Inoculants for Silage

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Presentation Outline

- Principles of Food preservation
- Methods of forage preservation
- The ensiling process
- Ensiling losses
- Aerobic deterioration of silage
- Inoculants for silage
- Aerobic spoilage and L. buchneri
- Effect of silage inoculants on animal performance

Environmental conditions for microbial activity

- Temperature
- Moisture
- pH
- Air/absence of air

Food Preservation

- Preservation of food is based on changing these conditions to inhibit spoilage microorganisms and pathogens.

- Preservation is aimed to avoid losses with minimal changes in nutritional value and palatability.

Curing & drying

Canning (heat)

pickling

Chilling & freezing

Vacuum package

- Large amounts of harvested forage crops must be preserved in order to avoid spoilage (heating) and losses (shrinkage).

The goal of preservation is to maintain the original quality of the crop.

Forage preservation has great impact on forage quality.

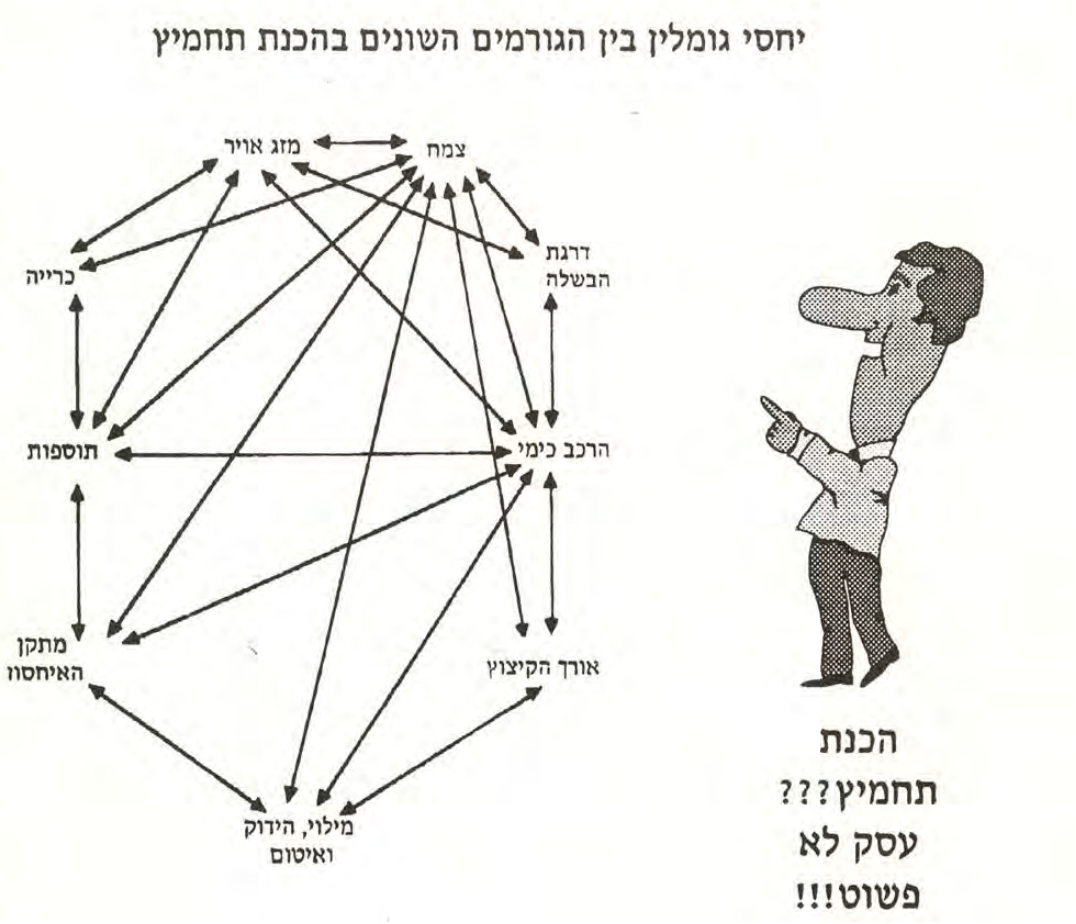
Methods of forage preservation

- Forage crops can be preserved either by making hay (drying) or by ensiling.
- Ensiling is a fermentation process by lactic acid bacteria which produces acids that preserve the crops.

