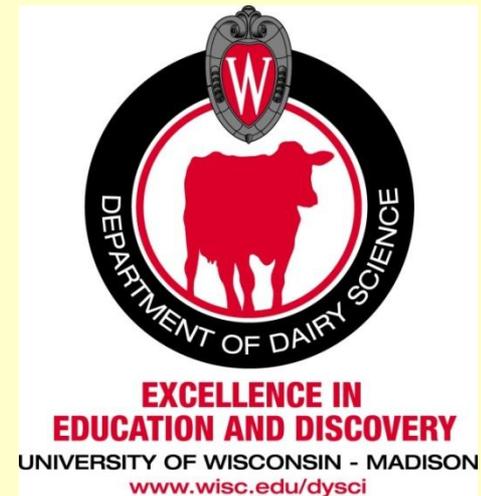


Corn silage, fermentation time, and starch digestibility – what makes it tick

P.C. Hoffman and R.D. Shaver
Department of Dairy Science
University of Wisconsin-Madison





The Wacky World of Starch Digestibility in Dairy Cows

It's these hybrids
Process it properly
Plant a floury corn
Hybrid doesn't matter for HMC
Ferment HMC 6 months before feeding
Kernels in fall manure
We need ruminal starchD
Low prolamin corn is the key
Gas production fermametrics
Resistant starch
Maturity and processing are the key
4 mm in vitro starch
Fecal starch

Hybrid has no effect on starchD
What does properly mean
Fine grind vitreous corn
but HMC feeds better in spring...
Who's paying for the extra storage
Spring corn acidosis
and starch kd of a two pool model
Greater starch yield is the key
Cow relevant starchD
Retrograde starch
Starch hydrolysis potential
Can't adjust to on farm MPS
Lab methods are wrong



The World of Starch Digestibility in Dairy Cows

Corn Chemistry and Morphology

Corn is a Seed

Floury Endosperm

Vitreous Endosperm

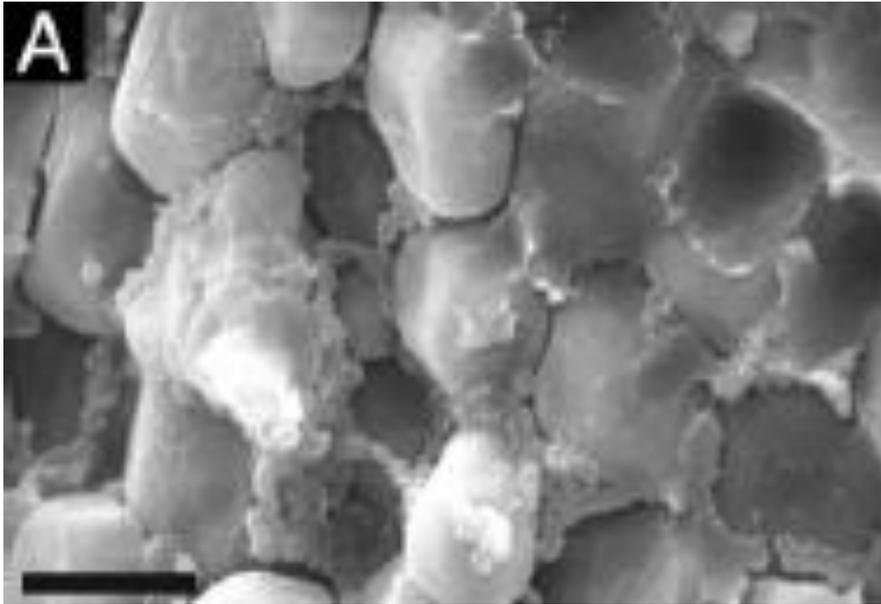


Germ

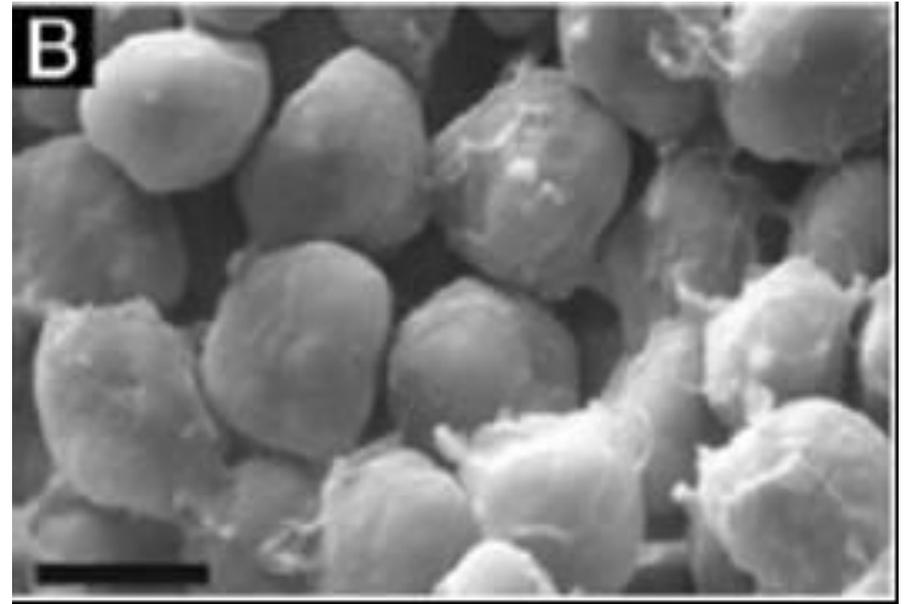


The Starch-Protein Matrix

Vitreous Endosperm



Floury Endosperm



Scanning electron microscopy of starch granules in corn: A) starch granules heavily imbedded in prolamin-protein matrix, B) starch granules in opaque corn endosperm with less extensive encapsulation by prolamin-proteins (Gibbon et. al., 2003).

