The background of the slide is a dense field of alfalfa plants, showing their characteristic trifoliate leaves and small yellow flowers. The image is slightly faded to allow the text to be clearly visible.

Getting More from Forage Nitrogen: Redesigning Alfalfa to Save Protein during Ensiling

Ronald Hatfield

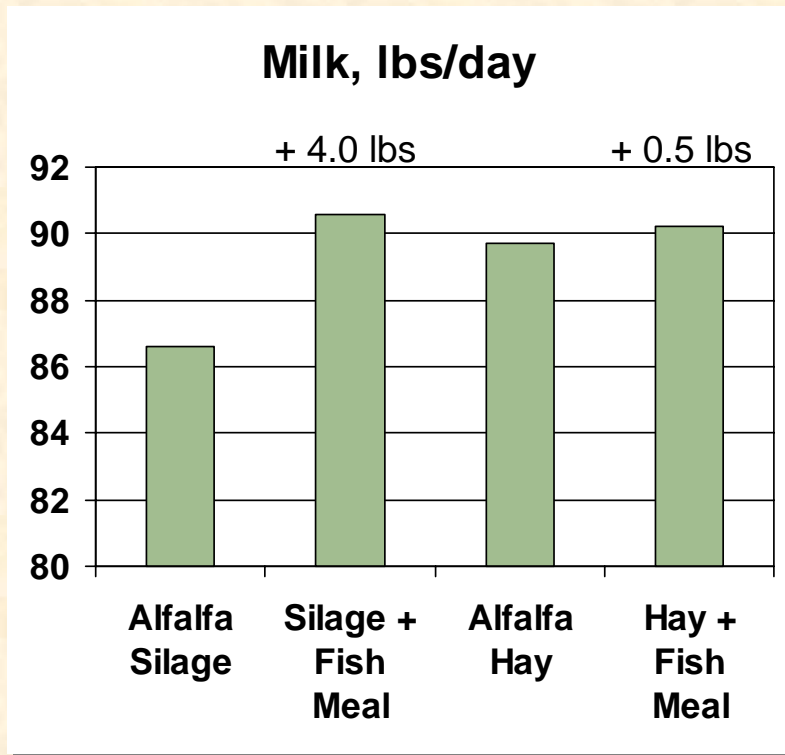
Richard Muck

US Dairy Forage Research Center

Isn't Alfalfa a Good Source of Crude Protein for the Cow?

- High in nitrogen
- However, not always used efficiently by the cow, particularly alfalfa silage

Milk Yield from Alfalfa Silage and Hay Diets



- Fish meal is beneficial in alfalfa silage diets, but not alfalfa hay diets.
- **Bottom line:** alfalfa silage nitrogen is not efficiently used by the cow