Forage Preservation Methods

- Ensiling by anaerobic fermentation
- Hay making by plant drying

Silage making is not that simple!



The ensiling challenge

- Ensiling is a multi step process which depends on many factors:
  - Crop factors (maturity, composition, etc.).
  - Management factors (compaction, sealing, feed-out rate).

The ensiling fermentation should be rapid in order to avoid losses.

Conditions for rapid ensiling

- Moisture in the ensiled forage 60-70% (for legumes 50%)
- Enough sugars (3-5% in DM)
- Lack of air (oxygen)

The effect of DM content on the rate of the ensiling fermentation

When do silage losses occur?

- During the ensiling fermentation
- During storage
- During feed-out.

Ensiling losses

- Even under good management practice one should expect a DM loss of up to 10%.
- Top layer and shoulders of silages in bunker silos may suffer up to **75% loss**!
- Such spoiled silage is not suitable for feeding animals.

DM losses (shrink)


Spoilage is greatest at the shoulders
shoulder
center
wall

Silage and Air

- Air is detrimental to silage because it enables aerobic spoiling microorganisms (e.g., yeasts and molds) to develop in the silage.

- Some silage types are more sensitive (e.g., corn, wheat)
  - Silage is exposed to air
    - During storage
    - Upon feeding

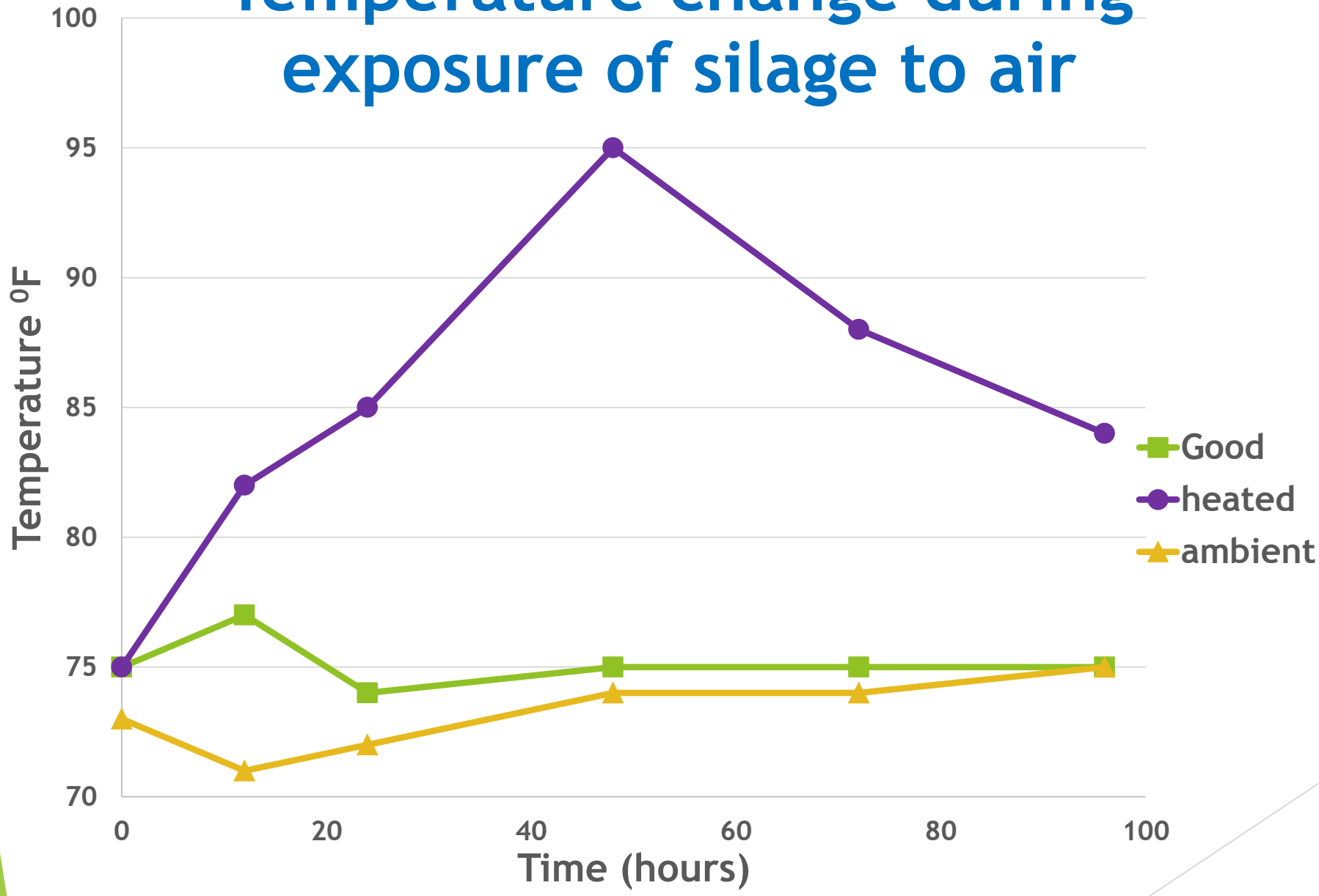
Aerobic heating leads to decrease in quality