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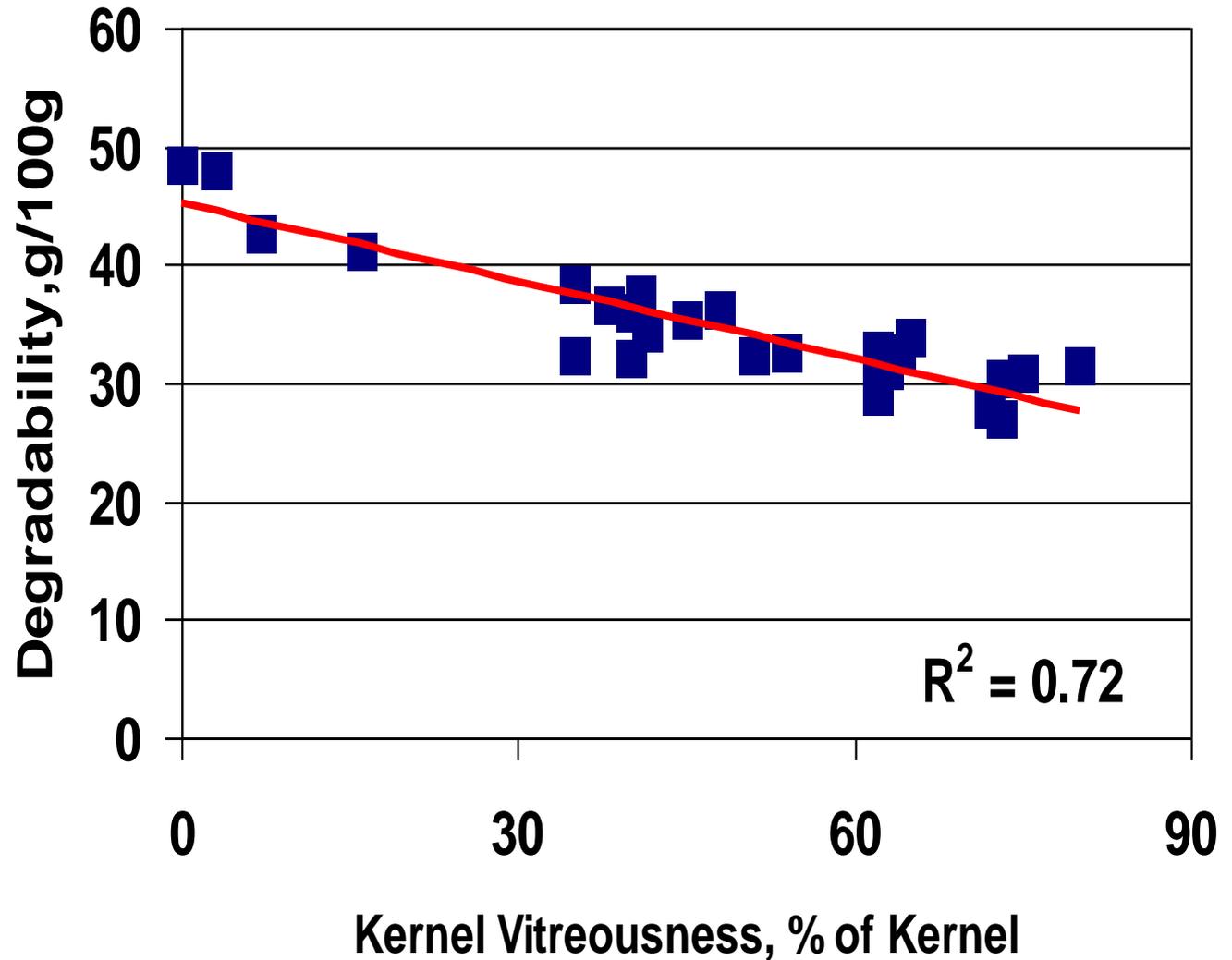
The Starch-Protein Matrix

- **Prolamin Zein (4 Types) – $\alpha\beta\gamma\delta$**
- **Form on the Starch Granule Surface**
- **Prolamin Proteins Can Cross-link**
- **Encapsulate Starch into a Matrix**

- *Degraded Via Fermentation*

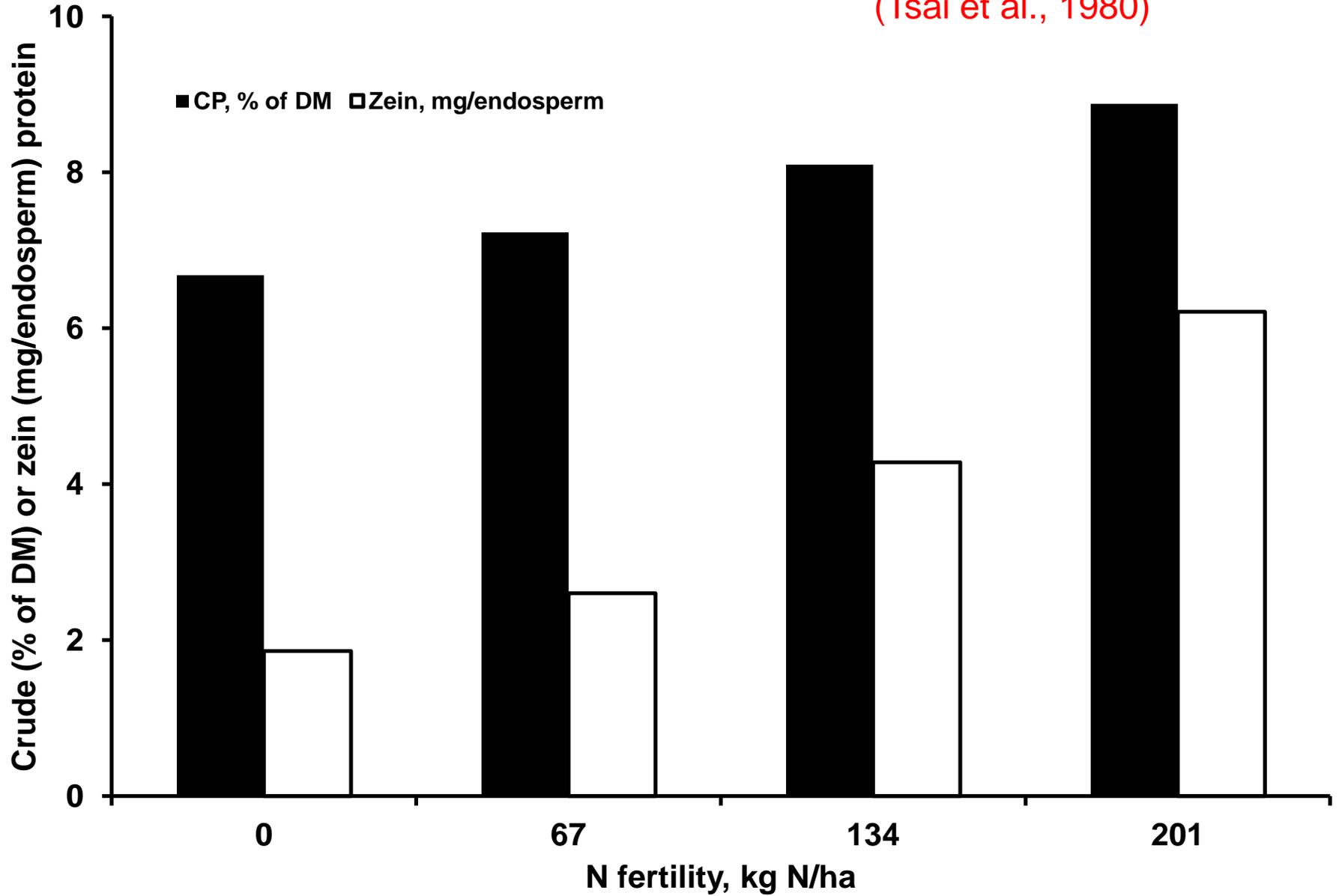
Increased Vitreousness Decreases Starch Degradability

Ngonyamo-Majee, et al., Anim. Feed Sci. Technol. 142:259-274.



Particle digestion resistance (PDR)

(Tsai et al., 1980)