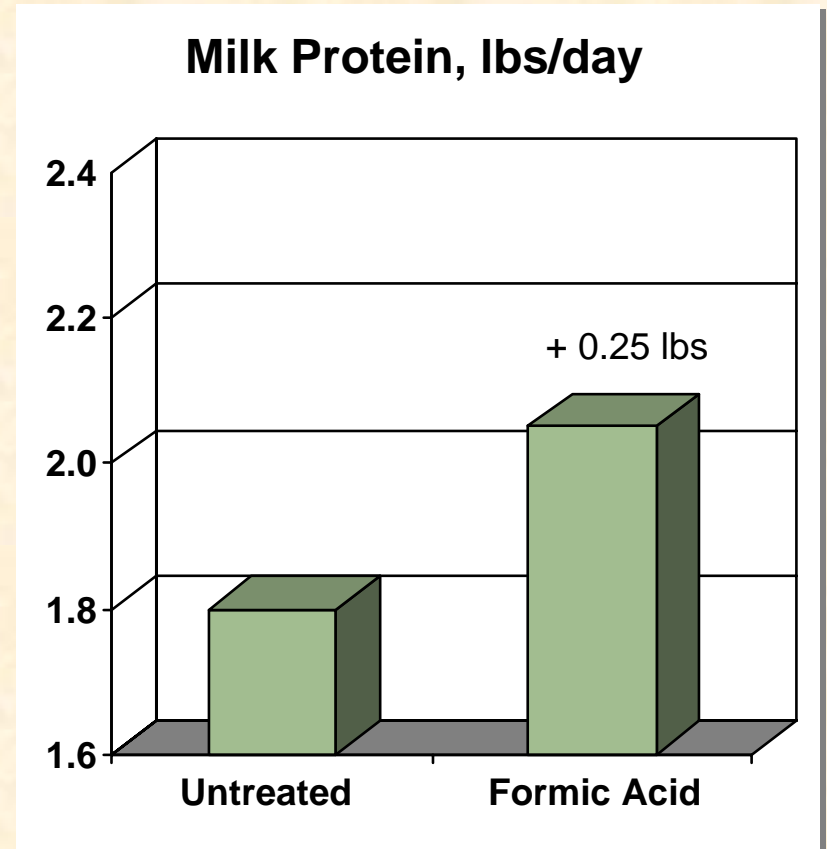
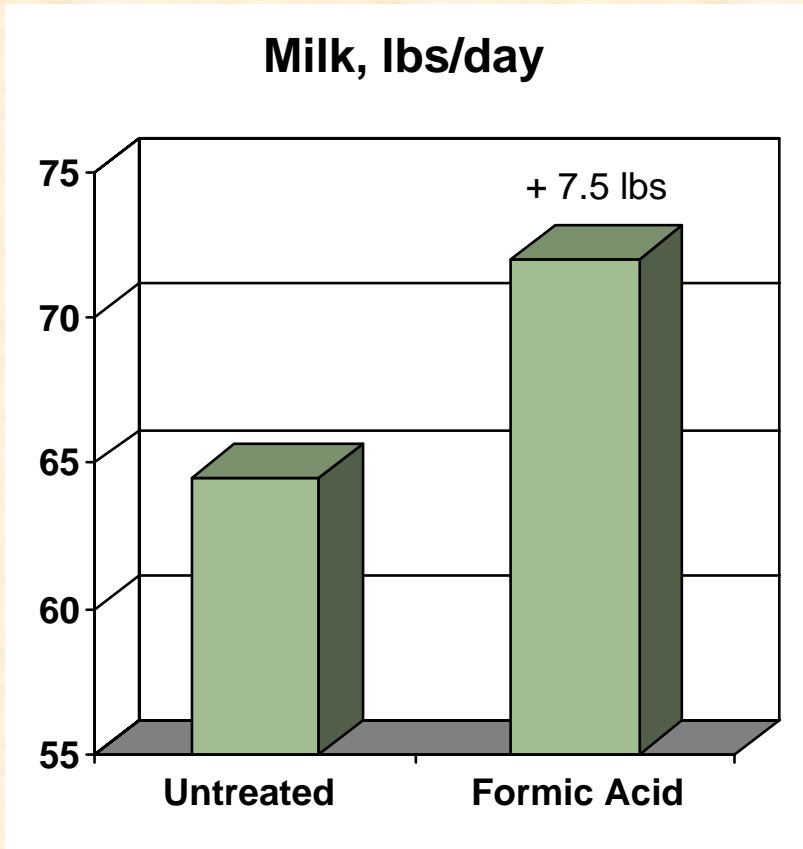
What Happens in Ensiling that Affects How the Cow Uses the Nitrogen?

True Protein as a percentage of total N

- Live Alfalfa Plant: 90%
- Alfalfa Hay: 75%
- Alfalfa Silage: 45%

Loss of protein (proteolysis) during harvesting and storage is due to plant enzymes (proteases)

Does Loss of True Protein during Ensiling Affect the Cow?



The Cost of Protein Breakdown in the Silo

- Proteolysis during ensiling results in annual losses of up to \$30 per acre for alfalfa silage.
- Net losses can be as high: **\$94 million** per year across the U.S.
- Negative environmental impacts from excess N in manure are not considered in these costs.