Silage type	Location	pH	Ash (% DM)	DMD (%)	NDFD (%)
Corn	Center	4.0[b]	5.1[b]	70.1[a]	50.4[a]
	Wall	4.2[b]	6.2[b]	67.5[a]	49.1[a]
	Shoulder	7.2[a]	12.0[a]	47.8[b]	28.6[b]

Indicators of spoilage

- Heating
- Browning
- Unpleasant, atypical odors
- Molding → mycotoxins
- Sticky texture
- Increase in pH values
- Seepage

Temperature change during exposure of silage to air



Consequences of heating

- Protein degradation (ammonia nitrogen)
- Energy losses
- Decrease in nutritive value
- Reduced intake and animal performance
- Mycotoxins
- Development of pathogens

How do we minimize losses and reduce aerobic losses?

Ways to minimize losses

- Good management practices
- Use of additives (such as inoculants)

Inoculants for silage

- Selected strains of lactic acid bacteria (LAB) which take over the ensiling fermentation and minimize shrinkage (improve DM recovery).

- Bacterial inoculants for silage are considered natural products, non-corrosive to machinery, non-pollutants and non-toxic.

What are Inoculants used for?

- To enhance the ensiling fermentation
- To reduce DM losses (shrinkage)
- To reduce aerobic spoilage (heating)
- To enhance animal performance

Types of LAB Inoculants for Silage

- **Homo-fermentative**
  (Lactobacilus plantarum, Pediococcus pentosaceus, Enterococcus Faecium)

- **Hetero-fermentative**
  (L. buchneri)

- **Combination**

Types of LAB fermentation

- Homo-lactic:
  - Sugars → Lactic Acid
- Hetero-lactic:
  - Sugars → LA + Acetic acid + CO_2
- Homo-lactic species are preferred because they result in rapid decrease in pH and minimize fermentation losses.