Starch

Digestibility-Corn Silage

Maturity & Kernel Processing





Kernel Processing



Digestibility Responses to Kernel Processing

Total Tract % units for Processed minus control

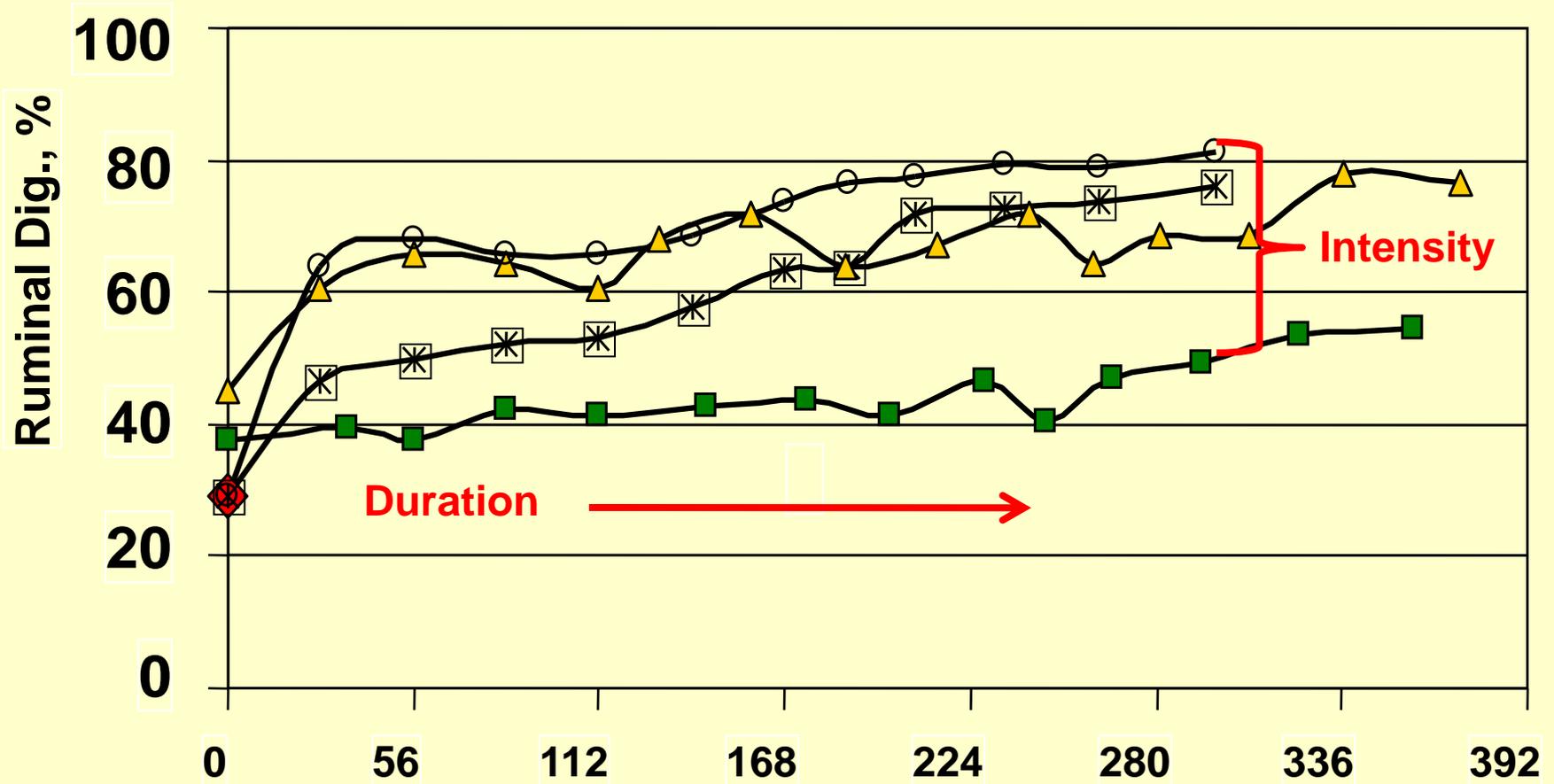
Trial	DMD	StarchD	NDFD
ISU	0	+5	-5
USDFRC ₁	NR	+3	-5
WI ₁	0	+4	-3
OSU	+2	+3	+2
WSU	0	+6	-3
USDFRC ₂	+4	+6	+3
WI ₂	0	+5	-9
USDFRC ₃	+4	+6	+3
GA-Tifton	+1	+6	...
DE	+10	+12	+9

Corn Silage Starch Digestibility Fermentation

Ruminal In situ starch degradability of corn silage over time in storage
Newbold et al., JDS, 2006 abstr.

	Starch	CP
Months in Silo	% Degradability	
2	53	39
4	54	36
6	59	34
8	64	43
10	69	47

Intensity and Duration Increases Starch Digestion in HMC



Benton et al., 2004
Univ. of Nebraska

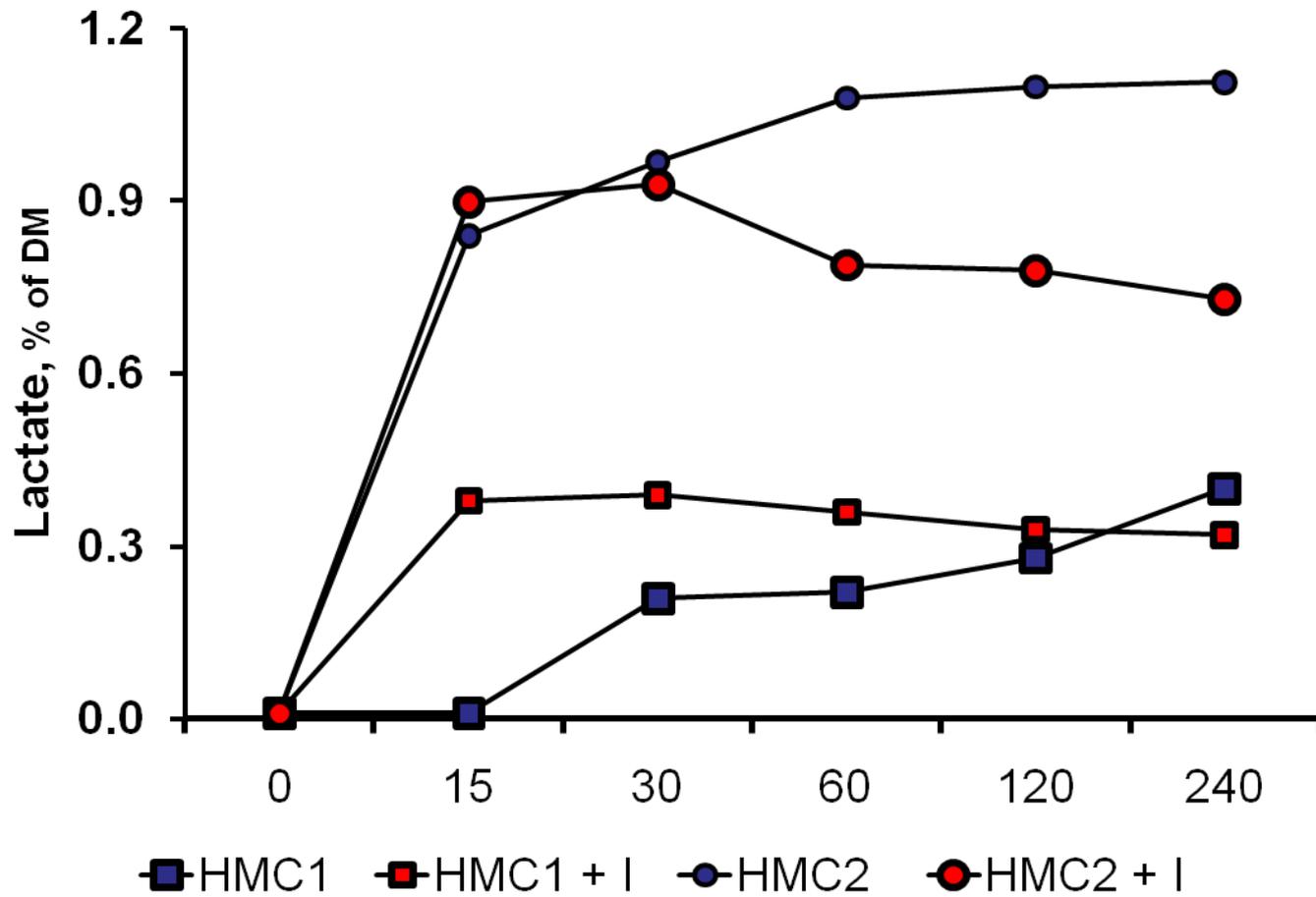
Ensiling Period (d)

