Impact of Processing and Genetics on Starch Digestibility

2012 VSFA / Cow College

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Factors Affecting Starch Digestion In Cattle

- Endosperm/Genetics - How "vitreous"
- Harvest and storage
  - Maturity
  - Moisture
  - Particle size
  - Heat (interaction with moisture)
  - Enzyme use
- Processing
  - Particle size

Starch availability in corn silage

(Hoffman, 2008)

Factor	Correlation with starch availability
Particle size	**-0.70**
Moisture	**-0.53**
Endosperm type	**-0.46**

Grain particle size > Grain/silage moisture > Endosperm type

The Problem

- How to characterize starch particle size
- How to characterize starch digestibility
- How to bring digestibility and particle size relationships together
- How to turn lab assays into routine commercial evaluations
- How to interpret results

The Problem

- To test it by invitro, we generally must process it, so:
  - Remove some but not all of the particle size effects from the original sample
  - We are attempting to look at vitreous characteristics
  - But vitreousness will impact how it grinds and the resulting particle size
  - So, we can't really standardize particle size when grinding…

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The Problem

- When we test for Starch Digestibility by in vitro, it is on sample milled to a certain size
- Particle size differences impact the digestibility results
- When attempting to establish an NIR equation for starch digestibility, you end up calibrating more on particle size than vitreousness.
- NIR evaluations of unknown samples are impacted by the grind of the sample presented to the NIR…

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The Problem

- We need a reliable surrogate measurement of starch degradability in the rumen
- There are different approaches
  - *In situ*
  - *In vitro*
  - Gas production
  - Enzymatic

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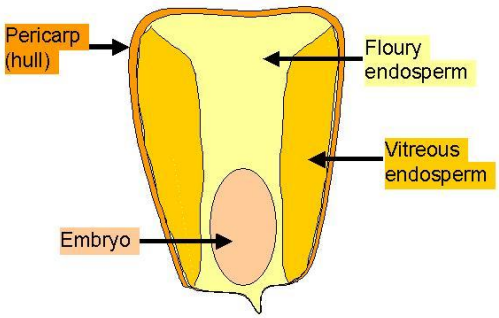

Lutz, 2007

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Corn Prolamin Content Classifications

Prolamin % of Starch	Classification
>10.0	Extremely High
10.0	
9.0	Very High
8.0	
7.0	High
6.0	
5.0	Moderate
4.0	
3.0	Low
2.0	
< 2.0	Very Low

Hoffman & Shaver, 2009

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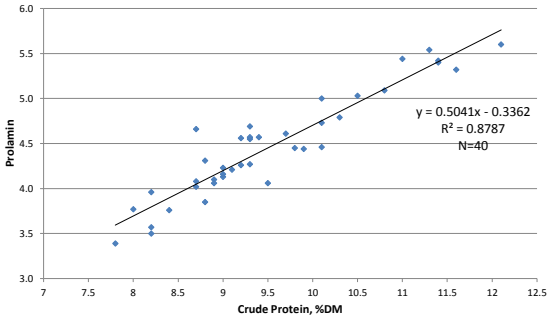
Relationship between Crude Protein and Prolamin in Corn Grain
CVAS, 2011



Starch Digestibility of Corn
Knowlton et al., JDS, 1998

	Dry Ground	Dry Rolled	HMC Ground	HMC Rolled
DM %	85	85	70	70
MPS microns	618	1725	489	1789
Ruminal Starch D, %	61	69	87	81
TT Starch D, %	89	76	98	96

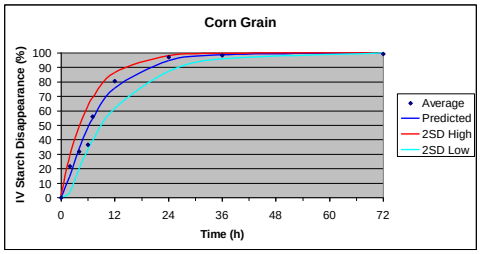
Published Digestibility Coefficients for Starch Huntington, 1997