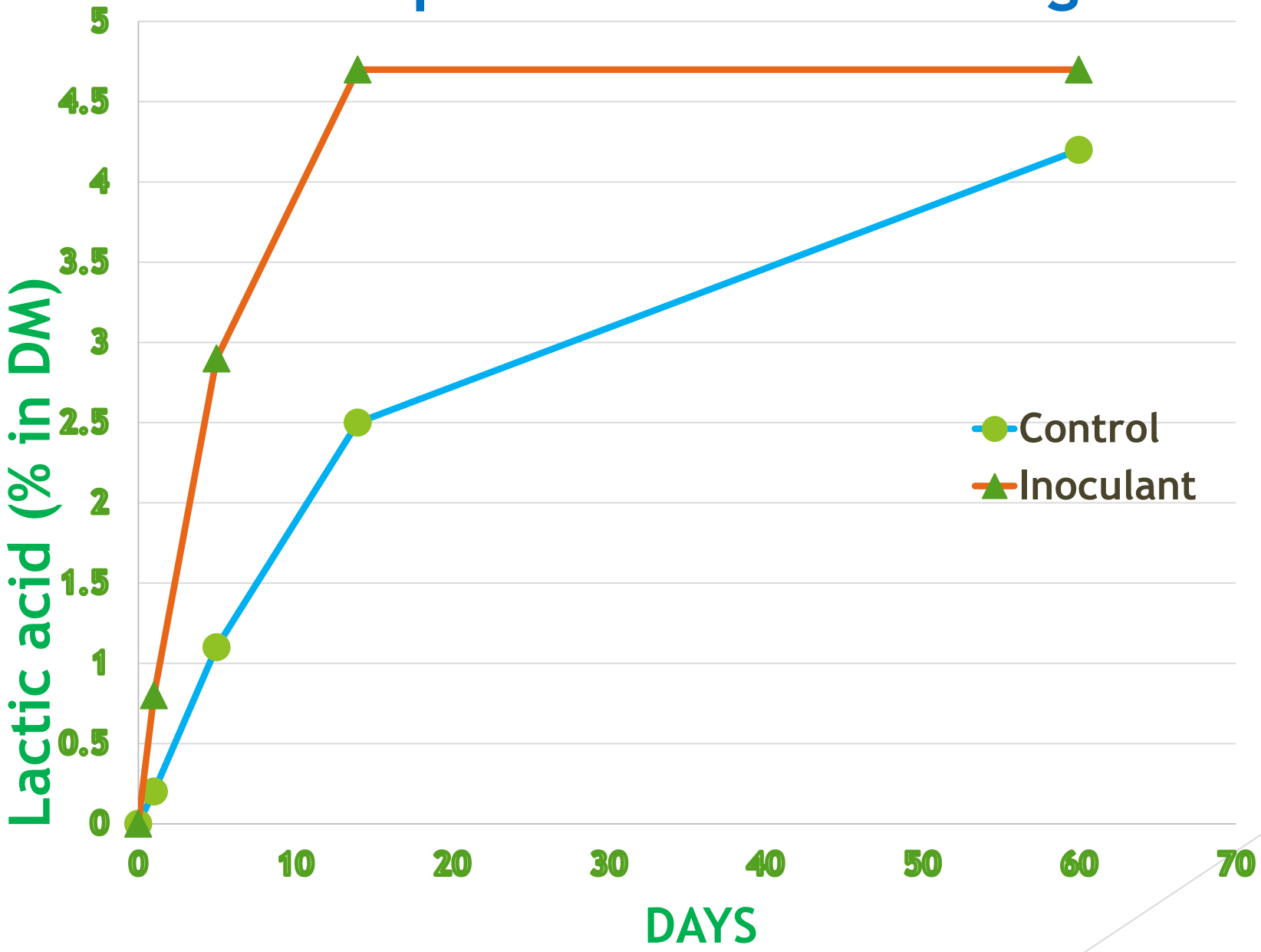
Multi-strain Homo-LAB inoculants

- Some commercial inoculants for silage include mixed strains that are active at different phases of the ensiling fermentation.
- Multiple strains are used in case a certain strain is not well established in the silage.

