The Effects of an Exogenous Protease on the Fermentation and Nutritive Value of Corn Silage Stored at Two Temperatures

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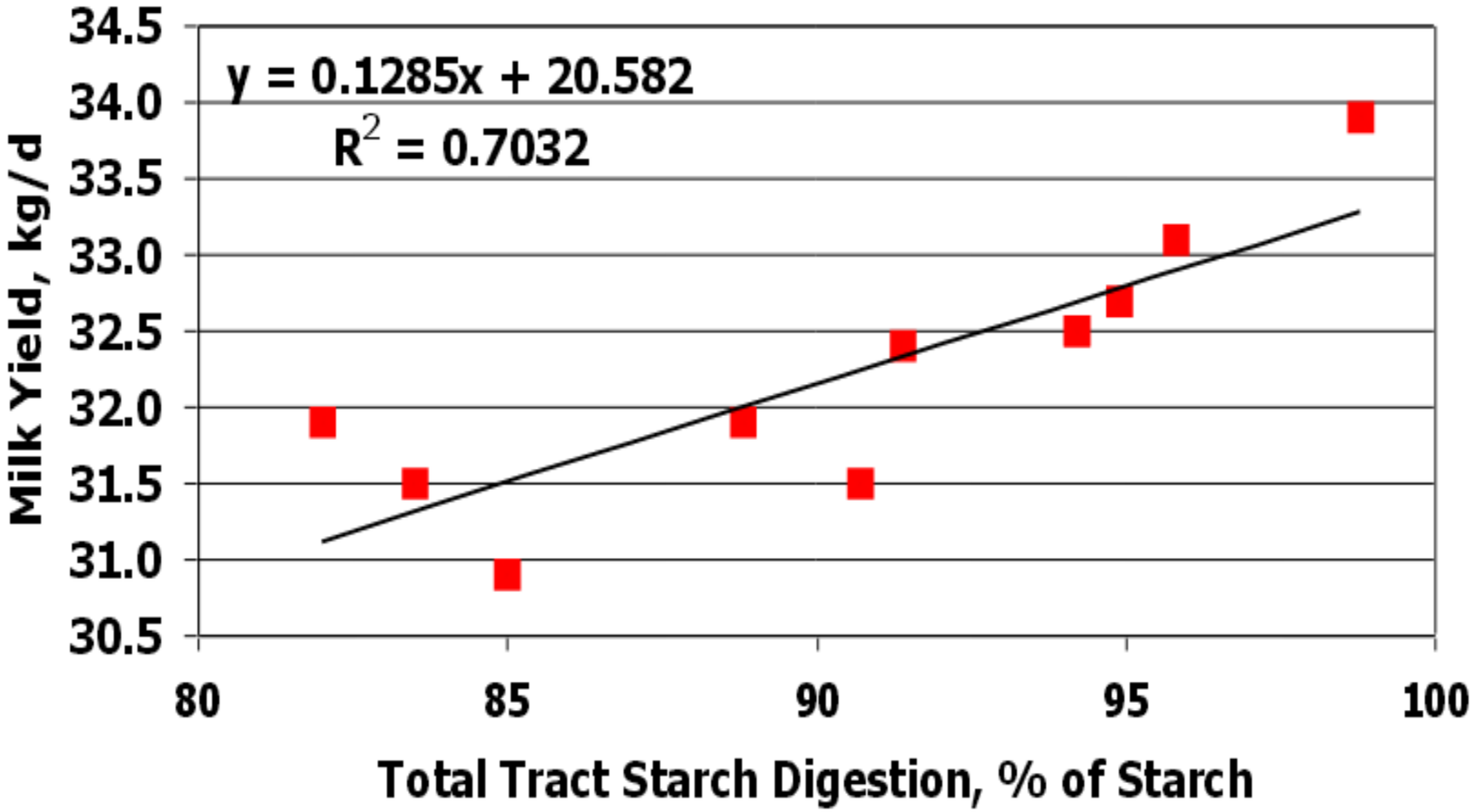
Starch Digestion is Highly Correlated with Milk Production

