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What is silage?
How Fermentation Works

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Baleage and Silage Short Course
February 26, 2019 | Moultrie, GA

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What is Silage?

Forage preservation by fermenting sugars into acid, which prevents spoilage.

- Plant sugars → lactic acid (1°), acetic acid (2°), & other products.
- Must occur in *anaerobic* conditions to prevent spoilage by molds, yeasts, and bacteria.
- Low pH reduces enzyme activity, inhibiting growth undesirable bacteria (e.g., clostridial bacteria).

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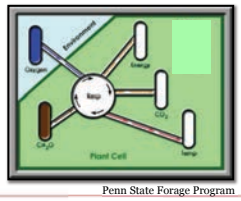
Phase 1: Aerobic Phase

- **Age**: 0-2 days
- **Activity**: Cell respiration → production of CO_2, heat, and water
- **Temperature***: 69 → 90°F (15°F above ambient)
- **pH**: 6.5 → 6.0



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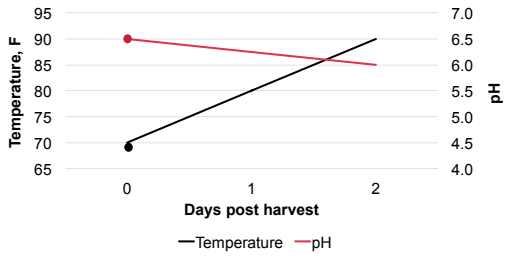
Phase 1: Aerobic Phase



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Phase 1: Aerobic Phase

Goal: *minimize* this phase to protect forage quality!

- Utilization of soluble carbohydrates by aerobic bacteria → limits availability for beneficial bacteria or livestock
- Respiration → buildup of heat → damages proteins
- Proteolysis → breakdown of plant proteins

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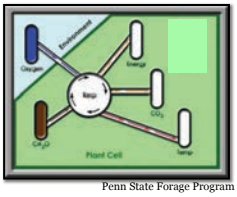
Phase 1: Aerobic Phase

Reduce oxygen as quickly as possible!



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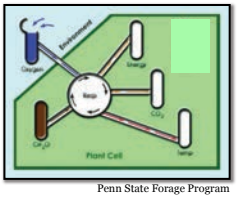

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Key management practices: proper maturity, moisture, chop length and rapid filling; adequate packing and proper sealing.

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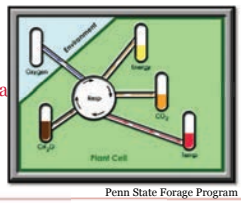
Phase 2: Anaerobic fermentation begins

- **Age**: 2-3 days (*begins when oxygen has depleted*)
- **Activity**: Heterofermentative bacteria ferment soluble carbohydrates → acetic acid → drops pH
- **Temperature***: 90 → 84° F
- **pH**: 6.0 → 5.0
- **Products**: Heterofermentative bacteria (acetic acid producing)



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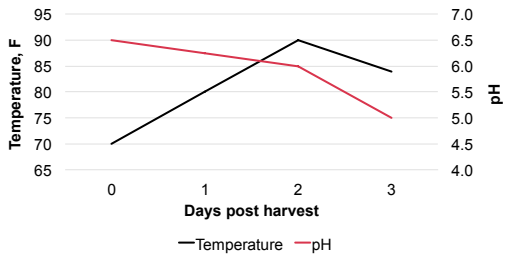
Phase 2: Anaerobic fermentation begins



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Phase 2: Anaerobic fermentation begins

Goal: produce acetic acid and decrease pH!

- Acetic acid
  - can be used by livestock as an energy source
  - initiates the pH drop
- When pH < 5.0 → acetic bacteria decline

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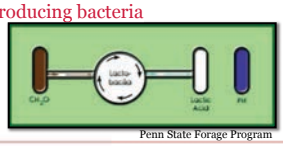
Phase 3: Acetic acid bacteria → lactic acid bacteria

- **Age**: 3-4 days
- **Activity**: transition to homofermentative bacteria → lactic acid formation
- **Temperature***: 84° F
- **pH**: 5.0 → 4.0
- **Products**: Lactic acid producing bacteria



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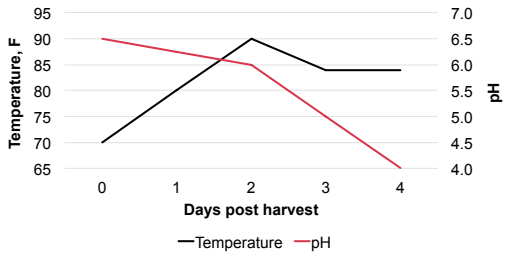
Phase 3: Acetic acid bacteria → lactic acid bacteria



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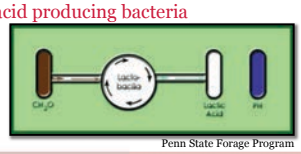
Phase 4: Continuation of Phase 3

- **Age**: 4-21 days
- **Activity**: ↑ lactic acid formation until soluble carbohydrates used up or pH sufficiently decreases
- **Temperature***: 84° F
- **pH**: 4.0
- **Products**: ↑ lactic acid producing bacteria



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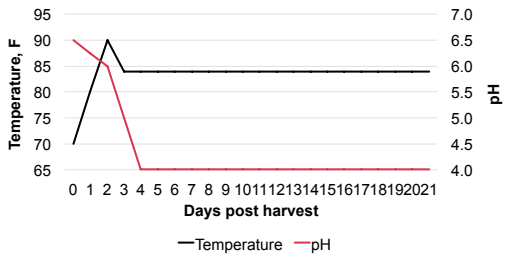
Phase 4: Continuation of Phase 3



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Phase 4: Continuation of Phase 3

Goal: increase lactic acid bacteria!

- Lactic acid = most desirable fermentation acid
  - Important for efficient preservation
  - Ideally 60% of total silage organic acids produced
  - Can also be used by livestock as an energy source
- Longest phase in the ensiling process
  - No further destructive processes *should* occur

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faster fermentation

↓

higher quality product

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Phase 5: Storage

- **Age**: 21 days – until feed out
- **Activity**: ↑ protein solubility and ↑ starch digestibility
- **Temperature***: 84° F
- **pH**: 4.0 (*depends*)

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Phase 6: Feed out

- **Age**: < 1 year
- **Activity**: Aerobic decomposition from *any* re-exposure to oxygen (storage *or* feeding)
- **Temperature***: 84° F
- **pH**: 4.0 → 7.0 (*depends*)
- **Products**: Mold and yeast activity

Up to 50% dry matter loss can occur from this secondary aerobic decomposition.

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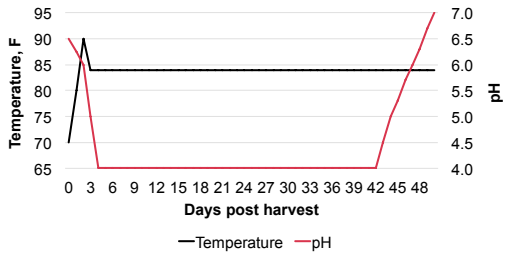
Putting it all together…



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Good silage management will help prevent losses at each of the six phases.

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Slides adapted from:

- Schroeder 2013. Silage fermentation and preservation. (NDSU)
- Hancock 2018. Silage Fermentation. (UGA)
- Penn State Forage Program 2019. Silage Fermentation. (PSU)

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Questions?

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