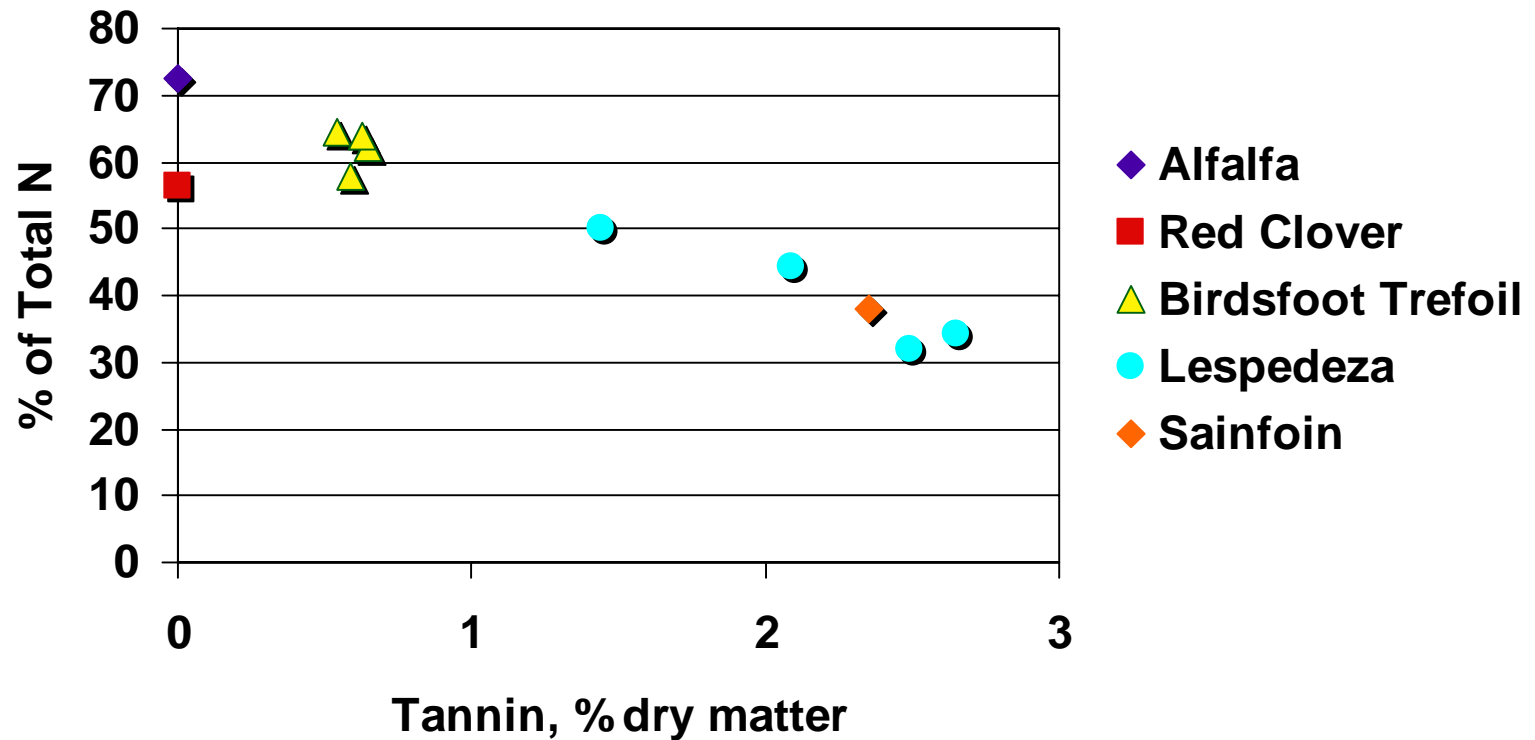
How Can We Preserve Alfalfa Protein During Ensiling?

- Additives
 - Acids like formic, sulfuric
 - But safety issues, corrosion of equipment as well as cost
 - Other additives have little effect

How Can We Preserve Alfalfa Protein During Ensiling?

- Additives
- Look at other forages
 - May have mechanisms to preserve protein during storage that alfalfa does not
 - May be the source of new techniques, genes to improve alfalfa

Nonprotein Nitrogen in Various Legume Silages



Birdsfoot Trefoil

- Up to 50% less proteolysis during ensiling
- But relative to alfalfa
 - Lower yield
 - Lower persistence