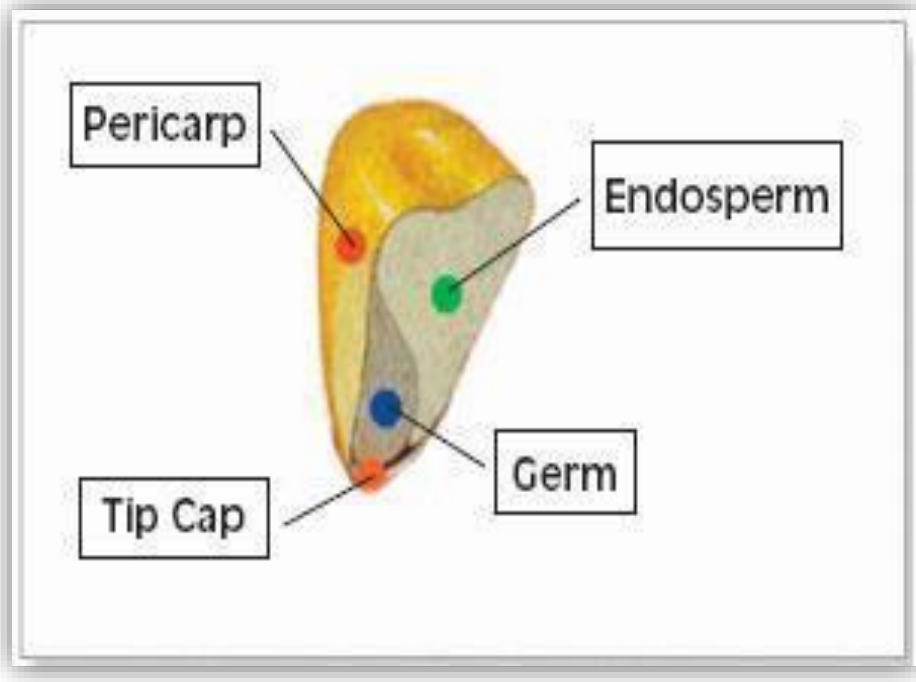


Firkins et al., 2001

Accessibility of Starch in Feeds

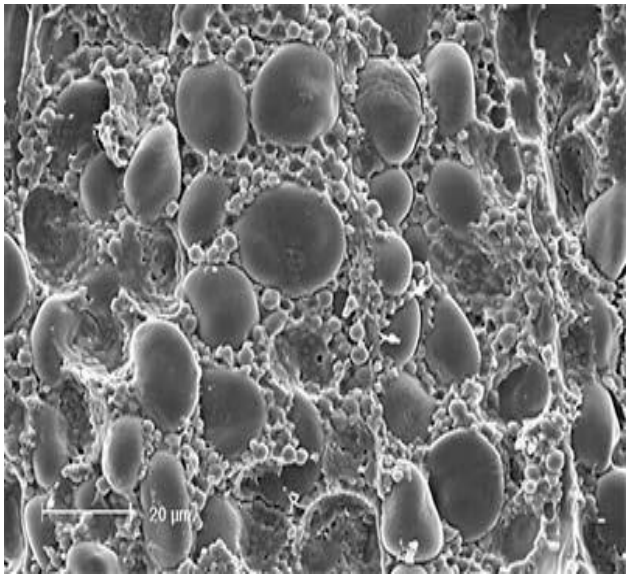
- Starch must be accessible by bacteria in the rumen and intestine of the cow for fermentation and digestion, respectively.

- Two primary factors limit the access to starch
  - Pericarp
  - Protein/starch matrix



The Protein/Starch Matrix

- Starch is embedded in a prolamin protein matrix
  - Major amino acid: proline
  - Hydrophobic, so difficult to digest

