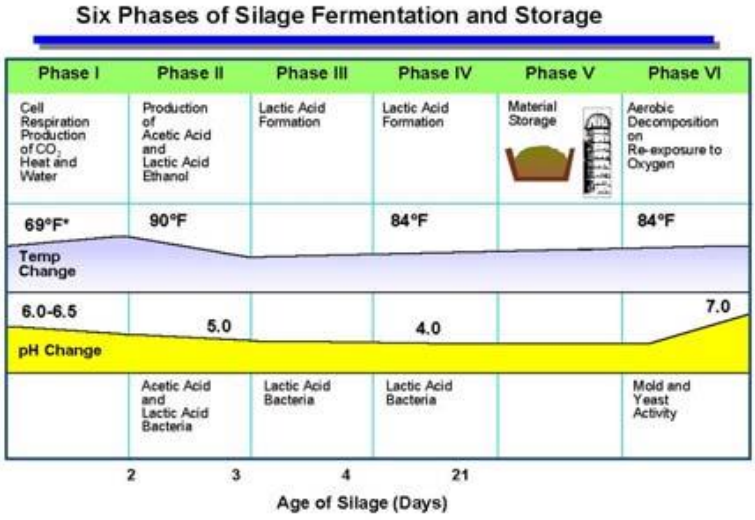
Important Steps during the Silage Fermentation Process

College of Agriculture, Food and Environment
Cooperative Extension Service

By: Donna Amaral-Phillips, Ph.D.

A general understanding of what occurs during the fermentation process is critical to implementing sound management practices when storing and feeding silages. The fermentation process involves both aerobic (oxygen needing) and anaerobic (non-oxygen needing) bacteria and is generally dividing into 6 different phases. Aerobic fermentation occurs when the silo or bag is being filled (phase 1) and at feedout (phase 6). The remainder of the phases (phases 2 through 5) occurs under anaerobic conditions.

Figure 1. Six phases associated with silage fermentation and storage. (Seglar, W. 2003. Fermentation Analysis and Silage Quality Testing. Proceedings from Minnesota Dairy Health Conference. Pg. 119.



Good silage management practices can help prevent or at least minimize losses in forage dry matter. Often times these losses in dry matter go undetected unless the amount of forage ensiled and feed being removed from the storage structure is measured accurately. Most farms do not complete and summarize these measurements. Also, well fermented silages are more readily consumed by dairy cattle. At harvest, good silage management practices include harvesting the crop at the proper moisture and stage of maturity, rapid filling of the storage structure, firm packing of the ensiled material and then properly sealing the structure with plastic. What happens during the fermentation process determines the quality and quantity of stored feed that will be available at feedout.

Phase 1: Phase 1 starts at harvest and under ideal conditions of moisture, chop length, and firm packing lasts only a few hours. This initial phase continues until either the oxygen supply or water-soluble carbohydrates have been depleted. The most notable feature of this phase is the increased temperature of the newly fermenting crop resulting from ongoing cell respiration where carbon dioxide, water and heat are produced. In poorly sealed and/or packed silos, bunk life of the resulting feed can be reduced since the initial growth of aerobic spoilage organisms (yeasts and Bacillus species) occur

during this phase. Once feedout occurs, yeasts can rapidly increase in numbers causing heating in the feedbunk and lowered feed consumption.

Phase 2: Phase 2 begins when the trapped oxygen supply is depleted and generally lasts no longer than 24 to 72 hours. During this phase, anaerobic (without oxygen) hetero-fermentation occurs. The primary bacteria during this phase are *Enterobacteria.* They can tolerate the heat produced during the aerobic phase and are viable in a pH range of 5 to 7 which is found in the fermenting forage at this time. These hetero-fermenters produce both acetic and lactic acid, but tend to be inefficient at producing these acids relative to nutrients lost in the fermenting crop. The final proportions of these acids depend on the crop maturity, moisture, and natural bacterial populations. When the pH drops below 5, homo-fermenters predominate and phase 3 of silage fermentation begins.

Phase 3: Phase 3 is a transitional phase that generally lasts only 24 hrs. During this phase, the homo-fermentative bacteria, which are more efficient than the hetero-fermenters, rapidly drop the pH of the fermenting forage by efficiently producing lactic acid as an end-product. As the temperature of the silage mass decreases and the pH continues to drop, the bacteria in this phase become inhibited and phase 4 lactic acid bacteria increase.

Phase 4: This phase is a continuation of phase 3 with a stabilization of temperature of the fermented crop. Homo-fermentative bacteria convert water-soluble carbohydrates to lactic acid, which is very effective at dropping the pH which helps preserve silage. In well-fermented silages, lactic acid can account for over 65% of the total volatile fatty acids.

The final pH of an ensiled crop depends on the type of forage and moisture content of the ensiled forage. Legumes, i.e. alfalfa, have less water-soluble carbohydrates, a higher buffering capacity, and generally reach a final pH of about 4.5. Corn silage, in contrast to grasses and legumes, has a lower buffering capacity, more water-soluble carbohydrates, and generally reaches a pH around 4.0. When the terminal pH is reached, the forage is preserved within the silo. Silage pH does not indicate the rate or quality of the resulting fermentation. To determine the quality of the fermentation, a fermentation analysis is needed where the amount of acetic, lactic and other acids are determined.

Phases 2, 3, and 4 generally are completed within 10 days to 3 weeks from harvest. Thus, the general recommendation is to wait at least 3 weeks before feeding newly harvested forages. The length of this fermentation process will vary depending on the crop harvested (related to buffering capacity), moisture, and maturity of the ensiled crop. Properly-applied, high-quality inoculants may decrease fermentation time required.

Phase 5: This phase lasts through the remainder of storage where the fermentation process is stable as long as oxygen does not penetrate silage, i.e. through silo walls

with final temperature of well-preserved silage being 75 to 85° F. However, changes do occur in the digestibility of the nutrients found in these forages. First, studies show that with longer storage times, starches become more quickly degraded in the rumen. Secondly, changes also may occur in the digestibility of the neutral detergent fiber (NDF). Some studies have shown an increase in the digestibility of NDF with longer storage times whereas another study has shown no changes with storage. In one study where NDF digestibility was significantly increased, NDF digestibility appeared to plateau 6 months from ensiling.

Phase 6: This phase occurs during feed out, is just as important and often neglected part of the fermentation process, and can result in substantial dry matter losses as oxygen is reintroduced into the fermented crop. Proper management of the silage face and at the feedbunk can minimize dry matter losses and optimize feed intakes by dairy cows.

Take home messages: When applying these concepts on-farm regarding the fermentation process for silage,

1. Harvesting ensiled forages at the proper moisture and stage of maturity, rapidly filling and properly packing of silages, and properly covering of silages directly impact the fermentation process. Well fermented silages result in reduced dry matter losses, in more feed being available for feeding dairy cows, and a higher quality feed (more lactic acid) which could improve feed intake, milk production, and profitability.
2. Changes do occur in the nutritive value of forages after the fermentation process is complete. These changes may help partially explain why dairy cows produce more milk on silages fermented longer than 3 months from harvest.
3. The fermentation process takes 10 days to 3 weeks for completion. Silages should not be fed until after this process is completed for the best milk production and feed intake. Thus, the recommendation is to wait at least 3 weeks before feeding new crop silages.
4. To extend bunk life, minimize the exposure of fermented feed to oxygen at the silo face (phase 6). By properly handling silage at feed out, the feed will heat less in the feedbunk and be more acceptable to dairy cows.