Birdsfoot Trefoil Has Less Protein Loss During Ensiling

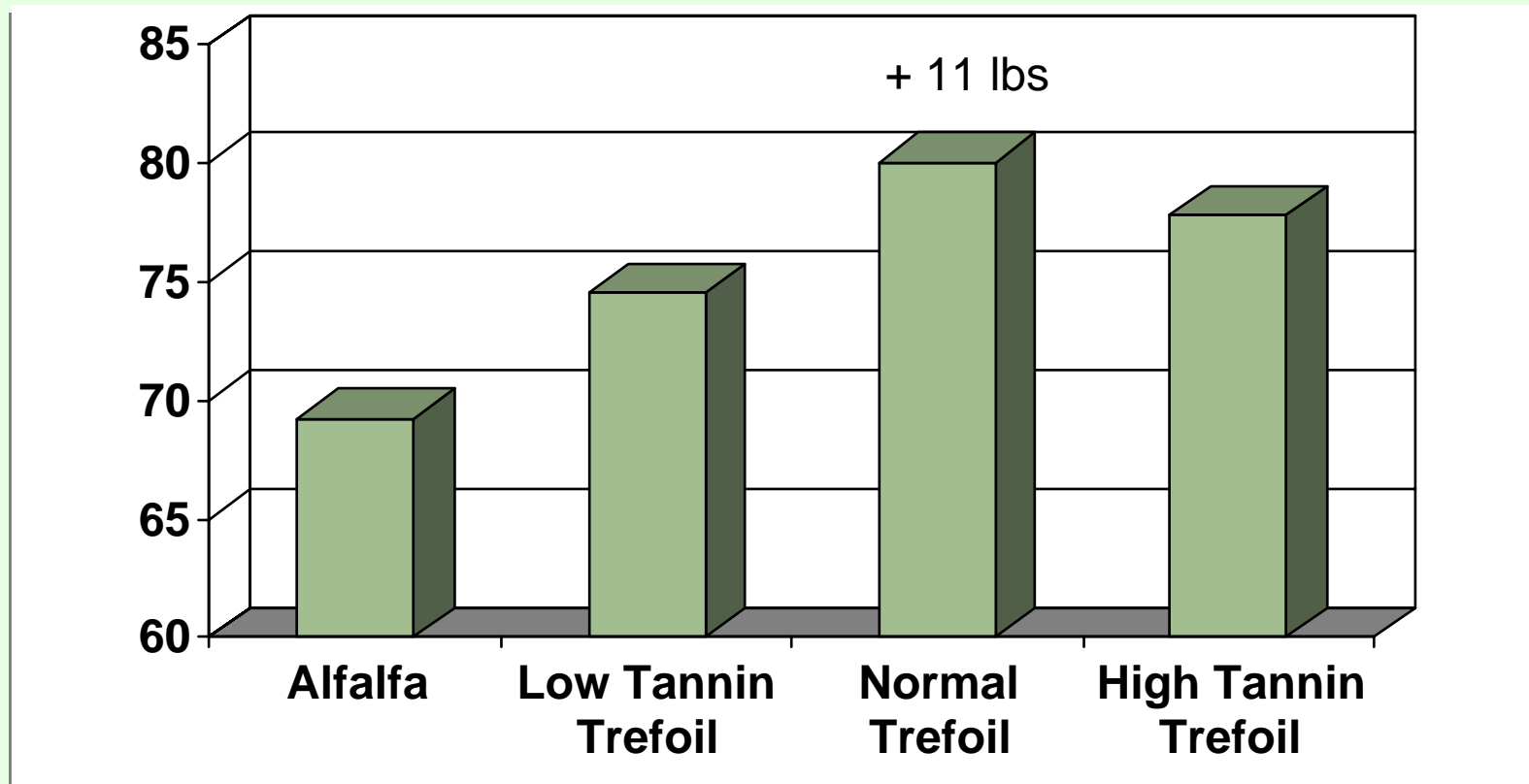
- Tannins combine with proteins so that:
 - Proteases less effective in the silo
 - Proteins are less degradable in the rumen
 - Birdsfoot trefoil is bloat resistant

What Are Tannins?