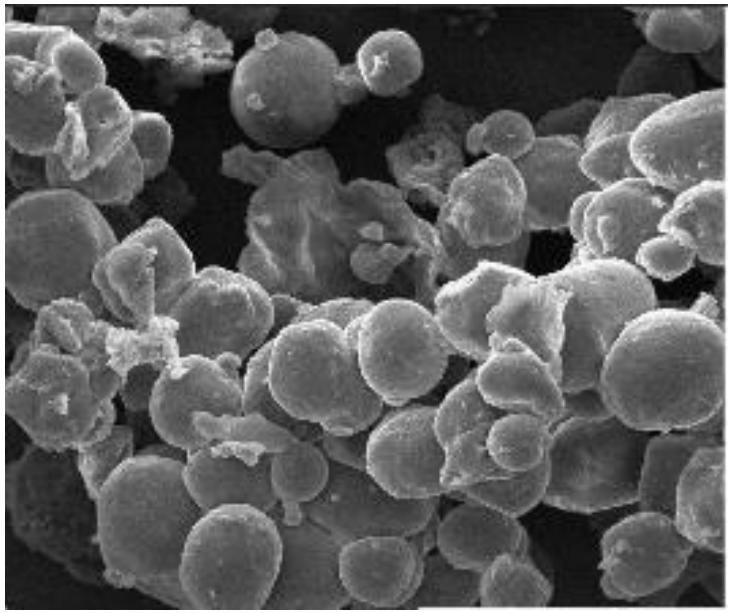


- Acts as a barrier, hindering access to starch

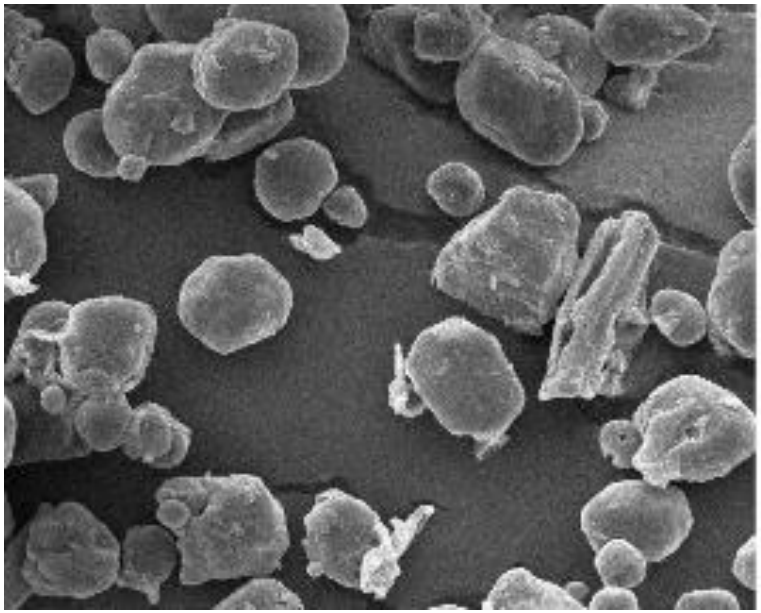
- Starch-D decreases 0.86 percentage units for each unit increase in prolamin protein content (as a percent of starch)

Proteolysis of the Protein/Starch Matrix During Storage Results in Increases in Starch-D

