Grain and Kernel Particle Size
The Math

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1

The Universe Kernel Particle Size

Corn silage	HMC	Snaplage	Dry corn	MPS, *microns*
No processing				4000
				3800
				3600
				3400
				3200
				3000
Average processing	Coarse			2800
				2600
				2400
		Coarse		2200
				2000
Well processed	Medium			1800
		Medium		1600
				1400
	Fine	Fine		1200
			Coarse	1000
		Very fine	Medium	800
	Very fine		Fine	600
			Very fine	400
				200
				50
				25

2

Mean Particle Size

- ASAE Methods (2008)
- 14 Sieves + Pan
- Available @ Commercial Labs
- Shake 10 m + tapping

Surface Area: Can be different depending particle distributions!

American Society of Agricultural and Biological Engineers. 2008. Methods of determining and expressing fineness of feed materials by sieving. ASAE S319.4. St Joseph, MO.

Baker, S., and T. Herrman. 2002. Evaluating particle size: MF-2051. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS.

Caution: Determination of high moisture corn (wet) MPS results in a large overestimation of MPS (> 500 um)!

3

Kernel Processing Score
Mertens, USDFRC

- Ro-Tap Shaker
  - 9 sieves (0.6 thru 19 mm) and pan
  - Analyze for starch on 4.75 mm & > sieves

% of starch passing 4.75 mm sieve	KPS
>70%	Excellent
70% to 50%	Adequate
< 50%	Poor

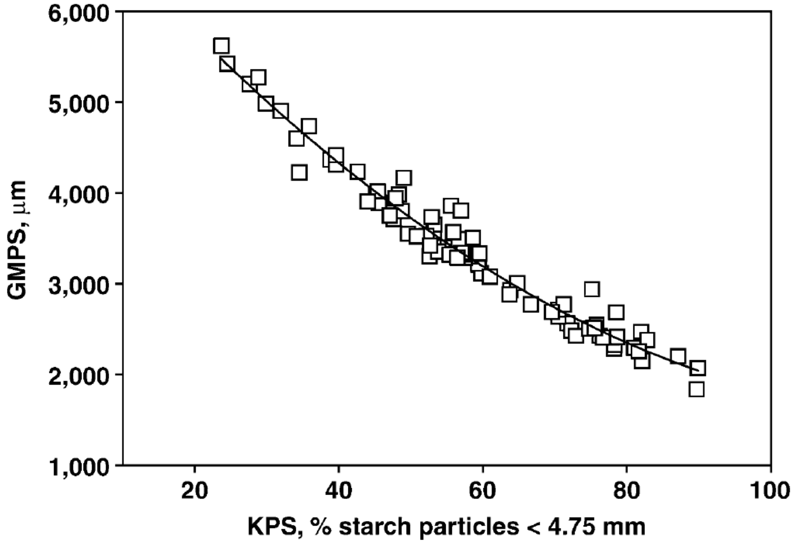
4

Kernels and Large Fragments Were Retained on > 4.75-mm Sieves

USDA-ARS US Dairy Forage Research Center

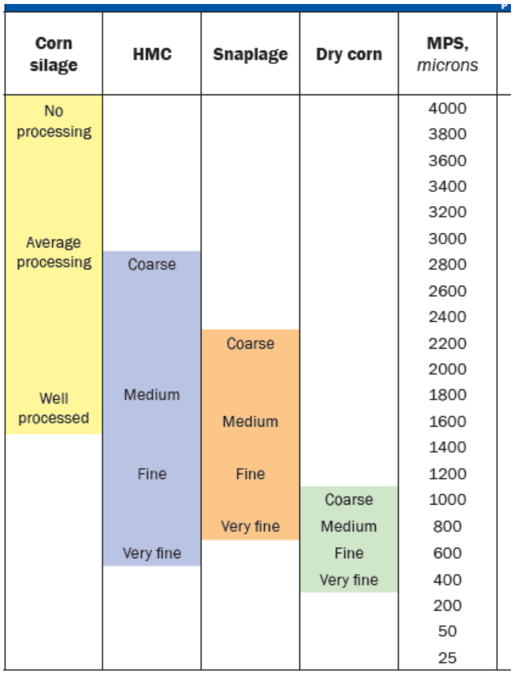
5

ZWALD ET AL.



