

Interactive, Web-Based, Silage Fermentation Module

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Abstract

The fermentation of forage into silage is a dynamic and multifaceted process that can be conceptually challenging to understand. Our objective was to develop a web-based learning module to help people better understand the processes involved in silage fermentation and how management practices could influence them. The module was developed for a broad audience including extension and NRCS personnel, individual producers, and consultants in forage management. The [Understanding Silage Fermentation Learning Module](#) is incorporated within this article and can be used effectively in presenting forage fermentation concepts during group training sessions as well as for individual training and consultations.

The forage-livestock industry represents the major agricultural enterprise in Pennsylvania and the northeastern United States. Forages comprise 40 to 60% of the dairy cow's diet with many producers feeding 50 to 100% of their forage as silage (3). Harvesting forages as silage continues to increase as the size of farms increases and the mechanization of silage harvesting allows timely harvest of more acres. There are many factors that affect the quality of silage and producers need to better understand these factors to optimize their silage-making process. In the following sections we describe a web-based learning module designed to help people better understand the processes of silage fermentation and factors that influence it.

Module Development and Description

Introductory and background information about the various processes involved in silage fermentation (1,5) are presented using JavaScript (Sun Microsystems, Inc., Santa Clara, CA). This portion of the module contains text and non-interactive, animated graphics that visually illustrate the principle phases and reactions that occur during the silage making process: respiration (Fig. 1), fermentation (Fig. 2), and interactions with Clostridia bacteria (Fig. 3). When the user has completed this section and feels comfortable with the basic concepts of fermentation, they can move to the interactive portion of the module by clicking on the "Interactive Module" icon on the menu bar.

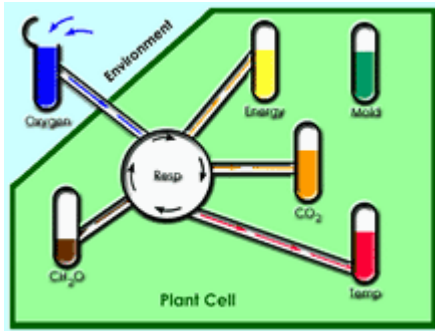


Fig. 1. Still frame from the animated diagram showing the consumption of oxygen and carbohydrates during the aerobic phase of fermentation (click image for animation).

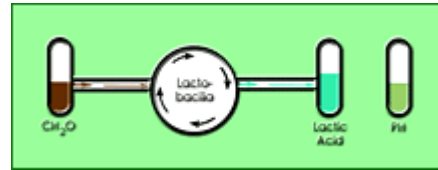


Fig. 2. Still frame from the animated diagram illustrating the conversion of carbohydrates into lactic acid by lactobacillus bacteria and the concurrent drop in pH (click image for animation).

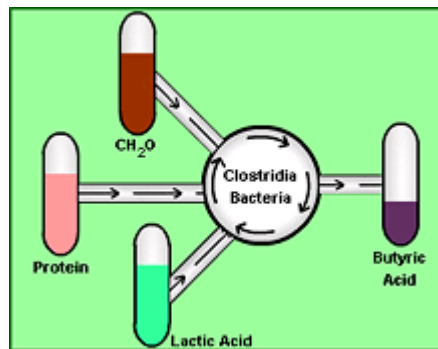


Fig. 3. Still frame from the animated diagram illustrating the consumption of forage carbohydrates, proteins, and lactic acid by Clostridia bacteria, and the resulting production of butyric acid (click image for animation).

The interactive “what if” simulation segment of the module that follows forage through completion of the fermentation process was constructed using Flash (Macromedia, Inc., San Francisco, CA). This segment begins with a series of five questions about the silage making process that determine the results of the simulation model (Fig. 4). Assistance is available while answering these questions by clicking on either the “Why we ask” or “Factors” icon associated with each question. (2,4).

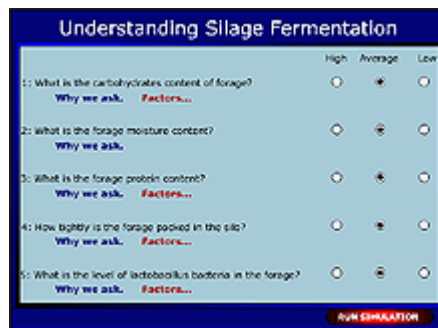


Fig. 4. Screen capture of questions to answer before running the simulation model (click image for interactive form).