Prior to ensiling

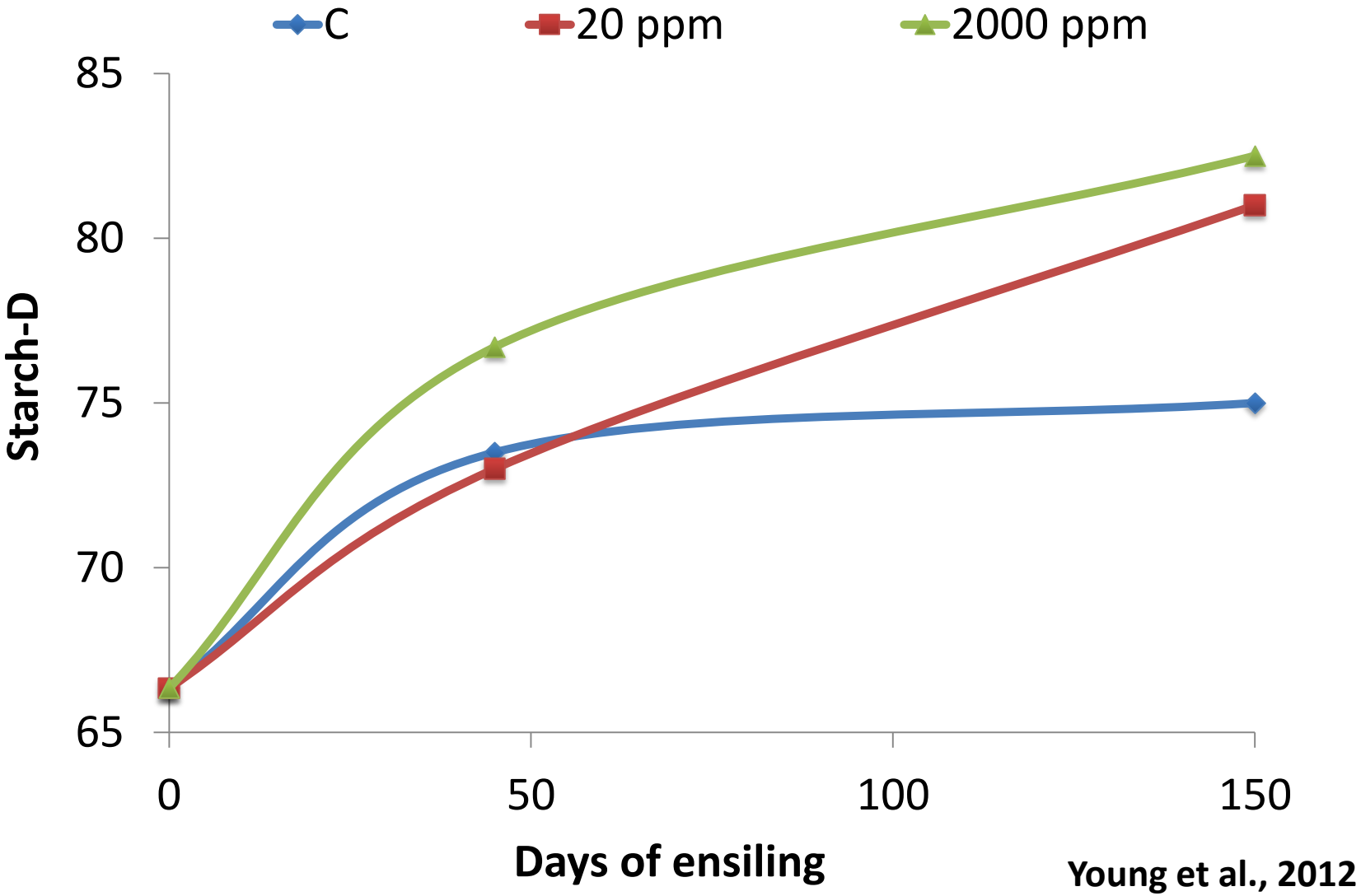


After 240 d of ensiling



Hoffman et al., 2011

Using a Protease to Increase Starch-D



Young et al., 2012

Effect of Temperature on Fermentation

- Protease activity is affected by pH as well as temperature
- Forages are often harvested in hot weather
- Silages heat during fermentation and retain heat during storage
- Temperature affects fermentation
  - Cool temperatures may retard fermentation
  - Warm temperatures (>40°C) may cause an altered or restricted fermentation

Objectives

- To evaluate the potential use of exogenous proteases to improve ruminal starch digestion after short periods of ensiling

- To determine if the temperature of storage affects ruminal starch digestion with or without an exogenous protease

Materials and Methods

- Whole plant corn was harvested at about 37.3% DM
- Forages ensiled in 5 replicated bag silos per treatment and opening
- Treatments
  - Additive: Control (**C**) or Protease (**EZ**, 2000 ppm)
  - Storage Temperatures: 22°C or 40°C
- Silages were ensiled for 0, 2, 7, 45, 90 d

Materials and Methods

- Silages analyzed for standard nutritive components and 7h *in vitro* ruminal starch digestibility (**IVSD**, 3 mm particle size).

- Protease activity measured using hemoglobin as a substrate
  - pH 3.6, 3.9, 4.2
  - 4°C, 22°C, 40°C