			Digestibility			
			Rumen	Postrumen		Total
Grain	Processing[a]	Starch intake, kg/d	% Intake	% Intake	% Entering	tract, %
Corn	DR	2.06 ± 1.08	76.2 ± 7.9	16.2 ± 6.7	68.9 ± 18.4	92.2 ± 3.0
	SF	2.20 ± .52	84.8 ± 4.1	14.1 ± 3.7	92.6 ± 4.1	98.9 ± 0.8
	SR	6.91	72.1	19.0	68.2	91.2
	HM	3.89	89.9	6.3	67.8	95.3
	G	10.65	49.5	44.0	86.5	93.5
Sorghum	DR	4.81 ± 1.49	59.8 ± 12.0	26.1 ± 11.4	62.5 ± 16.2	87.2 ± 5.4
	SF	4.78	78.4	19.6	89.9	98.0
	HMG	3.64	73.2	19.6	46.1	92.8
	G	3.81	70.0	15.4	51.0	91.0
Barley	DR	4.09 ± 1.74	80.7 ± 3.9	13.7 ± 3.8	75.2 ± 5.2	94.3 ± 2.9
	SR	4.53	84.6	13.6	88.0	98.2
Wheat	DR	2.94	88.3	9.9	85.4	98.2
	SR	2.87	88.1	10.0	88.2	98.6
Oats	DR	1.53	92.7	5.6	76.3	98.3
	SR	1.49	94.0	4.5	78.8	98.8

[a]DR = dry-rolled; SF = steam-flaked; HM = high moisture; G = ground; SR = steam-rolled.

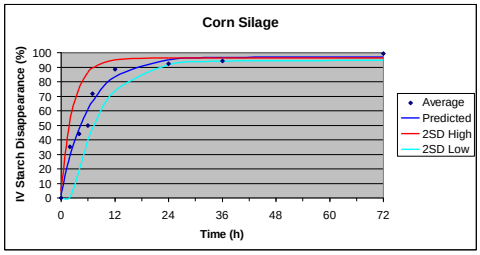
In Vitro Starch Disappearance

- Corn grain IVSD kd varied from .09% to .16%/h

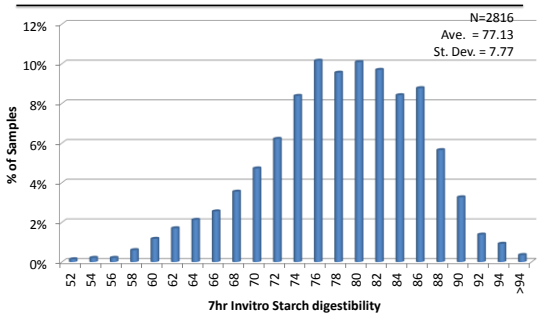


In Vitro Starch Disappearance

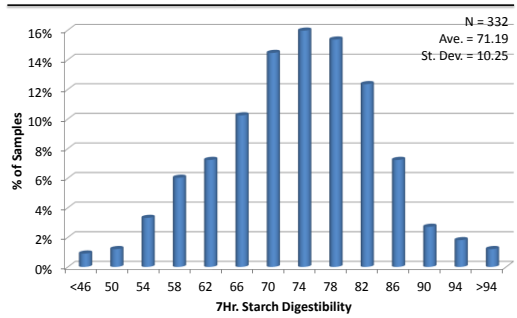
- Corn silage IVSD varied from .16% to .37%/hr



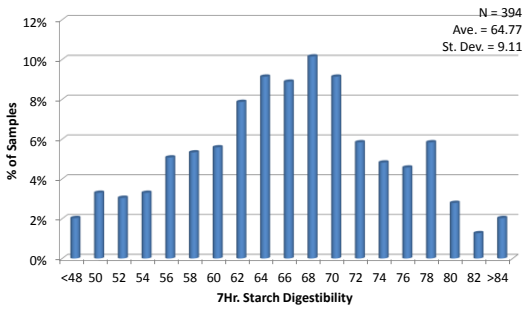
7 Hour In Vitro Starch Digestibility of Corn Silage, CVAS 2010-2011