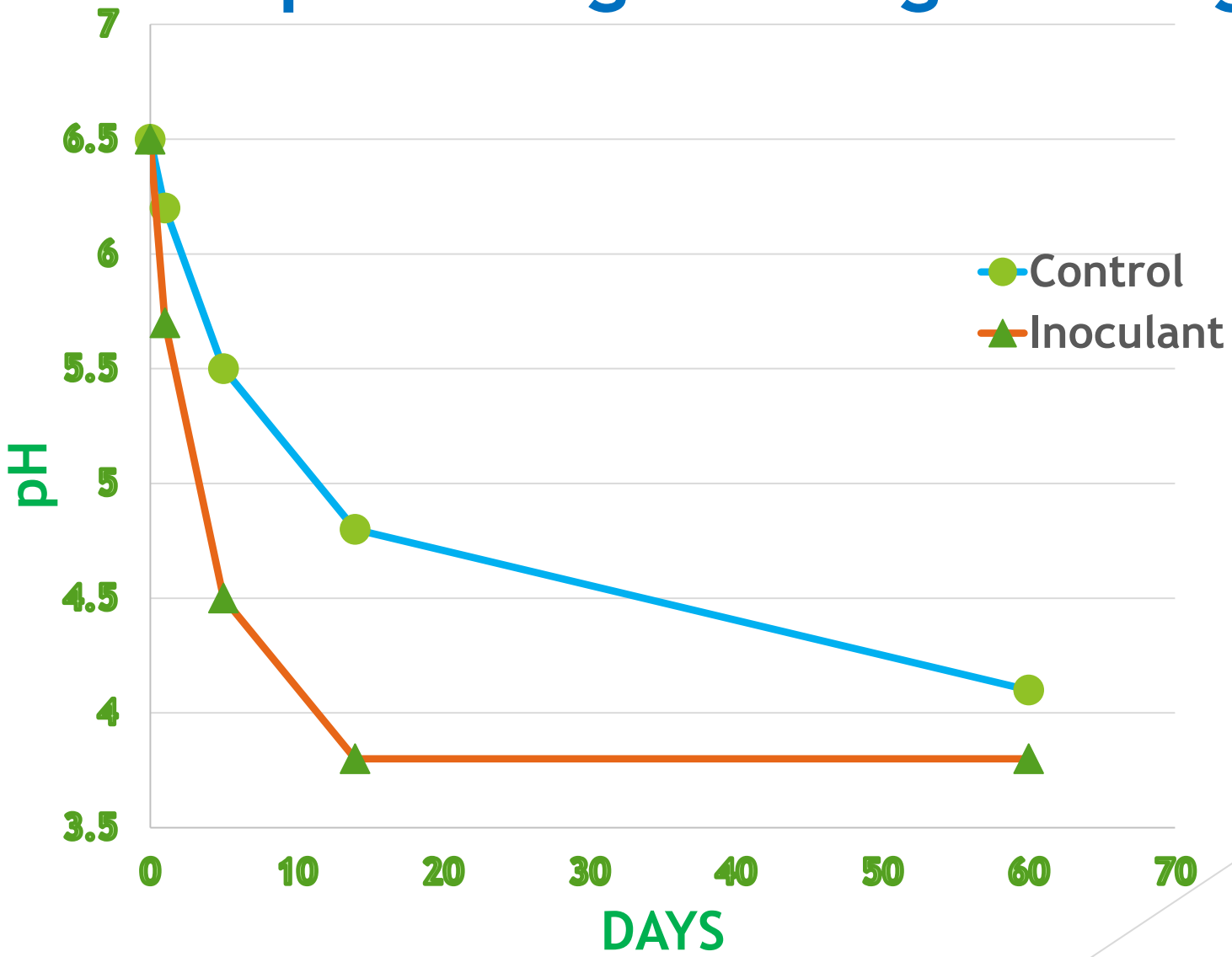
Application of Inoculants

- Inoculants should supply at least 100,000 colony forming units (CFU) per gram of forage.
- Follow the application instructions provided by the manufacturer.

Build-up of lactic acid during ensiling



pH change during ensiling



Types of Inoculants

- Homo-fermentative which produce only lactic acid in the silage.
- Hetero-fementative which produce both lactic and acetic acids.

LAB and Aerobic Spoilage

- Homo-fermentative LAB inoculants may enhance aerobic spoilage of sensitive silages.
- Because they produce only lactic acid in the silage which many aerobic yeasts can utilize.
- Sensitive silages: corn and small grain in bunkers/piles with a slow feed-out rate.