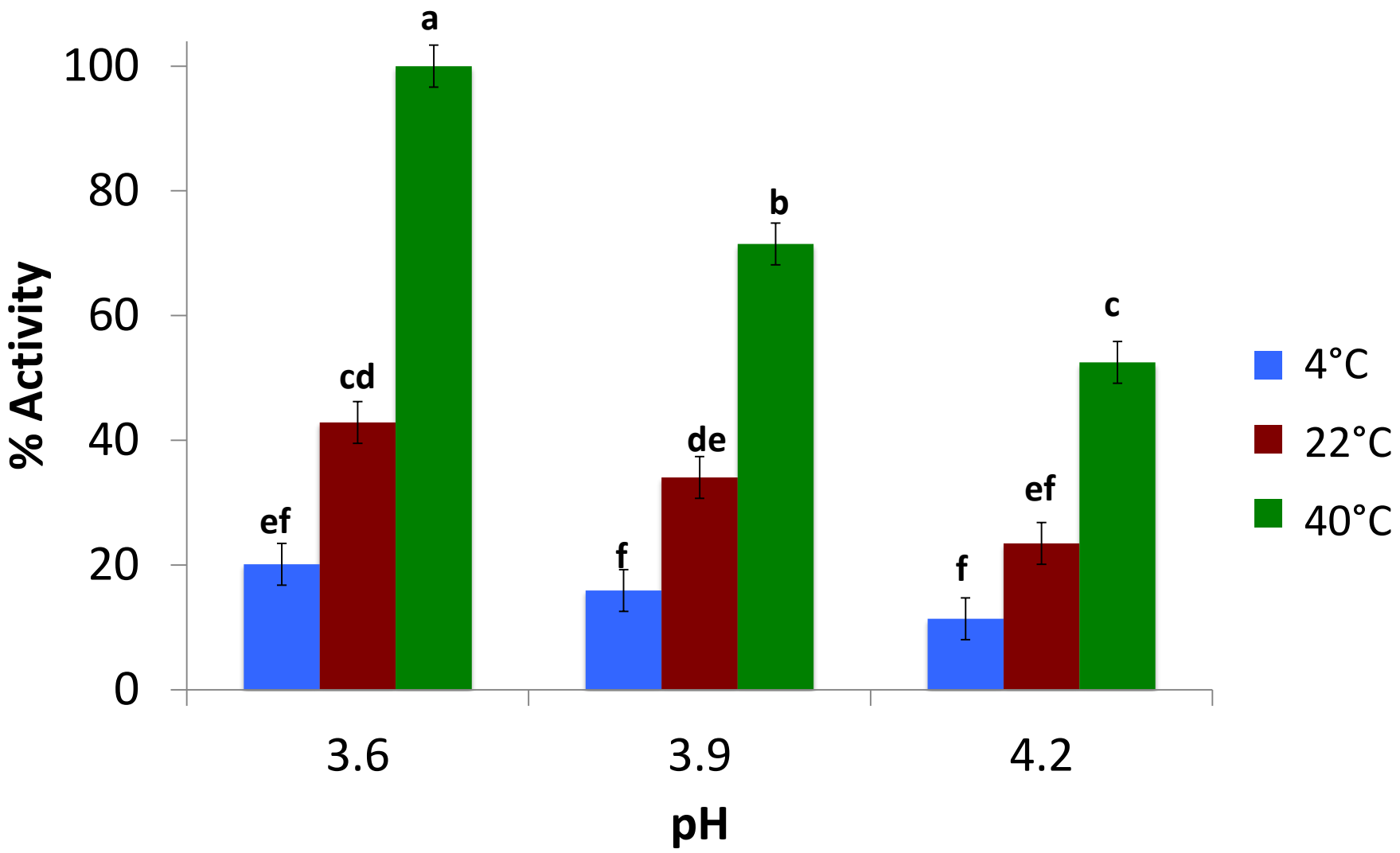
- Statistics
  - 2 × 2 × 5 factorial arrangement of treatments
  - Analyzed using the Fit Model procedure of JMP
  - Significance declared at $P \leq 0.05$

Protease Information

- The experimental metalloprotease was supplied by Novozymes, Bagsvaerd, Denmark

- Carboyhydrase activity analysis: no detectable amylase, xylanase, or endogluconase activity