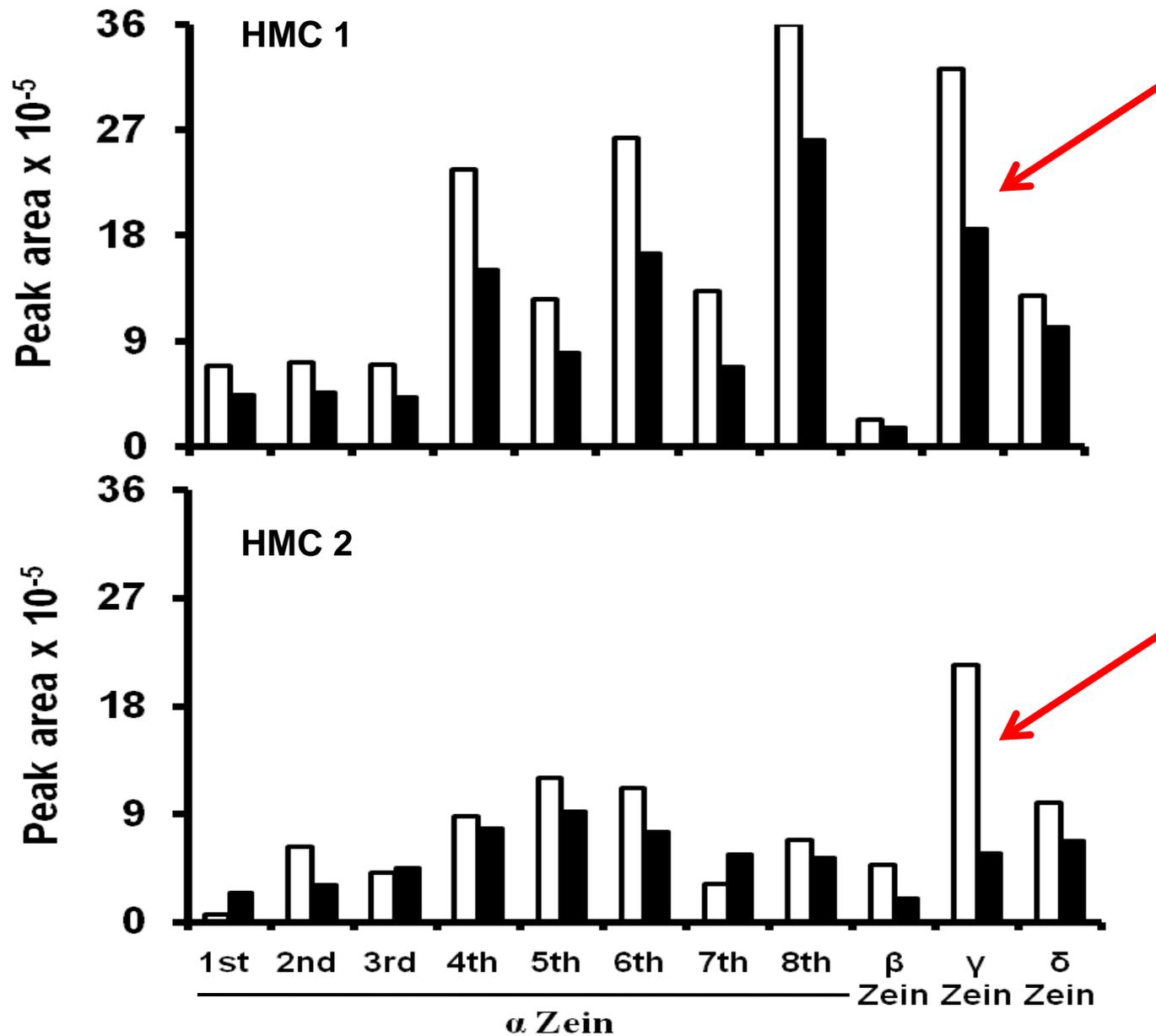
◆ DRC ■ 24 HMC * 28RECON ▲ 30 HMC * 35RECON

Hoffman et al., JDS 2011

Methods:

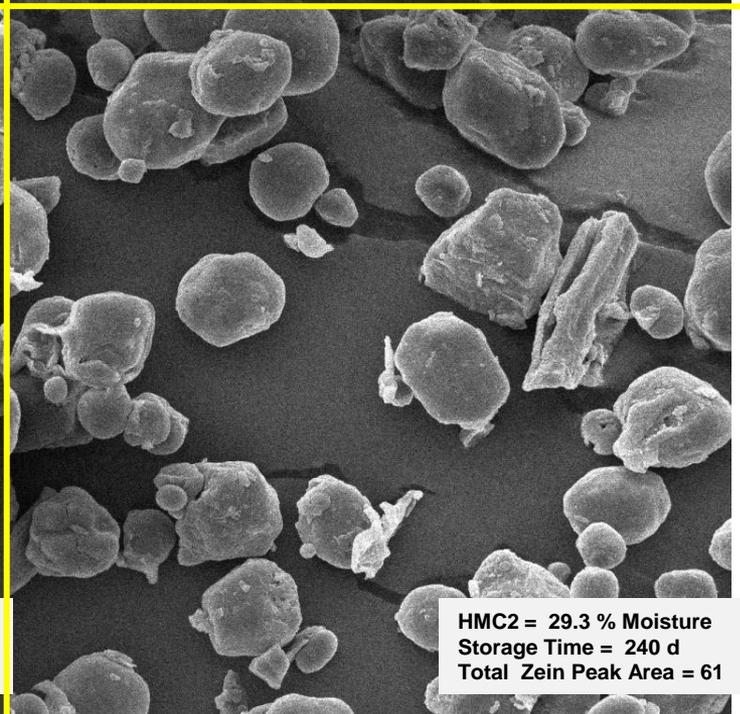
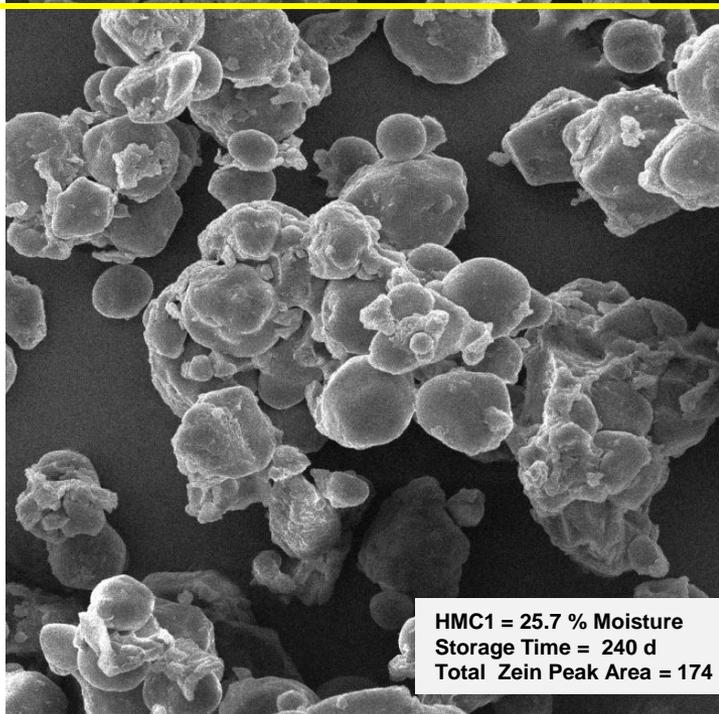
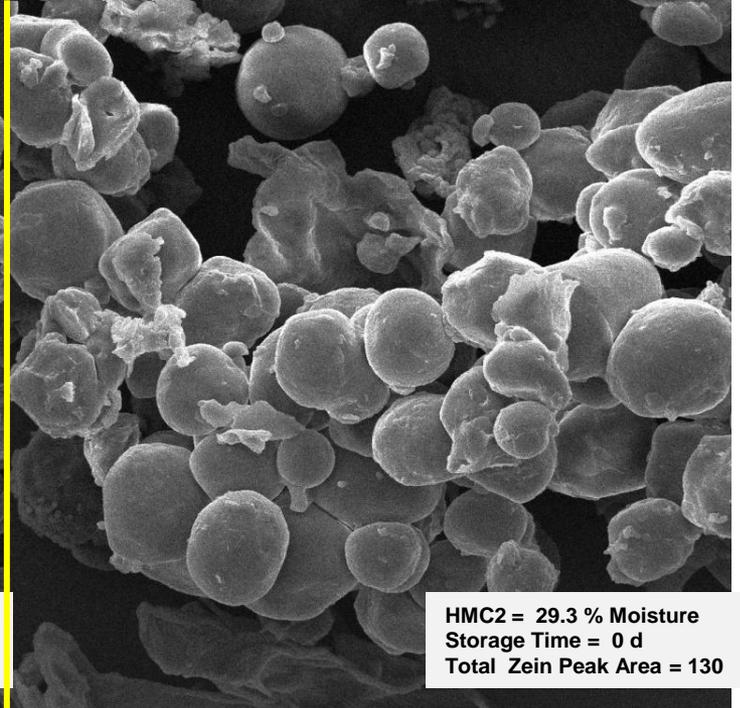
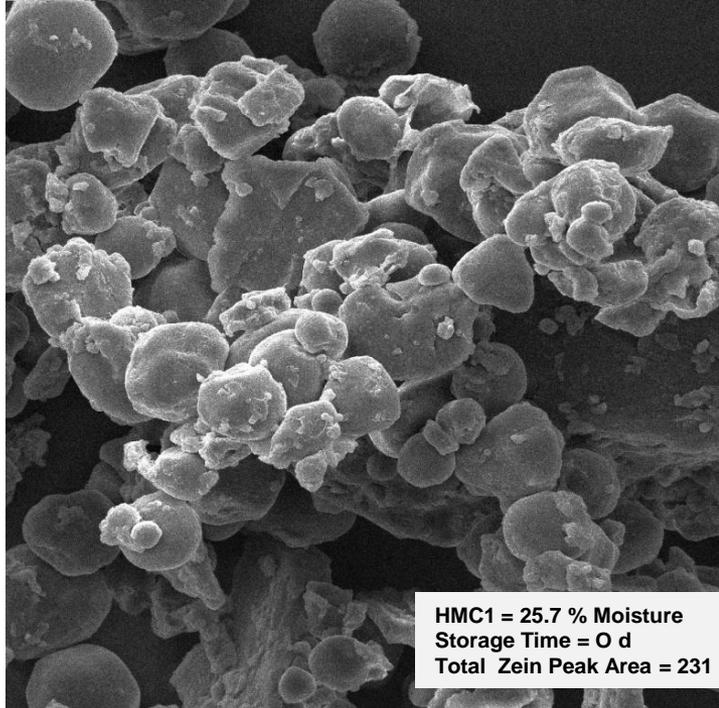
- 1) 2 random HMC (25.7 and 29.3 % moisture)
- 2) Treated with or without 600,000 cfu/g of *L. Buchneri* 40788
- 3) Ensiled in vacuum sealed plastic bags
- 4) Storage time = 0,15,30,60,120,240 d



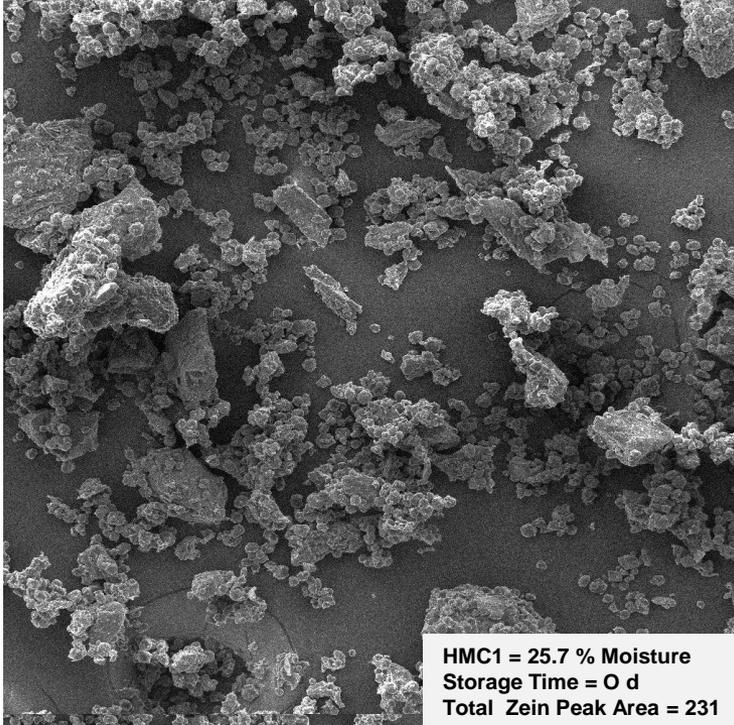


Electron Microscopy

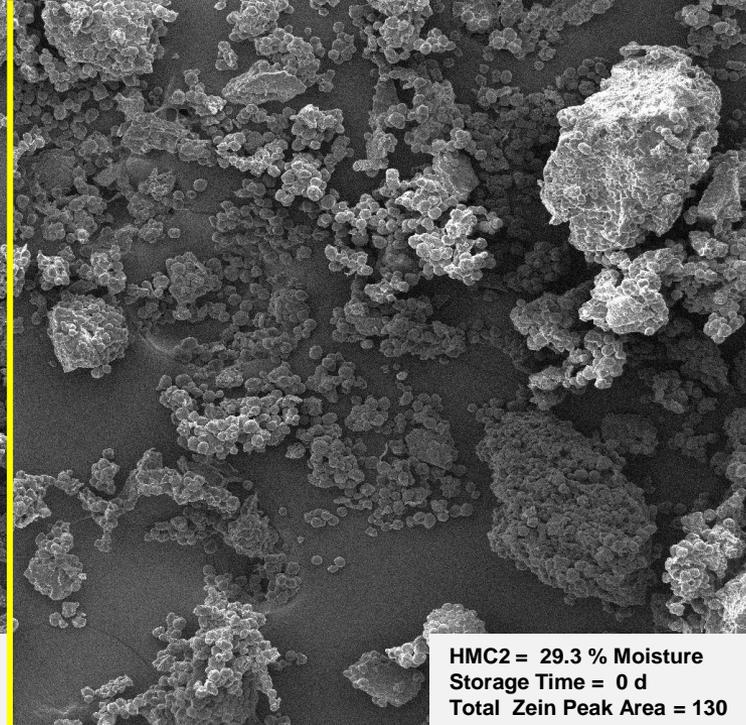
**High Moisture Corn
Electron Micrographs**