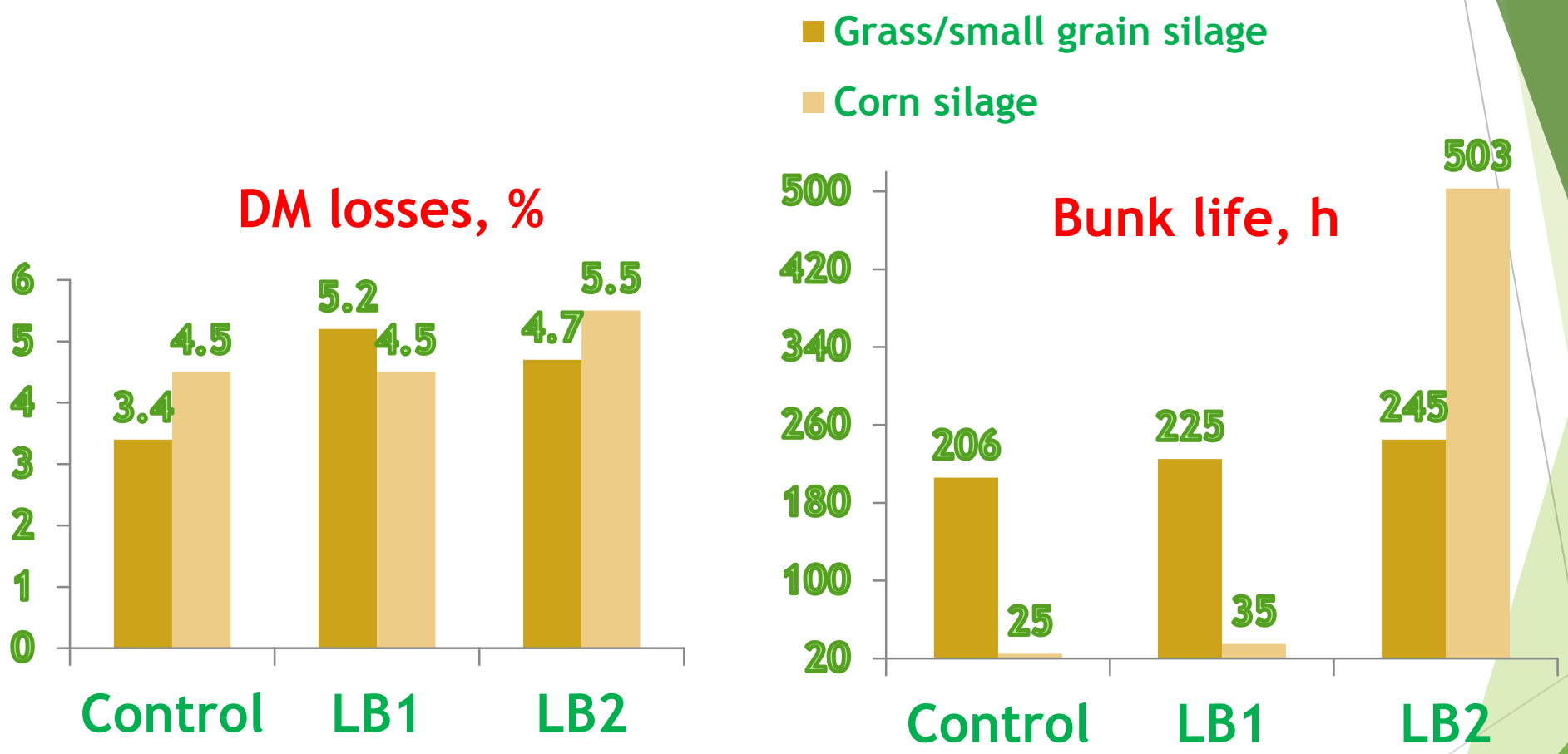
The Solution

- Yeasts and molds are inhibited by volatile fatty acids (acetic, propionic and butyric acids).
- L. buchneri improves aerobic stability (bunk life)
- However, L. buchneri results in silages with slightly higher pH values and losses as compared to those with L. plantarum.
- May use a combination of L. buchneri and homolactic inoculants.

Aerobic stability (Bunk life)

- Measured by the time (hours) it takes for a silage to heat by 2-4°F above the ambient temperature.
- The longer the time required, the more stable the silage.

Effects of L. buchneri (LB) in 43 studies



LB1 = <100,000 cfu/g
LB2 = >100,000 cfu/g

(Kleinschmit and Kung, 2007)

Sometimes inoculants have no effect

- The control silage is as good in experiments.
- Inadequate crop composition (lack of sufficient fermentable sugars, very low moisture).
- Inadequate storage conditions of the inoculant such as high temperatures.

Intermediate summary

- If the ensiling fermentation is slow like with alfalfa, clover and other legumes, L. plantarum along with other homo-lactic strains could be very useful.
- If the silage is sensitive to aerobic spoilage, L. buchneri should be used.
- Combination products of both could be a good choice.