6

The Universe Kernel Particle Size



7

Production Responses to Kernel Processing

- 10 publications with 18 treatment comparisons summarized
  - Average milk response of +0.80 kg/cow/day with a range of –1.2 to +2.0 kg/cow/day
  - Positive response in 14 treatment comparisons with an average milk response of +1.2 kg/cow/day and a range of 0.1 to +2.0 kg/cow/day

8

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

9

•Question

•How does kernel processing improve starch digestibility?

A - Smaller particles digest faster

B - Exposes starch to "particle decay" by silage bacteria

10

•Question

• Its B !

•How does kernel processing improve starch digestibility?

A - Smaller particles digest faster

B - Exposes starch to "particle decay" by silage bacteria

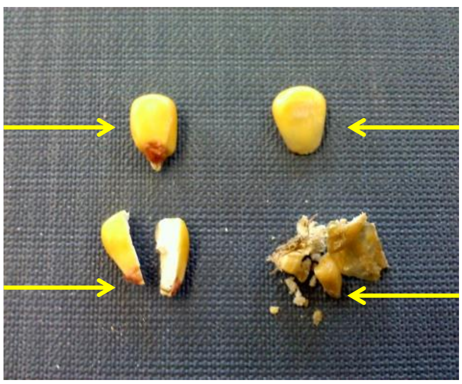
11

Effective Mean Particle Size (eMPS)

MPS is adjusted based on its bonding strength, Hoffman and Mertens, 2012.

A visual example

MPS = 4000 um
Dry corn
kernel



MPS = 4000 um
HM corn
kernel
(*prior to ensiling*)

4000 um are Effective

(after 1yr fermentation)

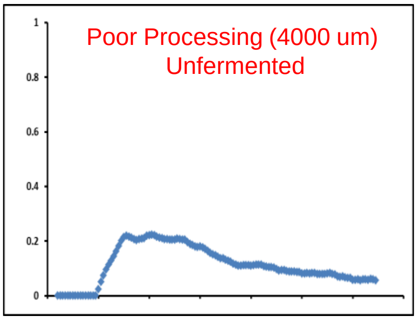
eMPS = 4000 um **eMPS = 320 um**

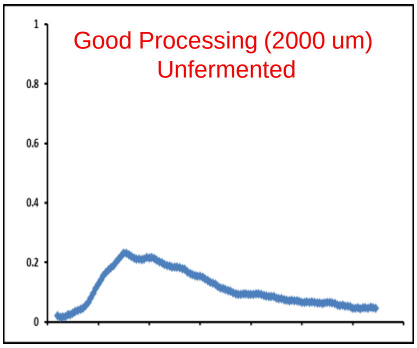
MPS means: The physical size of the particle
eMPS means: The dry corn equivalent particle size at which it ferments in the rumen