**High Moisture Corn
Electron Micrographs**

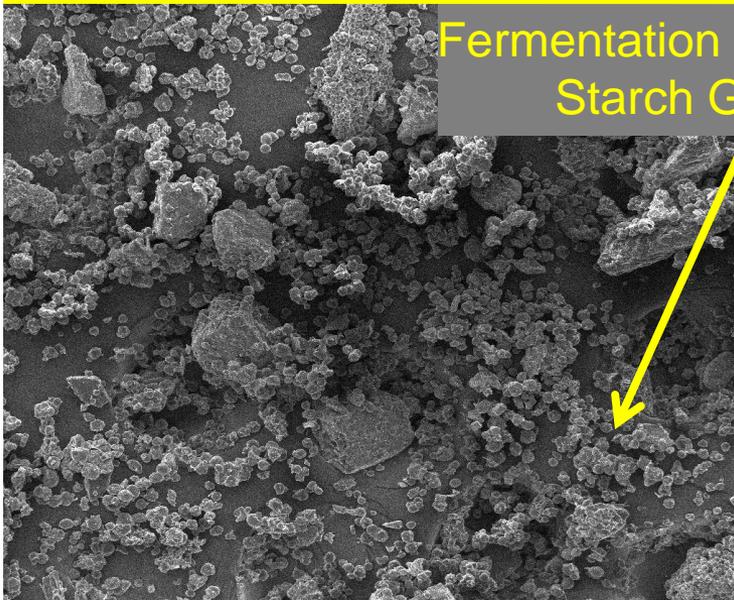


HMC1 = 25.7 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 231

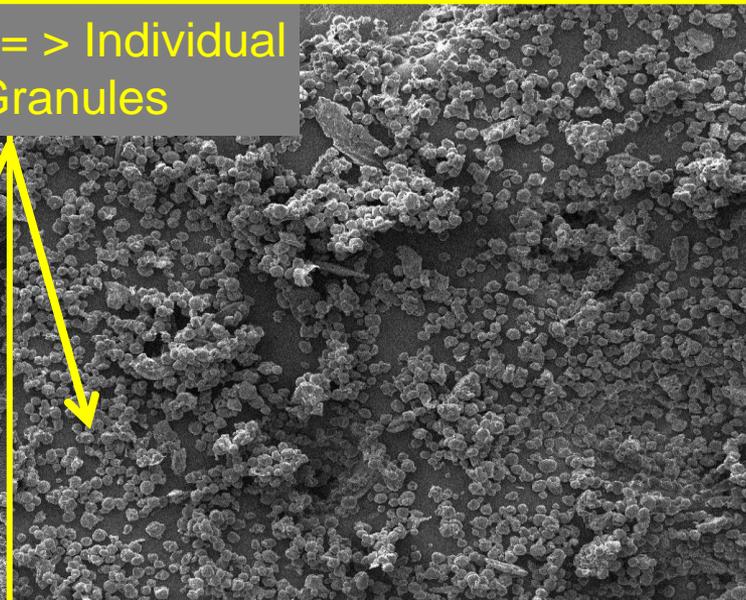


HMC2 = 29.3 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 130

**Fermentation = > Individual
Starch Granules**



HMC1 = 25.7 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 174



HMC2 = 29.3 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 61

Starch Digestibility and Fermentation

“ **A product of fermentation intensity and duration** ”

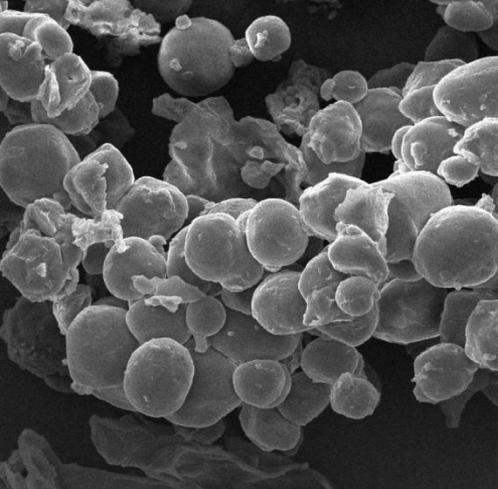
-Fermentation Intensity

- Moisture Content
- Temperature
- Bacteria
- Access to Endosperm Proteins (Processing)

-Duration

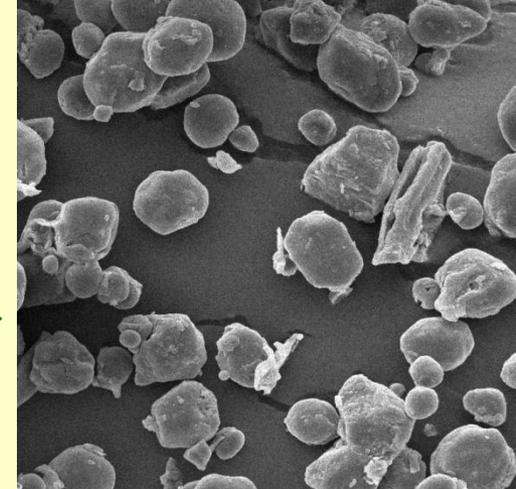
- Length of Ensiling Time
- Chronic Proteolytic Activity

