found to thaw more quickly. Silage did not ferment until mid-April once thawed. It should be considered that unfermented corn silage opened and fed in warm conditions can result in high yeast activity and poor aerobic stability due to the high sugar content still present in forage. In this situation, higher feeding rates are needed to minimize yeast growth in exposed silage. Proper bunker or pile management to maintain a smooth feeding face will help limit air entry to the rest of the silage. Frozen silages can be managed to maintain good forage quality even when fermentation is limited.