Activity of the Protease at Different pH and Temperatures

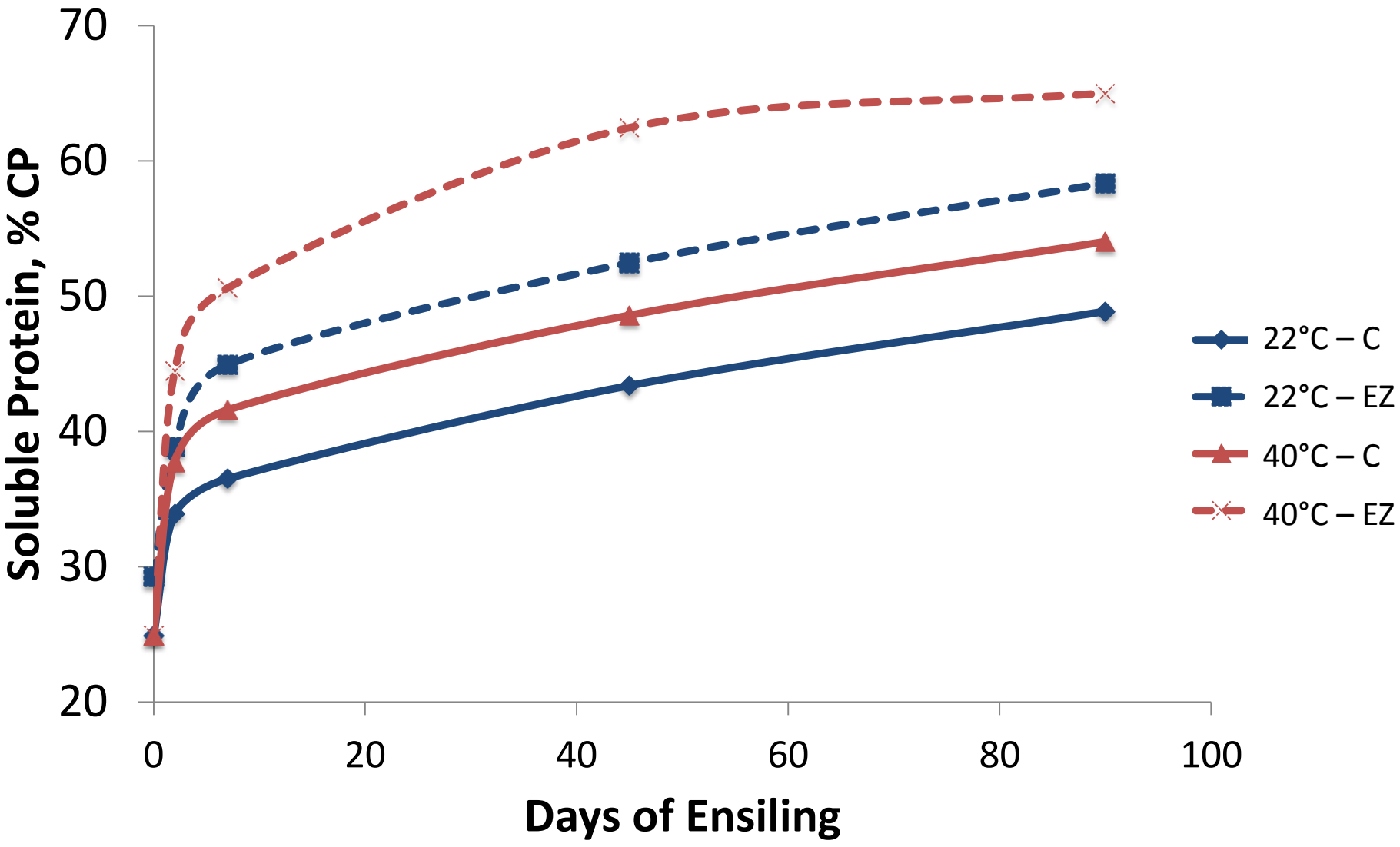


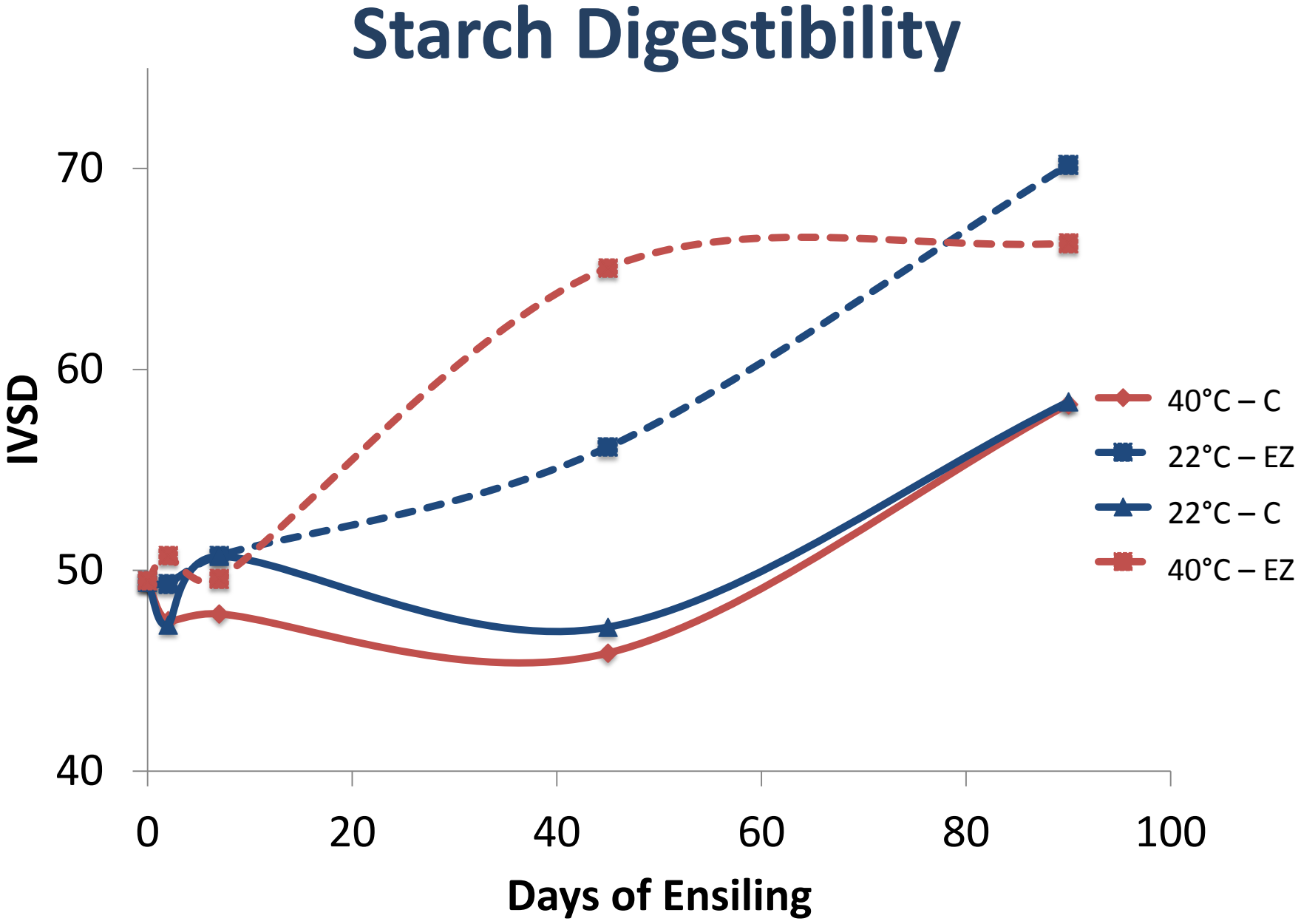
Fermentation after 90 d

	Cool Untreated	Cool Treated	Hot Untreated	Hot Treated	SEM	Temp	Enz	Temp x Enz
pH	3.65	3.58	3.59	3.60	0.02	0.28	0.15	0.10
Lactic acid, %	5.17^{a}	5.14^{a}	3.46^{b}	4.82^{a}	0.31	**<0.01**	**0.05**	**0.04**
Acetic acid, %	0.87^{a}	0.82^{a}	0.53^{b}	0.73^{ab}	0.05	<**0.01**	0.15	**0.02**
WSC, %	0.89	0.89	2.94	3.38	0.34	**<0.01**	0.53	0.53
Yeast, cfu/g	4.15	4.39	ND	1.47	0.23	**<0.01**	0.08	0.19

- No effect of temperature/protease on pH
- Fermentation was altered in Hot silages:
  - Lower contents of lactic and acetic (esp. in untreated silages)
  - Higher concentrations of WSC
- Less yeasts in Hot silages

Soluble Protein




Starch Digestibility
IVSD
70
60
50
40
0
20
40
60
80
100
Days of Ensiling
40°C – C
22°C – EZ
22°C – C
40°C – EZ

Conclusions

- Although temperature does affect proteolysis during ensiling (as measured by sol-N), temperature alone does not appear to affect the increase in IVSD that occurs naturally with time.

- Adding an exogenous protease to corn silage at the time of ensiling did not in result in better IVSD during the very early stages of fermentation.

- However, by 45 d, protease addition resulted in increased IVSD compared to untreated silages and the effect was greatest at 40°C.