Hoffman et al, 2011



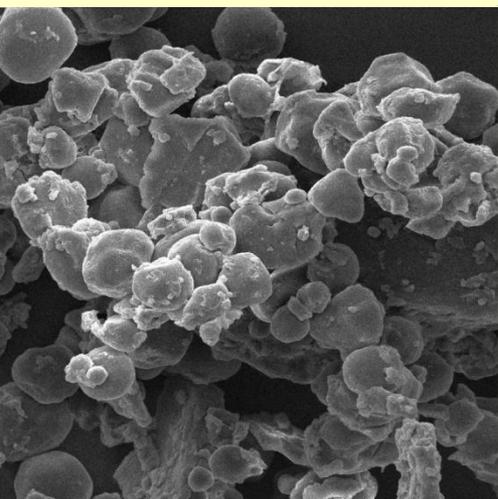
+

Prior to Ensiling

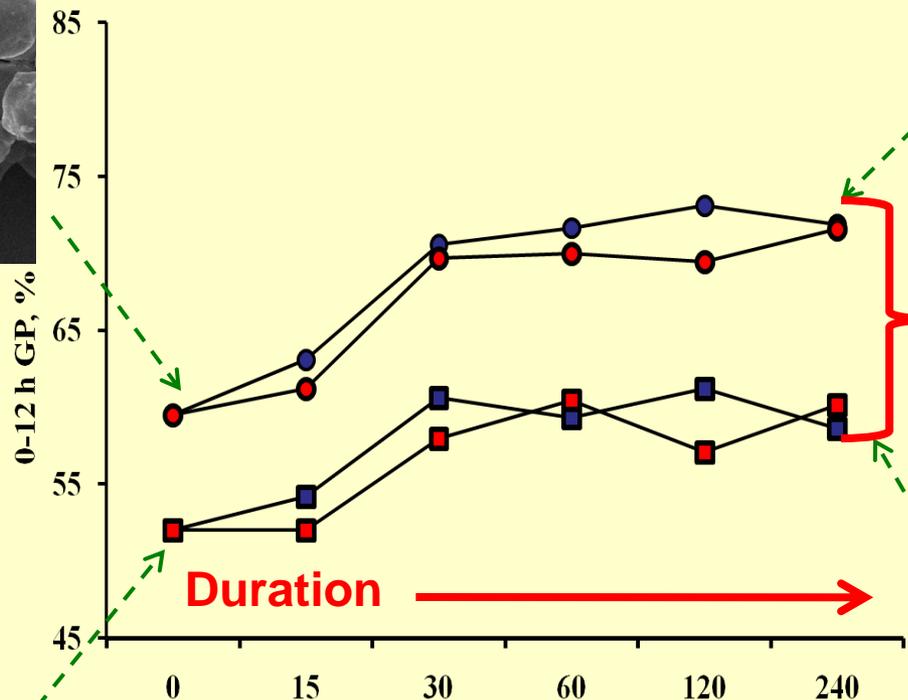


Intensity - - -

Ensiled 240 d



++

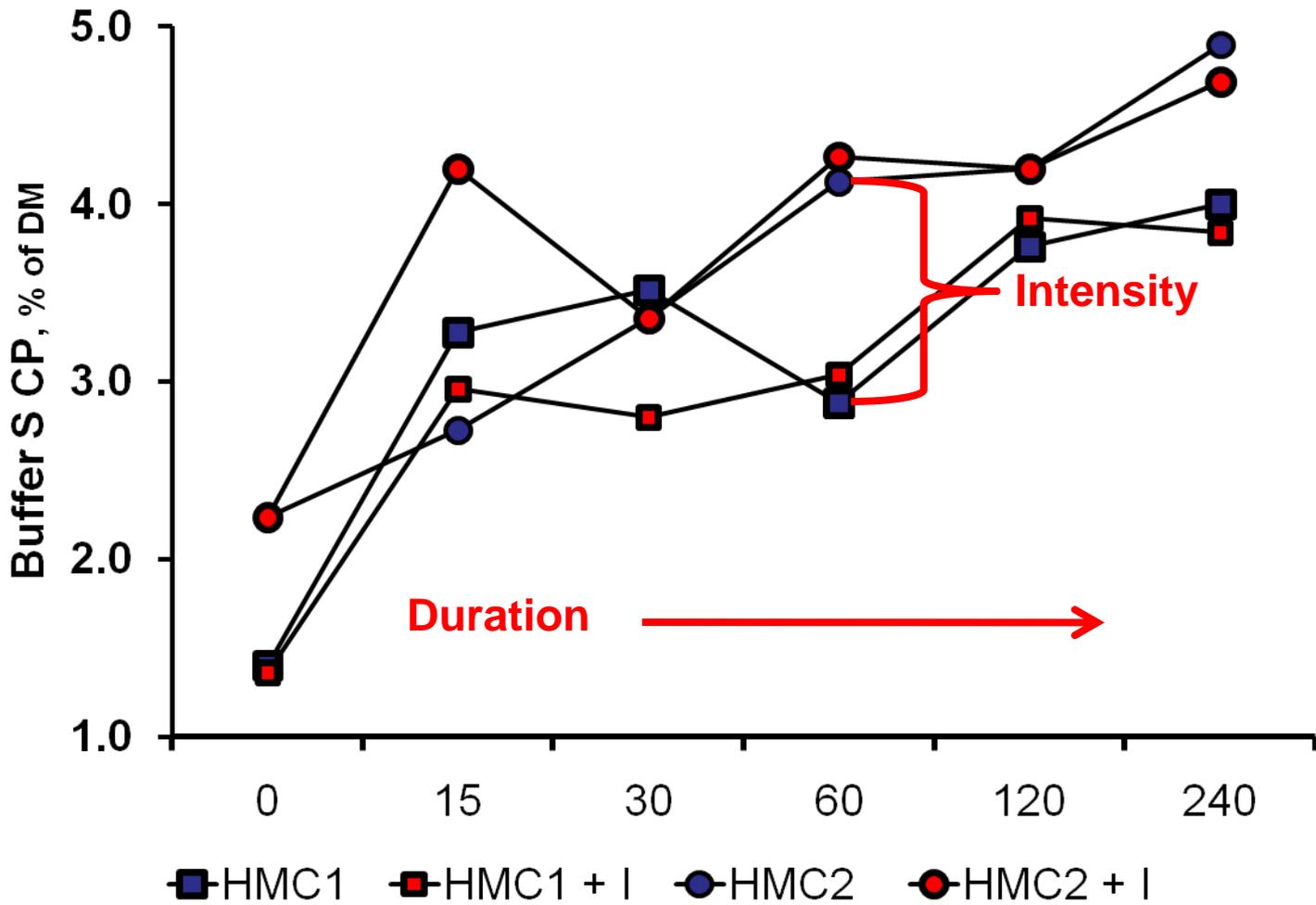


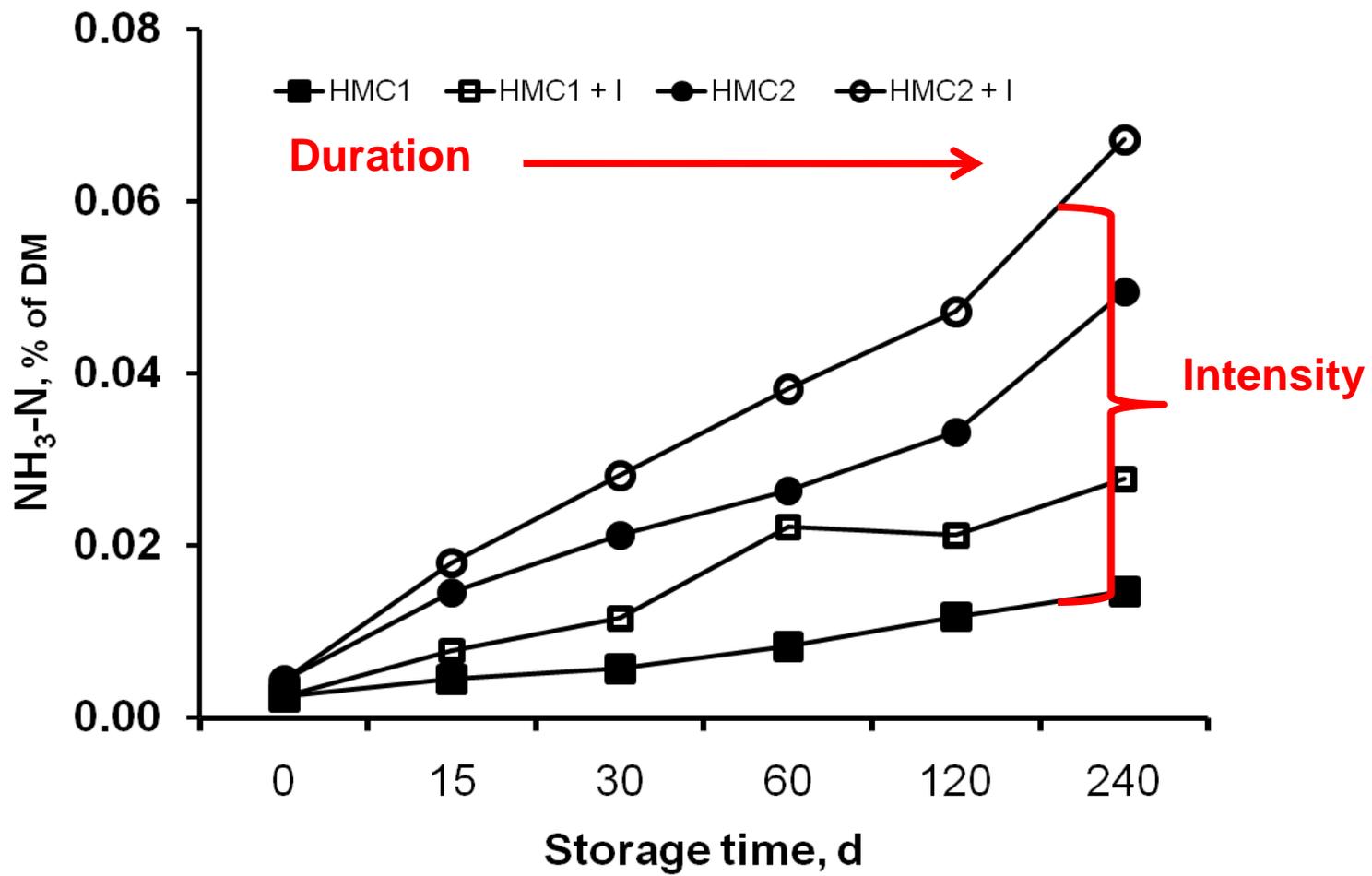
■ HMC1 ■ HMC1+I ● HMC2 ● HMC2+I

High Moisture Corn

Fate of Degraded Proteins =

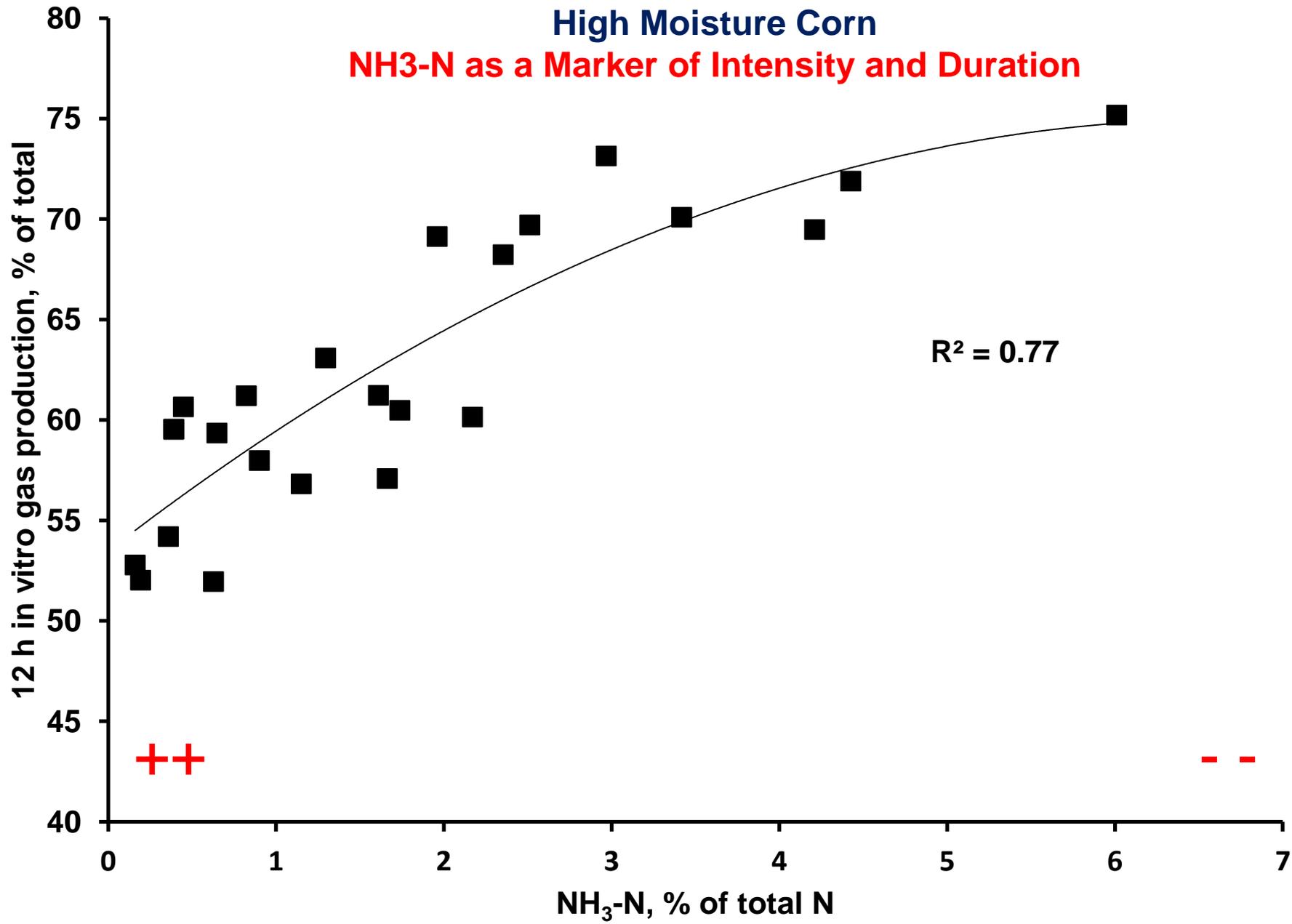
Markers of Fermentation Intensity and Duration





High Moisture Corn

NH₃-N as a Marker of Intensity and Duration



Corn Silage Starch Digestibility

Changing Definitions

Corn Silage Starch = Static, constant, fixed

Corn Silage Starch_v = Variable, change, moving