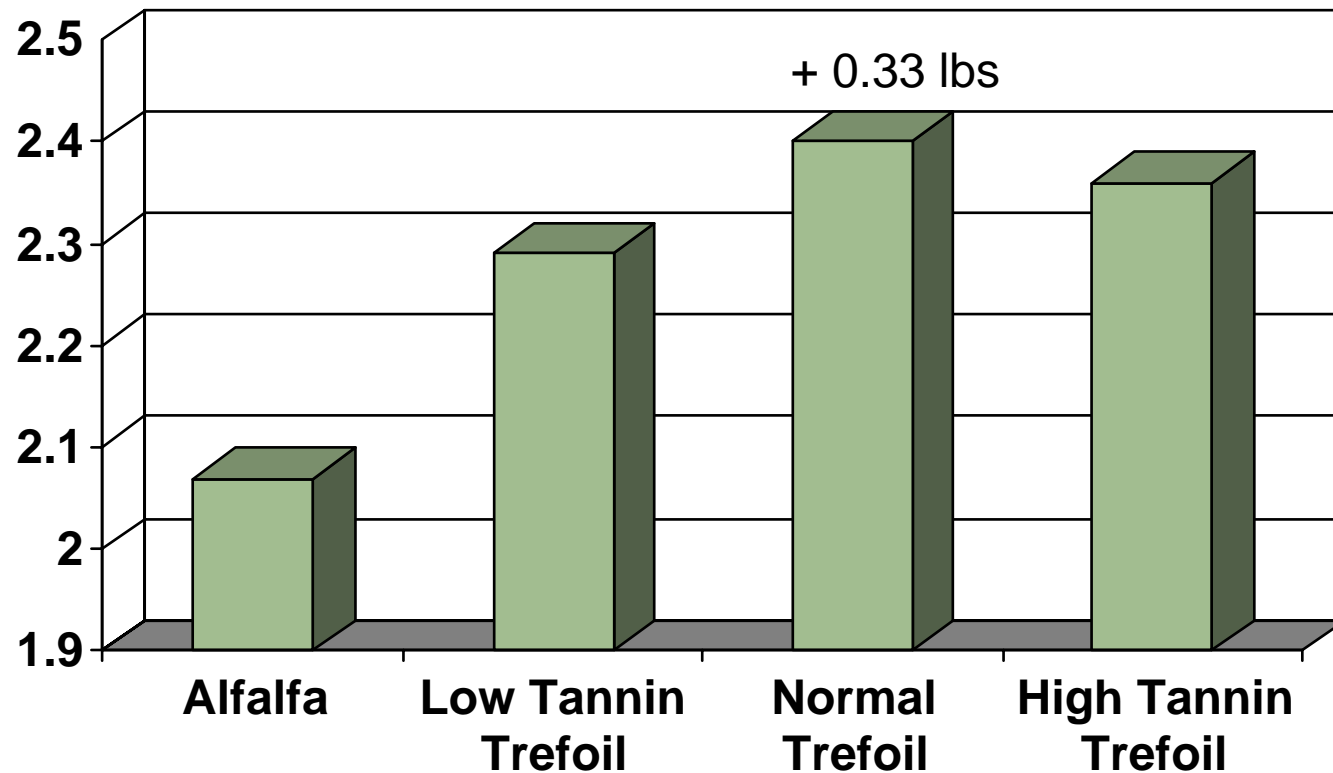
- Complex polyphenols
- Commonly found in tree bark and leaves (oaks for example)
- Used in tanning leather
- Give woodland streams, lakes brownish color



Comparison of Alfalfa and Birdsfoot Trefoil Silages on Milk Yield (lbs/day)



Comparison of Alfalfa and Birdsfoot Trefoil Silages on Milk Protein Yield (lbs/day)



Challenge of Moving Tannins into Alfalfa

- Alfalfa already makes some tannin in the seed coat.
- Several groups have worked at getting alfalfa to produce tannins in leaves.
- However, the goal has been elusive.

Redesigning Alfalfa to be the “Perfect” Forage

- Collaborative effort with private and public institutions and ARS,
 - Forage Genetics, Noble Foundation, Plant Research Unit St. Paul, MN, and USDFRC
 - Formed a consortium to achieve this goal

Consortium
for
Alfalfa Improvement

Redesigning Alfalfa to be the “Perfect” Forage

- Current projects
 - PPO alfalfa
 - Reduced lignin alfalfa
 - Adding *o*-diphenols for PPO in alfalfa
 - Tannin alfalfa

Consortium
for
Alfalfa Improvement

Red Clover

- Up to 90% less proteolysis during ensiling
- But relative to alfalfa
 - Lower yield, persistence
 - Slower drying
 - Cows eat less



Red Clover Has Less Protein Loss During Ensiling

Less protein degradation during ensiling.