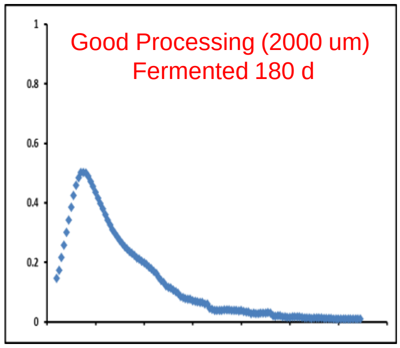
12

In vitro gas production
of corn kernels

Hoffman et al., 2012
unpublished





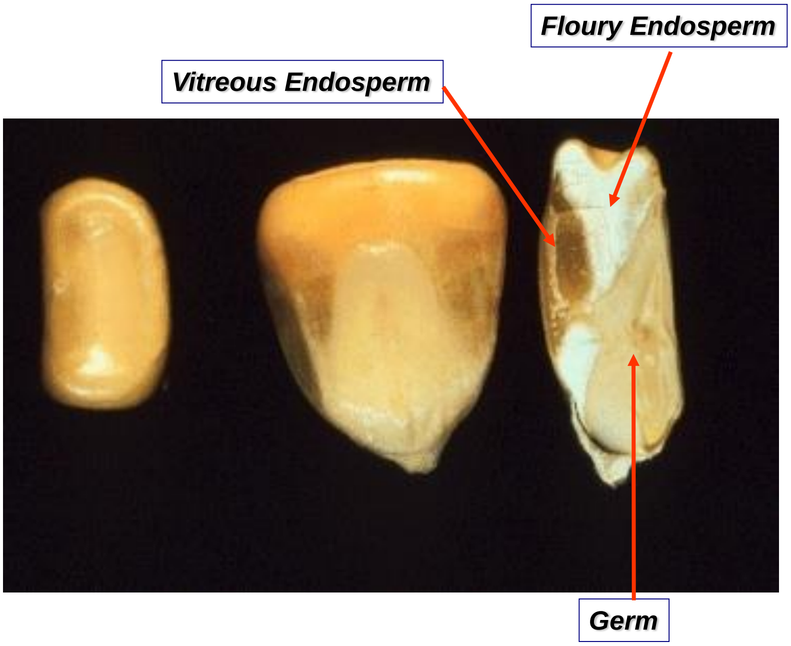


13

The Chemistry of Corn Digestion and Fermentation

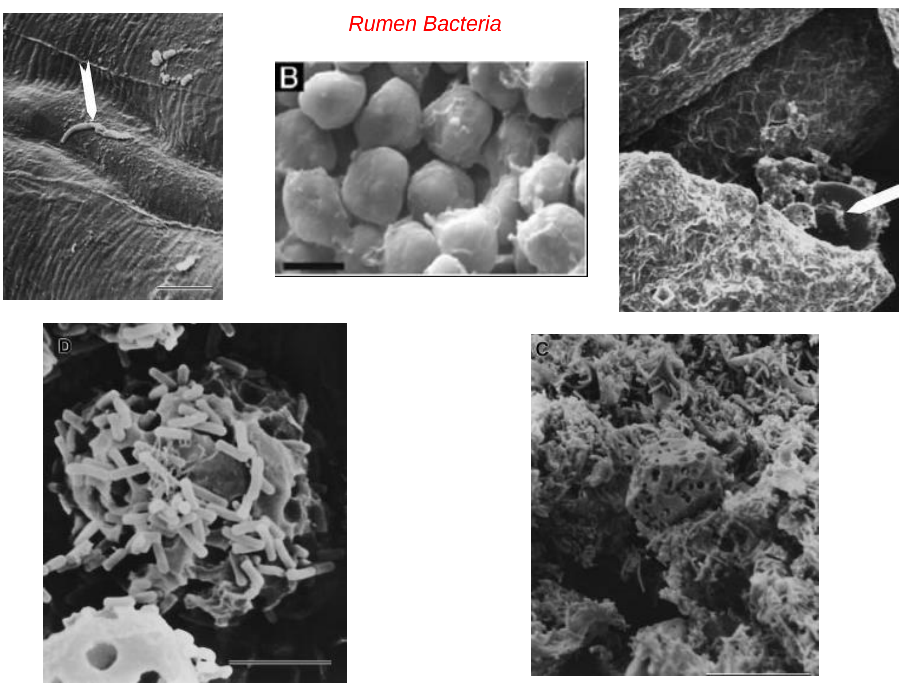
P.C. Hoffman*, R.D. Shaver and N.M. Esser**
Vita Plus Corp., Madison WI
University of Wisconsin-Madison