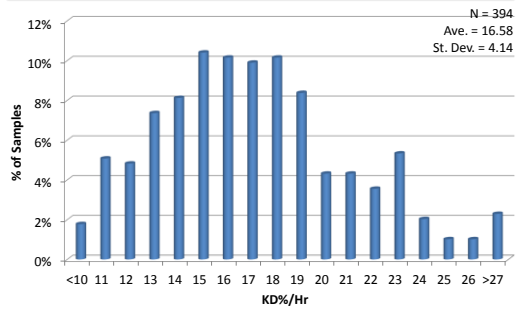
7 Hour In Vitro Starch Digestibility for HM Corn Grain (CVAS, 2011)



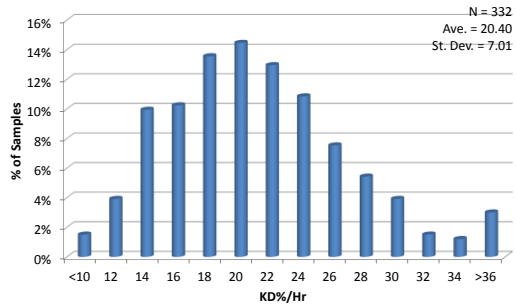
7 Hour In Vitro Starch Digestibility for Dry Corn CVAS, 2011



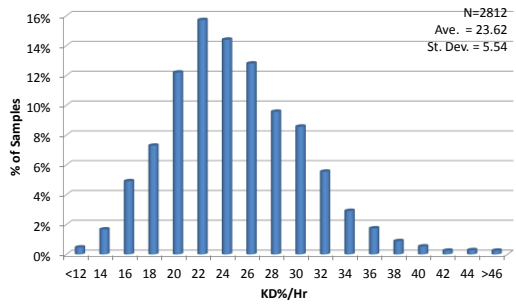
Dry Corn Starch KD%/Hour CVAS, 2011



Corn Grain Starch KD%/Hour CVAS, 2011



Corn Silage Starch KD%/Hour

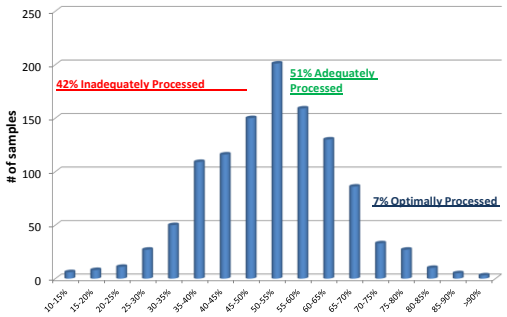


Ruminal Digestibility of Starch [kd/(kd+kp)]

	Kd %hr						
Kp %hr	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.3**	**0.35**
0.02	0.714	0.833	0.882	0.909	0.926	0.938	0.946
0.04	0.556	0.714	0.789	0.833	0.862	0.882	0.897
0.06	0.455	0.625	0.714	0.769	0.806	0.833	0.854
0.08	0.385	0.556	0.652	0.714	0.758	0.789	0.814
0.10	0.333	0.500	0.600	0.667	0.714	0.750	0.778
0.12	0.294	0.455	0.556	0.625	0.676	0.714	0.745
0.14	0.263	0417	0.517	0.588	0.641	0.682	0.714
0.16	0.238	0.385	0.484	0.556	0.610	0.652	0.686
0.18	0.217	0357	0.455	0526	0.581	0.625	0.660
0.20	0.200	0.333	0.429	0.500	0.556	0.600	0.636

Rotap shaker showing 4.75mm screen and corn

Corn Silage Processing Score, 1131 Samples, CVAS 200 - 2011

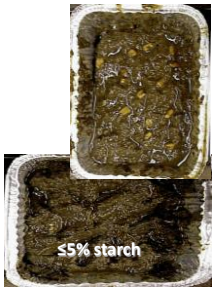


Assessing Physical Form of Corn Silage

- CSPS = % starch passing through 4.75-mm screen
  - >60-70% = optimal processing
  - 50-60% = average
  - <50% = inadequate (too coarse)
- May need to adjust ration formulation if CSPS much greater than 70% or less than 50%