Clicking the “Run Simulation” button at any time will graphically depict the fermentation process over time and highlight potential consequences of making silage too dry, too wet, with low carbohydrate or lactobacillus bacteria content, or not packing adequately (Fig. 4). From the simulation window, the user can restart or pause the simulation or go back and change their responses to the questions.

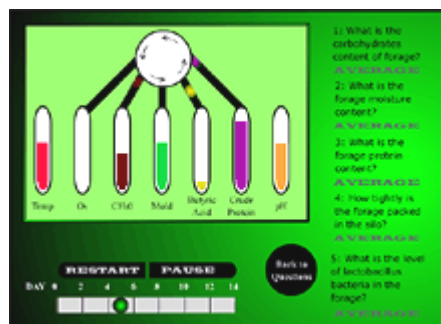


Fig. 5. Capture of simulation model screen showing the relative level of various constituents in the forage after five days in a sealed container.

Summary

This interactive learning module allows individuals to develop an understanding of the dynamic silage fermentation process. By providing a rich visual presentation along with the ability to create different management scenarios, it allows learners to explore the key management issues involved in making high-quality silage. Running the simulation model multiple times under various conditions designated by the user results in a more comprehensive understanding of the many dynamic and multifaceted processes involved in forage fermentation.

Go to the [Understanding Silage Fermentation Learning Module](#).

Literature Cited

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Understanding Silage Fermentation Learning Module

Forage Plant Cells Respire

Until plant cells are dead or have no oxygen available, they respire to generate the energy they need for normal activity. Respiration is the conversion of carbohydrates into energy (Fig. 1).

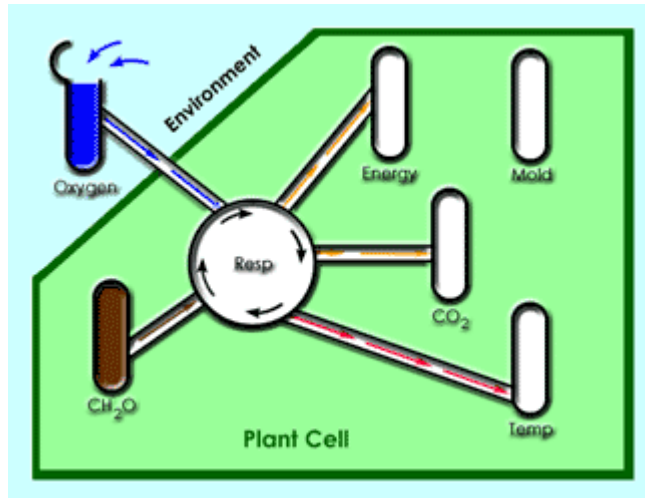


Fig. 1

Respiration is necessary to deplete the forage mass of oxygen shortly after it has been put in a sealed structure. However, respiration is burning up carbohydrates (forage quality) and producing heat so its duration should be minimized (Fig. 2).

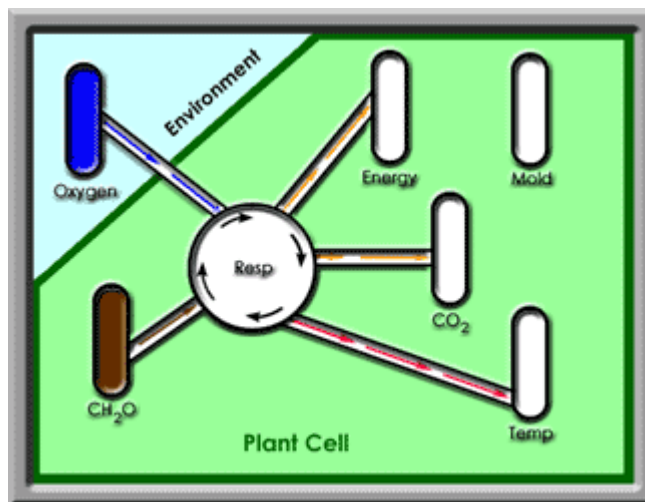


Fig. 2

Prolonged respiration in the forage mass can reduce forage carbohydrates levels which can jeopardize the fermentation process. In addition, prolonged respiration allows rapid mold growth in the forage and forage heating. Minimizing the amount of oxygen in the forage mass when it is in a sealed structure is the best way to shorten the respiration period and avoid unnecessary mold growth, quality loss or a potential silo fire.