14



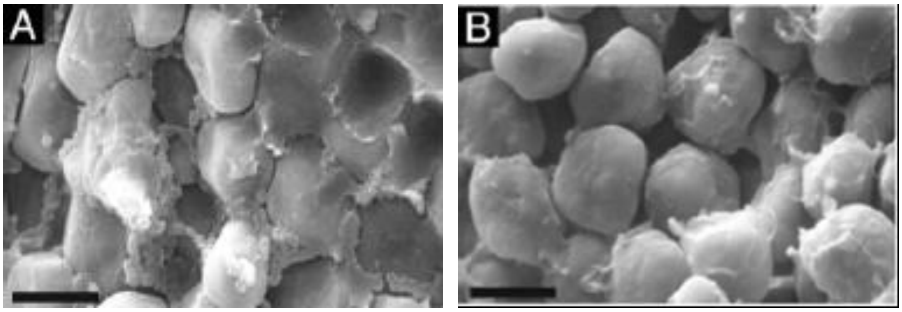
15

Rumen Bacteria



16

Why proteins are so important to measure in feed grains



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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17

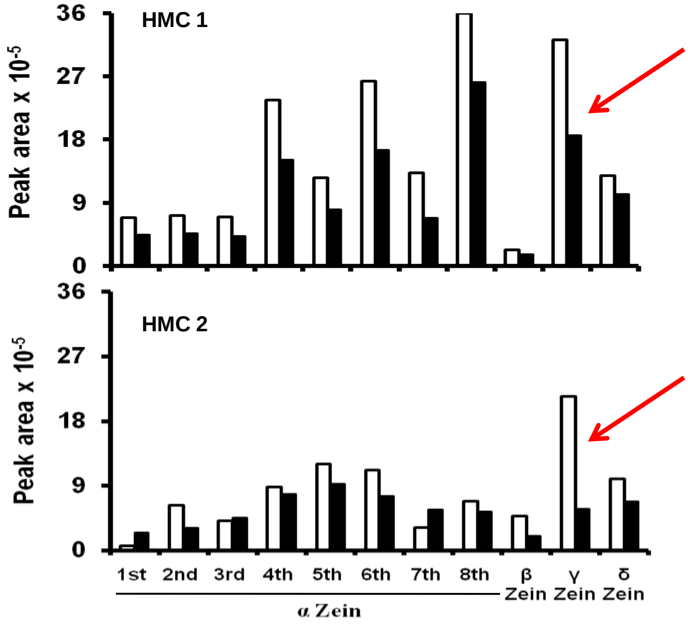
The Starch-Protein Matrix in Corn

- **Prolamin Zein (4 Types) – άβγδ**
- **Form on the Starch Granule Surface**
- **Prolamin Proteins Cross-link**
- **Hydrophobic (not soluble in rumen fluid)**
- **Mitigated in the Van Soest Fiber System (SDS)**
  - ***Sorghum = kafrin***
  - ***Corn = zein***
  - ***Wheat = gliadin***
  - ***Oats = avenin***
  - ***Barley = hordein***

Concentration in grains is a function of germination temperature (seeds)