Optimizing Corn Silage Starch Digestion

- ~3/4-in TLC, 2-3 mm roller clearance
- All kernels crushed, especially silage >33% DM
- Penn State Particle Separator
  - 10-15% top screen
  - 50+% second screen
  - <35% pan
- Corn silage processing score
  - % starch passing through 4.75-mm screen
  - ~70%

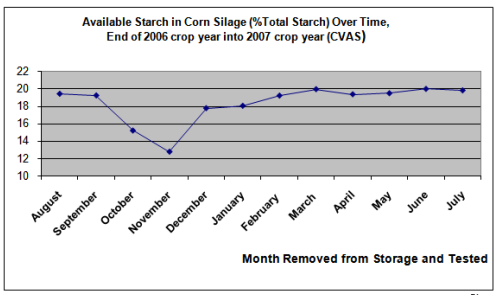


Sieves used In Micron Particle Size Evaluation of Corn Grain

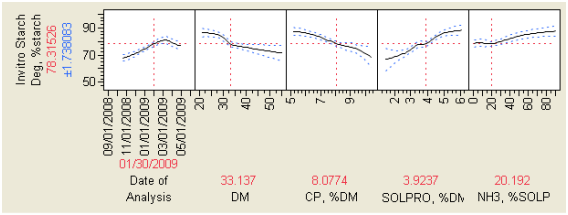
Table 1. Comparison of Tyler and USA sieve numbers

Opening in microns	Tyler Number (meshes/inch)	USA Number
3360	6	6
2380	8	8
1680	10	12
1191	14	16
841	20	20
594	28	30
420	35	40
297	48	50
212	65	70
150	100	100
103	150	140
73	200	200
53	270	270

Starch availability over time



Factors affecting corn silage starch degradability



CVAS Database

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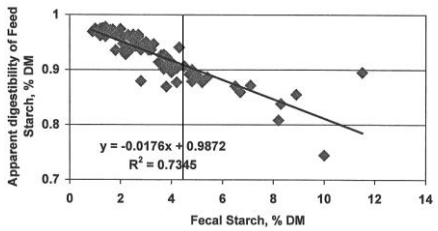
Fecal starch and digestibility



- **4.5% fecal starch ~ 90% starch digestibility**
- **1%-unit decrease in fecal starch ~ 1 pound more milk**

(Ferguson, 2006)

Fecal Starch

- Less than 3%, probably OK
- 4.5% relates to 90% total tract digestibility
- If more than 5% fecal starch, the possible problems
  - Check particle size of grains
  - Check processing of grain in corn silage
  - Consider total starch level in the ration
  - Consider reasons that rumen function may be less than optimal

Fecal Starch

- CVAS working on improved assay for estimating total tract Starch and NDF digestibility in a herd
- Apparent digestibility concept
- Will utilize indigestible NDF as a marker to relate intake starch and recovered starch for computation
- Adapting concept to NIR analysis
- Summer 2012

What Does This Mean to Me ?

- Characterize starch digestibility in feeds
  - Is it fermented, if so then how long?
  - Is it particularly wet or dry material?
  - How well processed is the corn silage grain?
  - How well processed are the other grains in the ration?
  - How mature is the corn?
  - What corn genetics were used?

Where does the lab fit in ?

- Use the corn silage processing score to benchmark processing of crop
- Evaluate particle size of grains for adequate processing
- NIR can provide qualitative evaluation of vitreousness of corn
- Possible evaluation of in vitro starch digestibility in problem situations or for bencharmarking

Where does the lab fit in ?

- Watch for new approach to characterizing starch digestibility:
  - Invitro is difficult to run and standardize
  - Prolamin may relate to dry corn digestibility
  - Ammonia level may relate to high moisture corn digestibility
    - Will this be adaptable to corn silage?

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