Fermentation

Once oxygen is depleted in the forage mass, fermentation begins. Fermentation is the lowering of the pH in the forage to a point where no organism (mold or bacteria) can function. The pH is lowered by lactic acid which is a byproduct of lactobacillus bacteria. The lactobacillus bacteria are on the forage when it is mowed and multiply rapidly until the forage is fermented. Lactobacillus bacteria consume forage carbohydrates for their energy source and excrete lactic acid. The lactobacillus bacteria continue to produce lactic acid and lower the forage pH until they can not function anymore. At this pH level, the forage is fermented and can exist unchanged for many years as long it is not exposed to oxygen.

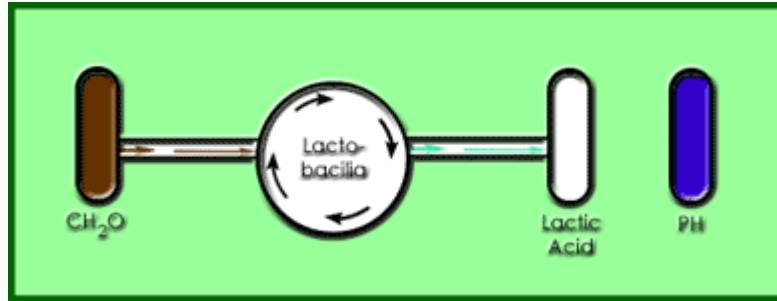


Fig. 3

Clostridia Bacteria

Clostridia bacteria are also on the forage when it is mowed and are put in the silo with the forage. Clostridia bacteria consume forage carbohydrates, forage proteins, and lactic acid as their energy source and excrete butyric acid. Butyric acid is associated with rotten or putrefied silage. Situations that might benefit clostridia growth are insufficient forage carbohydrate levels (rain while forage is wilting, extended respiration period due to poor packing, seepage due to excessive forage moisture) to complete the fermentation process and/or low lactobacillus bacteria levels.

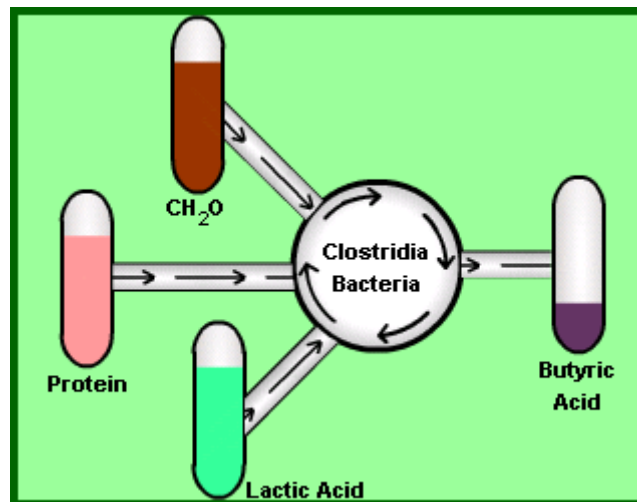


Fig. 4

Understanding Silage Fermentation

	High	Average	Low
1: What is the carbohydrates content of forage? Why we ask. Factors...	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
2: What is the forage moisture content? Why we ask.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
3: What is the forage protein content? Why we ask. Factors...	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
4: How tightly is the forage packed in the silo? Why we ask. Factors...	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
5: What is the level of lactobacillus bacteria in the forage? Why we ask. Factors...	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

RUN SIMULATION

1: What is the carbohydrates content of forage?
HIGH

2: What is the forage moisture content?
AVERAGE

3: What is the forage protein content?
HIGH

4: How tightly is the forage packed in the silo?
AVERAGE

5: What is the level of lactobacillus bacteria in the forage?
AVERAGE

RESTART **PAUSE**

DAY 0 2 4 6 8 10 12 14

Back to Questions