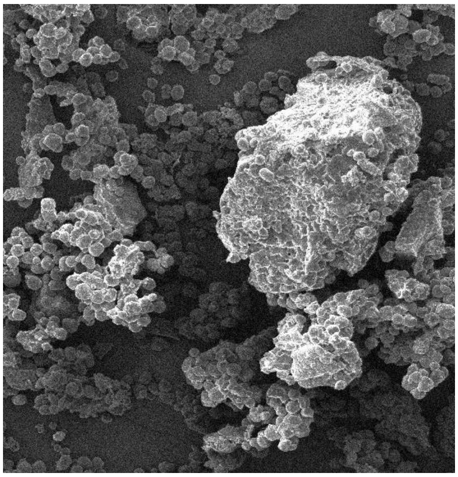
18

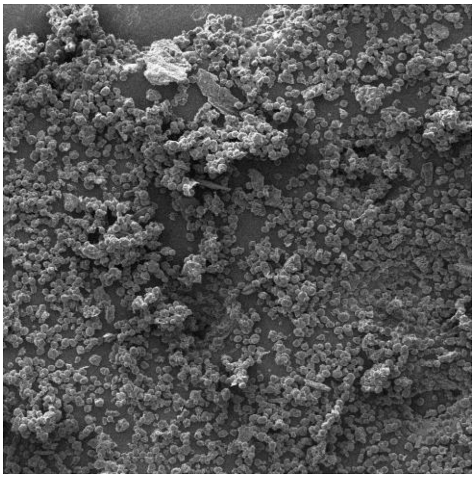
Quantitative HPLC – Bietz, 1983.



19

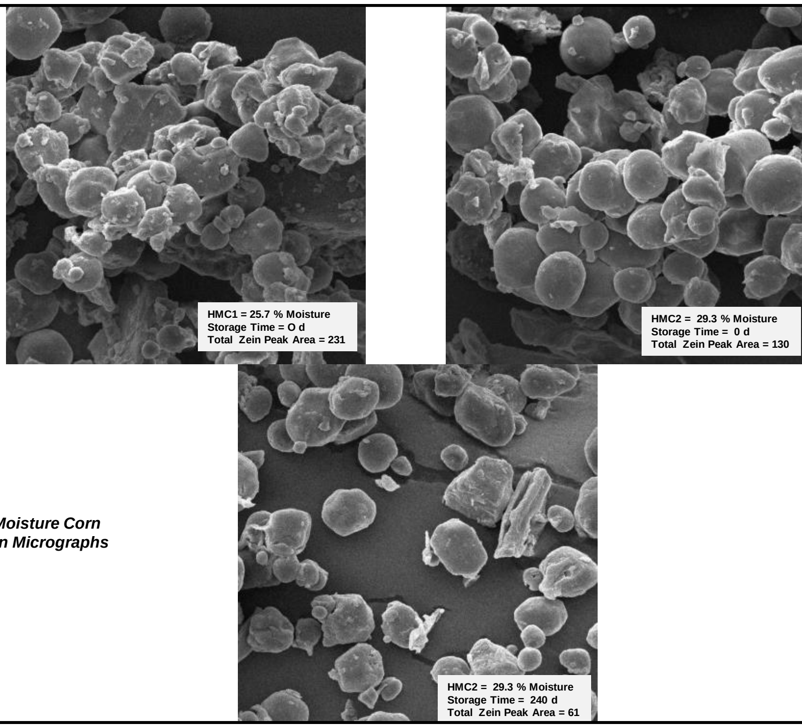
Particle Decay – Electron Microscope (Hoffman et al., 2010)