Contains polyphenol oxidase (PPO) and o-diphenols



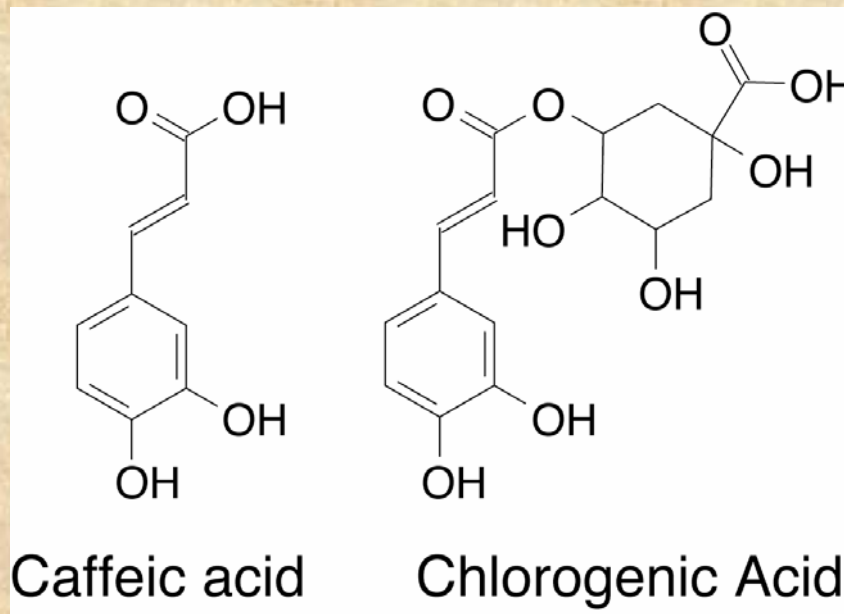
What is PPO?

- Enzyme found in numerous plants
- Causes browning of fruits/loss of quality

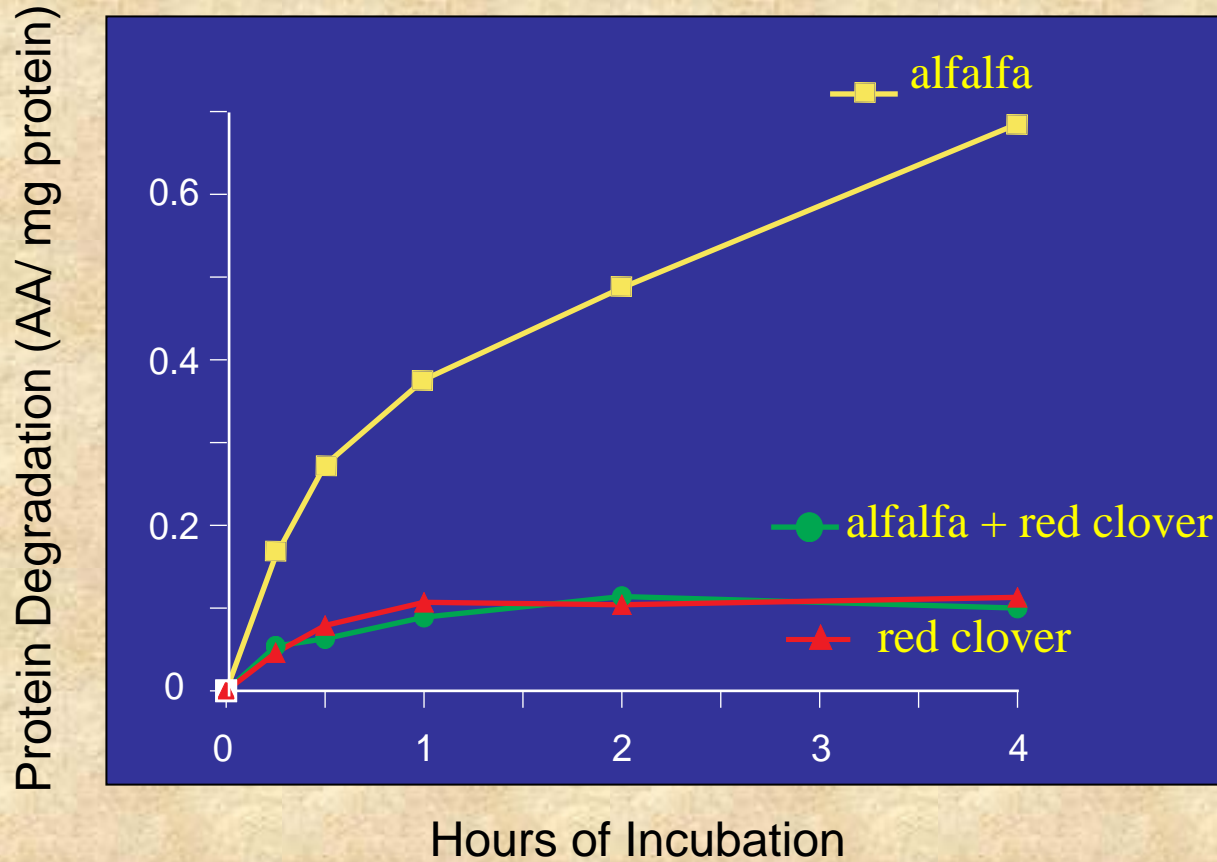


What is PPO?