Conclusions

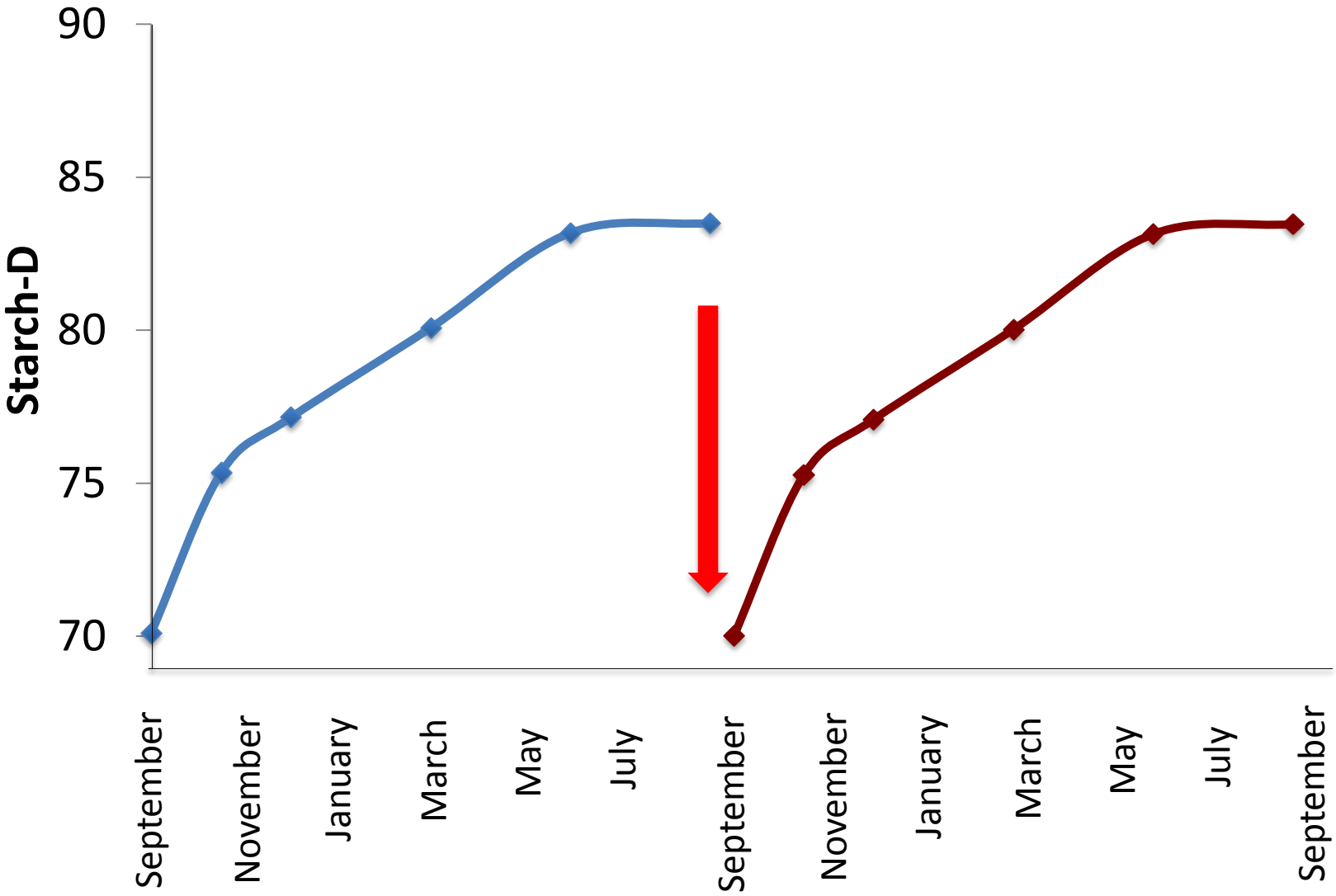
- By 90 d of ensiling, IVSD was higher and similar in protease treated than in untreated silage.

- Adding an exogenous protease at the time of ensiling has the potential to improve IVSD after a moderate length of ensiling.

- Further research is needed to establish whether a lower dose of enzyme that would be economical can be established.

Thank you

Effect of Days of Ensiling on Starch Digestion in Corn Silage



Effects of a Protease Added to High Moisture Corn Prior to Ensiling