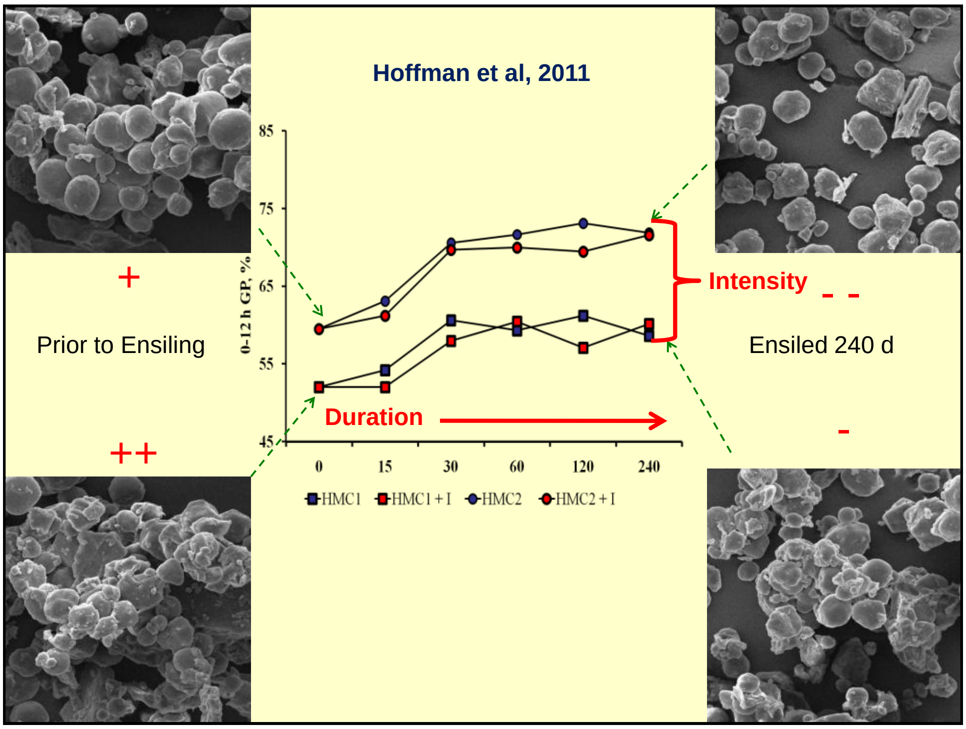


20

High Moisture Corn Electron Micrographs

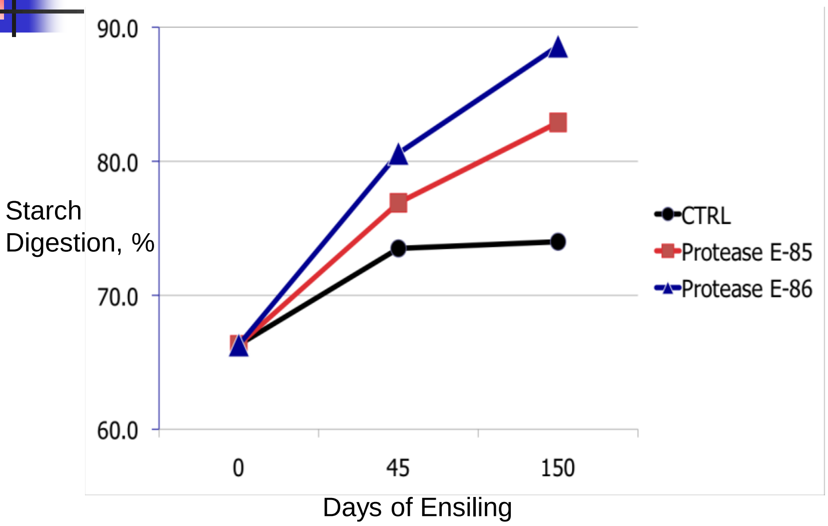


21



22

Addition of Experimental Proteases Improve In Vitro Ruminal Starch Digestion in the Silo



23

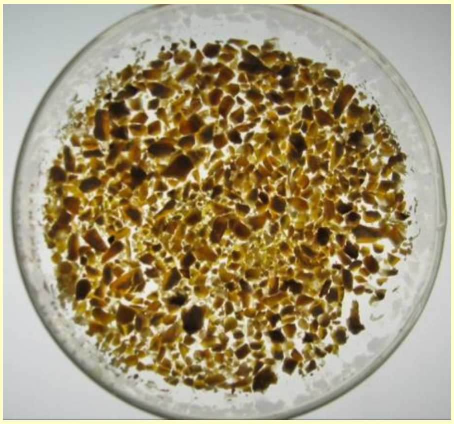
24

Differences in Starch Particle Decay (Same Hybrid)