Evaluating Grain Quality: A Dairy Cow's Perspective

Grain Quality: Simple Test

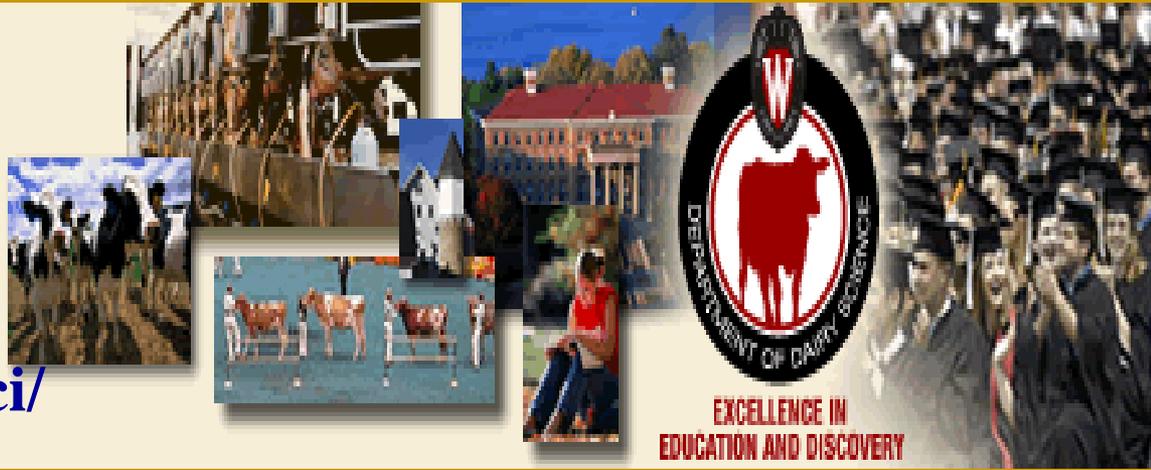
<i>Mean Particle Size</i>	<i>Dry and HMC</i>	<i>Surface area</i>
<i>Kernel Processing Score</i>	<i>Corn Silage</i>	<i>Surface area</i>
Vitreousness:	Dry Corn	+ PDR
Crude Protein:	Dry Corn	+ PDR
Prolamin Protein:	Dry Corn	+ PDR
Soluble Protein:	HMC Corn Silage?	- PDR
Ammonia Nitrogen:	HMC Corn Silage?	- PDR
Starch:	Dry&HMC&Corn Silage	Important
In Vitro Starch Digestibility:	Dry&HMC&Corn Silage	-+ PDR

PDR = particle digestion resistance



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