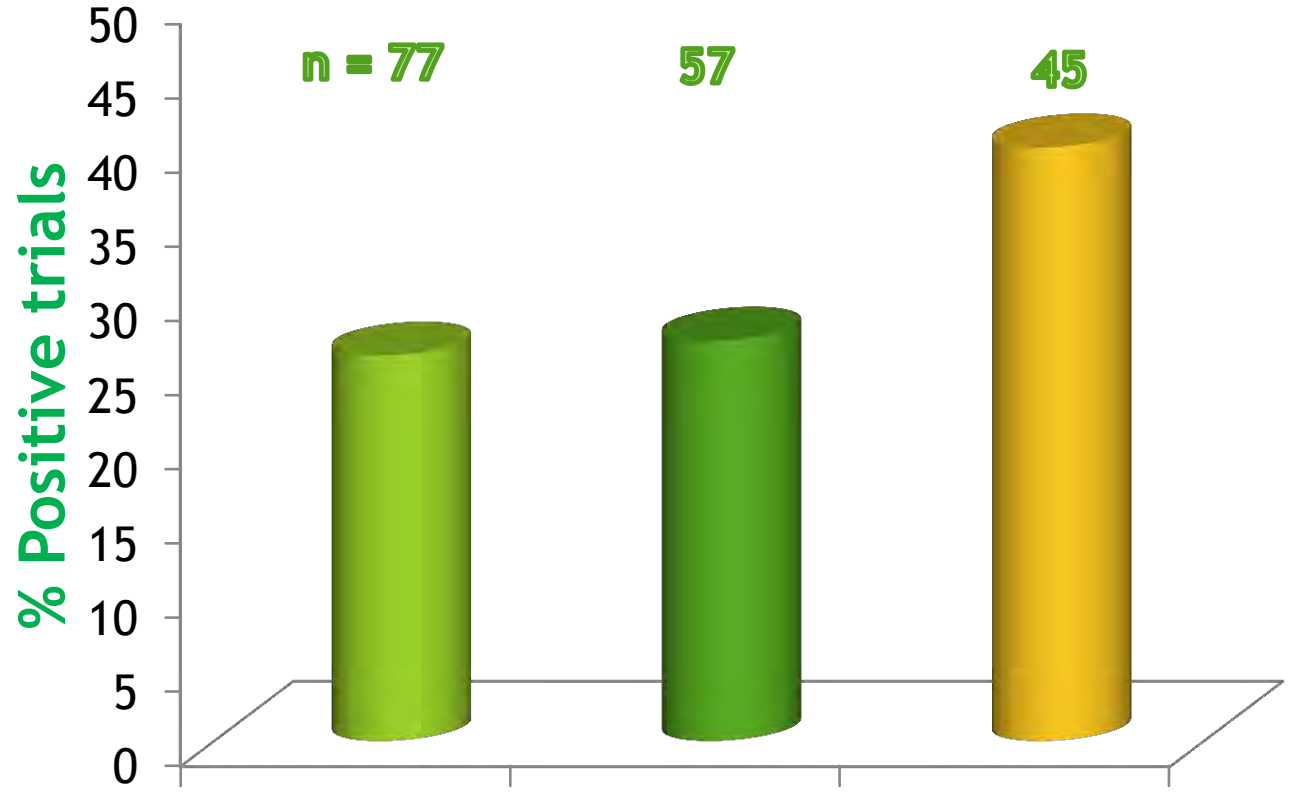
Inoculant effects on ruminant performance: probiotic effects?

Probiotic

- Probiotic is defined as live microorganisms which when administered in adequate amounts confer health benefits on the host (FAO/WHO, 2001).