Snaplage | **HMC**

Ammonia = 6.0% of CP
Kernel MPS = 1456 µ

Ammonia = 1.8% of CP
MPS = 1335 µ

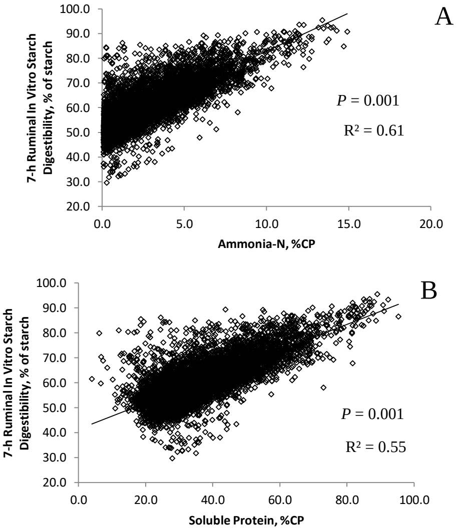


0 % translucent | 80 % translucent

25

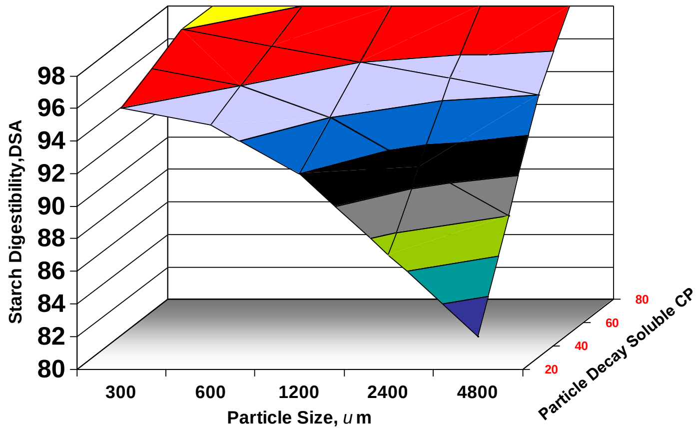
Soluble Protein, % of CP (Krishnamoorthy, et al., 1983)
NH3-N, % of total N, (NH3-N probe, Kjedahl, NIRS, etc)

Markers of Particle Decay in Corn Silage



26

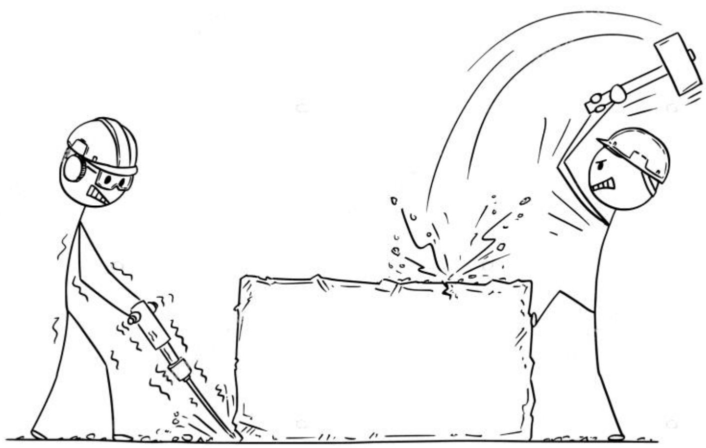
Theoretical Relationship
Between Corn Particle Size, Particle Decay (Soluble CP)
and Starch Digestibility



27

Fermentation

Kernel Processing



28

Take Home Messages -In Field Processing

Particle Size Suggestions					
Corn Silage	**HMC**	**Snaplage***	**Dry Corn**	**CSPS****	**MPS, microns**
					4000
< 30 Dry Matter				**60**	3800
					3600
					3400
					3200
					3000
35 % Dry Matter	**> 40 Moisture**			**70**	2800
					2600
					2400
		> 40 % Moisture			2200
					2000
40 % Dry Matter	**35 % Moisture**	**35 % Moisture**		**80**	1800
					1600
		30 % Moisture			1400
	30 % Mositure				1200
					1000
					800
	25 % Moisture				600
			Very Fine		400
					200
					50
					25

*** Due to husk and cob inclusion, requires finer processing to aid packing in the silo.**
**** Corn silage only**

29

30