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The Process of... SILAGE FERMENTATION

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Silage production is a two-part process. First, the ensiled forage begins to heat, then, acids are produced to preserve the forage.

The primary objective in making quality silage is to achieve and maintain an oxygen-free (anaerobic) condition within the forage mass as rapidly as possible. The absence of oxygen enhances the growth and development of desirable lactic acid-producing bacteria. The lactic acid, when produced in adequate amounts, preserves or "pickles" the forage and prevents the growth and development of undesirable organisms.

Silage fermentation is controlled primarily by four factors. These factors include:

- Moisture content of the chopped forage
- Fineness of chop
- Exclusion of air
- Carbohydrate (sugar) content of the forage

Understanding the process of silage fermentation will provide a basis for improving management decisions which influence the quality of silage produced.

The process of silage fermentation may be described as taking place in phases (Fig. 1). Normal silage fermentation is complete in about 21 days and occurs in four phases. A fifth phase may occur if silage production practices are not proper, causing undesirable or abnormal silage fermentation.

Phase 1, the RESPIRATION PHASE, begins as soon as the chopped forage is placed in the silo. Green plants, when chopped and placed in the silo, continue to live and breathe (respiration) for a short period of time. The tiny plant cells within the chopped forage mass continue to take in oxygen because many cell walls are still intact. At the same time oxygen-loving (aerobic) bacteria naturally present on the stems and leaves of plants begin to grow. These processes consume the more readily available carbohydrates or sugars and produce carbon dioxide, water and heat. Too much oxygen in the forage mass increases the use of carbohydrates which are essential for the production of lactic acid and causes high dry matter losses in the silo. In addition, excessive heating of the forage encourages the growth of undesirable fermentation organisms and lowers forage quality by decreasing protein digestibility.

The initial temperature rise in silage is due to plant respiration. A desirable temperature of the forage mass of about 80 to 100°F provides a near ideal environment for acid-producing bacteria. Excessive oxygen trapped in the forage mass will cause initial temperatures well in excess of 100°F.

The respiration phase of the fermentation process will usually last from three to five hours depending on the supply of oxygen present. This is an undesirable phase in silage fermentation. Silage production practices should be implemented that will keep this phase as short as possible. Use practices that will EXCLUDE AIR from the forage mass. Finely chopped forage, 1/4 to 3/8 inch theoretical length cut, harvested at the proper moisture content has a greater density and, if uniformly distributed in the silo, improves packing to exclude air. Forage chopped too dry will be difficult to pack. The ideal moisture content for silage in tower silos and/or bunker silos is about 65 to 70 percent moisture. Haylage stored in oxygen-free silos requires an average moisture of 45 to 50 percent to prevent excessive heat damage.