- O-diphenols molecules needed for a reaction with PPO
- Antioxidants found in many fruits and vegetables, may help reduce cancer risk



Proteolytic Activity

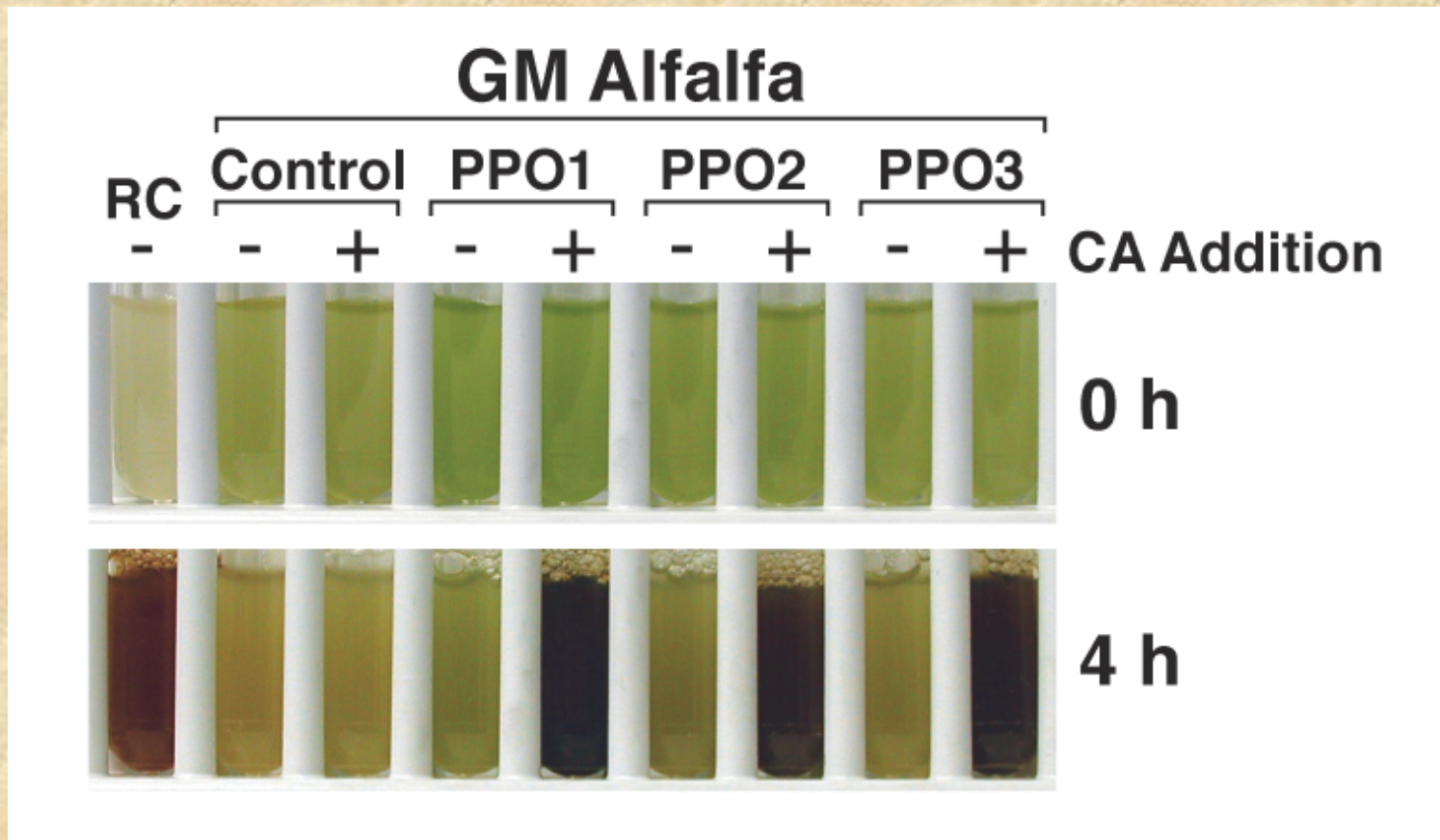


Alfalfa Lacks PPO

- Can redesign alfalfa to produce PPO
- Add polyphenols at the time of harvest
- Redesign alfalfa to produce the required polyphenols