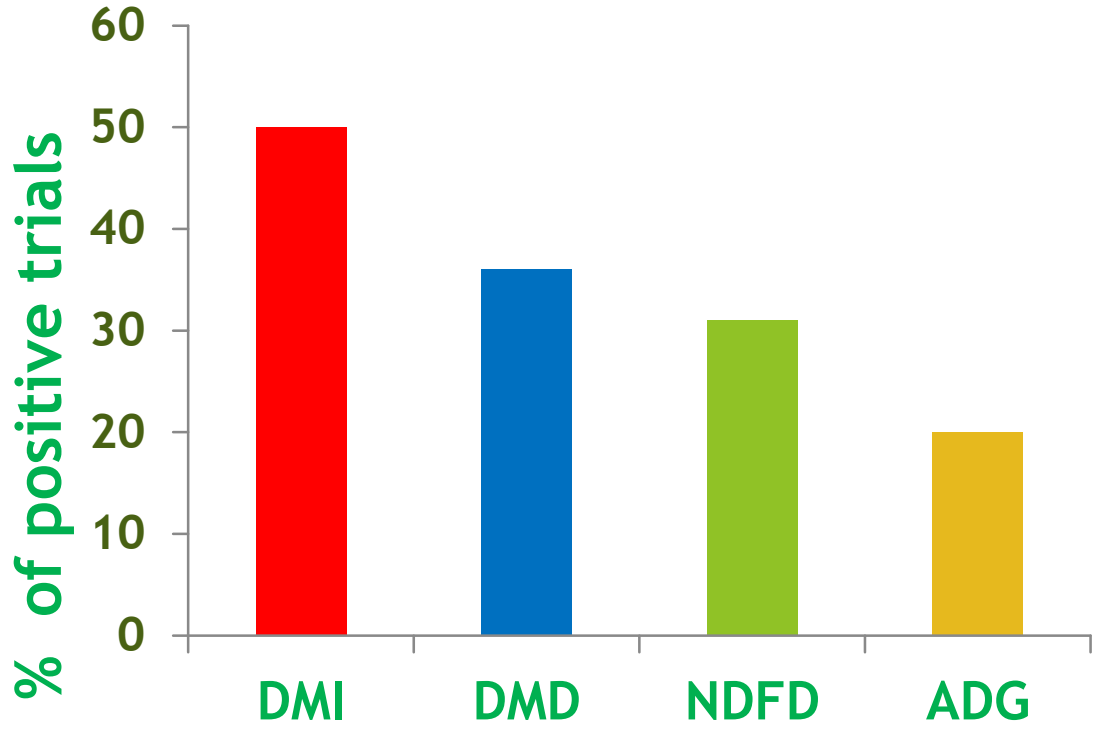
- Consumption of fermented dairy products in certain communities is associated with good health and long livelihood.

Effectiveness of (homolactic) inoculants in different studies



(Muck & Kung, 1997)

Effects of inoculants (homolactic) on animal performance in 39 studies



(Adesogan et al., 2009)

Effect of inoculants on animal performance (Muck and Kung, 1997)

Parameter	% of increase
Intake	4-11
Live weight gain	7-11
Milk production	3-5
Feed efficiency	9

LAB Directly Fed (DFM)

- Other studies showed that selected strains of LAB top dressed on to the rations a few weeks before calving and several weeks after calving improved DMI and milk yields.

How does it work?

We don’t know yet.

considerations

Return over Income for homolactic bacteria investment – DM recovery

- If treated tonnage = 1 tonne
- Inoculant cost = $1 at $1/tonne
- If DM loss reduced = 2.5%
- DM loss saved = 0.025 tons
- Value of DM saved = 0.025 x $50/ton = $1.25
- ROI = 1.25 to 1
- If performance improves, ROI increases further

Return over Income for L. buchneri investment - aerobic stability

- If treated tonnage = 1 tonne
- Inoculant cost = $1.5 at $1.50/tonne
- If spoilage avoided = 4% (Florida example)
- Silage saved = 0.04 tons
- Value of DM saved = 0.04 x $50/ton = $2
- ROI = 1.33 to 1 on saved silage alone
- If milk loss due to spoilage is saved, ROI increases further

Return over Income for homolactic bacteria investment - milk production

- If treated tonnage = 1 tonne
- If silage intake = 65 lb/day (wet)
- Silage will last = 31 days
- If milk increase by treatment = 2 lb/day
- If Milk response chance = 50%
- Milk increase by treatment = 1 lb/day
- Value of milk increase from 1 ton of treated silage
  = 1lb/d x $0.16/lb x 31 days
- = $4.96 or 16 cents/cow/d
- ROI = 5:1 at inoculant cost of $1/ton
- This is in addition to ROI for DM loss/aerobic stability

Finally, should we use inoculants for silage?

- Some farmers use “to be on the safe side”
- If savings from improved DM recovery, improved bunk life (aerobic stability) and increased milk yields exceed the break-even point with the inoculant price, then
- YES!

Summary

- Inoculants are used to improve the ensiling fermentation, to reduce silage heating and shrink, to prolong bunk-life and to enhance animal performance.
- There are various types of LAB inoculants for silage (Homo- and Hetero- lactic types).
- Select the inoculant product according to your silage, management and storage facility.
- Store the inoculants under cool and dry conditions
- Apply the inoculant according to the manufacturer's instructions to ensure they work well.

THANK YOU!