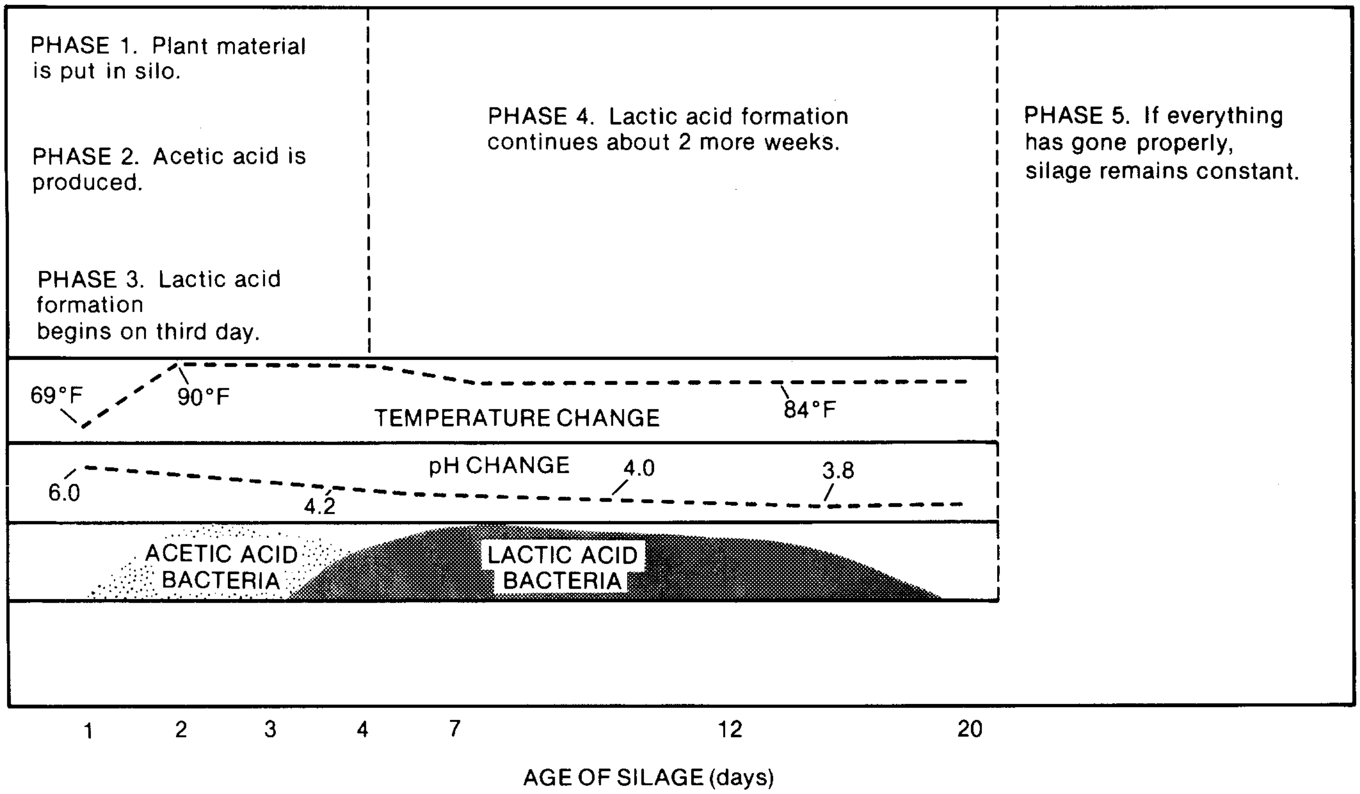

Fig. 1. Diagram of the normal silage fermentation process.

Seepage loss will be minimal from crops containing 70 percent moisture when stored in bunkers or above-ground piles. High moisture silage stored in tower silos should have a moisture content of about 65 percent in the lower half of the silo and 70 percent or less in the upper half to minimize seepage loss.

Phase 2, the ACETIC ACID PRODUCTION PHASE of the fermentation process, begins as the supply of oxygen is depleted in phase 1. Bacteria that grow without oxygen (anaerobic bacteria) begin to grow and multiply. The acetic acid bacteria begin the silage "pickling" process. They acidify the forage mass, lowering the pH from about 6.0 in green forage to a pH of about 5.0 which causes the acetic acid bacteria to decline in numbers. This phase of the fermentation process continues for one to two days and merges into phase 3.

Phase 3 of the fermentation process begins as the acetic acid-producing bacteria begin to decline in numbers. The increased acidity of the forage mass enhances the growth and development of another group of anaerobic bacteria, the LACTIC ACID-PRODUCING BACTERIA. Bacterial strains within this group are capable of growing with or without oxygen. The production of acid, especially lactic acid, is the most important change in the fermentation process.

Phase 4 of the fermentation process is a continuation of phase 3 when lactic acid production reaches its peak. It is the longest phase of the fermentation process. This phase will continue for a period of about two weeks or until the acidity of the forage mass is low enough to restrict the growth of all bacteria. The silage mass is stable within about 21 days and no further fermentation occurs if outside air is excluded from the silage.

The various phases of the normal fermentation process tend to overlap one another due to the variety of fermentation bacteria present and their tolerance to the presence of oxygen and different forage acidity levels. For example, lactic acid-producing bacteria begin to grow and multiply shortly after the chopped forage is placed in the silo. They reach near peak populations during phase 3 of the fermentation process, which is complete within three to four days.

Normal fermentation of silage is dependent on a readily available source of water soluble carbohydrates or sugars. These sugars are utilized during all phases of the fermentation process - plant respiration, growth of nonessential oxygen-loving bacteria and the production of acetic acid and lactic acid. If the supply of carbohydrates is limited, too little lactic acid will be produced to prevent the growth and development of undesirable fermentation bacteria. Every effort should be made to exclude as much oxygen as possible from the forage mass when filling the silo. This will shorten the respiration phase and maintain a higher level of the more readily available carbohydrates. High carbohydrate levels are needed to assure that an adequate supply of lactic acid is produced.

Phase 5 of the overall fermentation process involves the production of BUTYRIC ACID and other undesirable products such as ammonia. This phase of silage fermentation will not occur when proper silage production practices are followed, provided there is an adequate supply of readily available carbohydrates in the forage. Legume crops such as alfalfa possess relatively low carbohydrate levels and require field wilting. The wilted moisture level should average 65 percent or less depending on the type of storage structure. Wilting to reduce the forage moisture content increases the concentration of carbohydrates in the forage mass. Also, forage crops wetter than about 70 to 72 percent moisture favor the growth and development of undesirable fermentation bacteria. These conditions, low carbohydrate levels and forage that is too wet set the stage for phase 5 of the fermentation process - the production of butyric acid.

Butyric acid production is undesirable in silage fermentation. Its production increases dry matter losses during fermentation. Butyric acid-producing bacteria consume any remaining carbohydrates or sugars; acetic, lactic and other organic acids already formed and plant proteins. They produce a sour-smelling silage of low nutritional value.

HARVEST FORAGE AT THE PROPER MOISTURE CONTENT, CHOP FINE, PACK THOROUGHLY, FILL SILO AS FAST AS POSSIBLE AND COVER TO EXCLUDE OUTSIDE AIR are essential management practices for a normal silage fermentation and to maintain a stable silage once fermentation is complete.

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