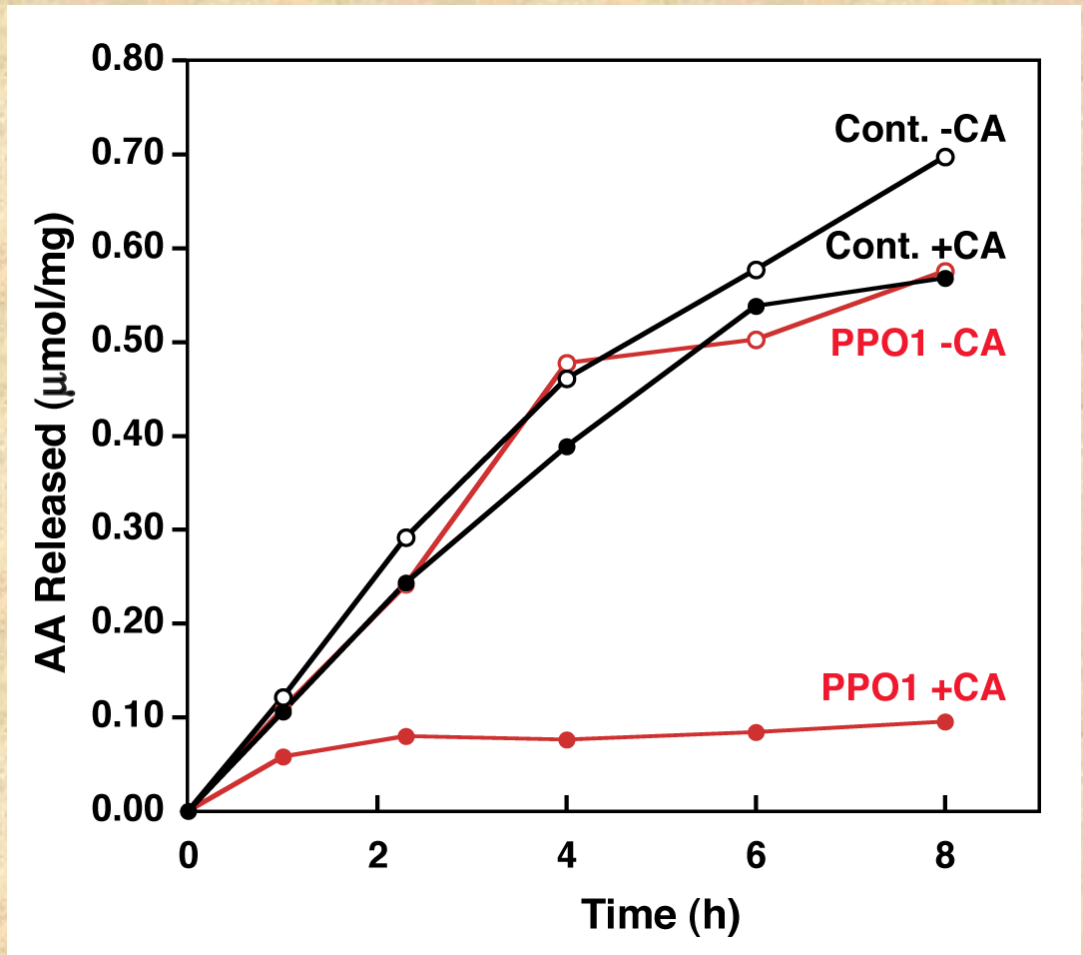


Alfalfa Browning



Impact of PPO

- Decrease protein degradation in extracts when o-diphenols are added



PPO Alfalfa

- Initial ensiling experiments with mini-silos indicate 20-25% reduction in protein loss.



Challenges of Making PPO Alfalfa a Reality on Farms

- With PPO alfalfa one must add *o*-diphenols
 - Requires source of *o*-diphenols (potatoes?)
 - Requires high levels of conditioning



Challenges of Making PPO Alfalfa a Reality on Farms

- Redesign alfalfa to produce PPO and o-diphenols
 - Alfalfa already makes precursors for needed o-diphenols
 - Requires modifying alfalfa to produce the appropriate enzyme