
Corn Silage
Managing the Manageable
from Field to Feedbunk
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Plant
Grow
Harvest
Store
Feed
The Silage Zone


Why Do We Grow Corn Silage?
DM Yield
Starch Content
Fiber Digestibility

Management

Planting Date/Practices
–
Harvest Maturity
–
Chop Height
–
Kernel Processing
–
Ensiling
–

FACTORS INFLUENCING CORN SILAGE YIELD, STARCH and NDFD

Environment

Water – Light – Heat
Soil – Drainage – Fertility
Field History – Disease/Pests

Let's discuss which of these factors we <u>can</u> and <u>cannot</u> control

Genetics

BMR vs. Standard Hybrids

Factors Influencing Corn Silage Value

<u>Yield</u>	<u>% Starch</u>	<u>Fiber Dig</u>
Growing Environment	Growing Environment	Growing Environment
Hybrid Genetics	Hybrid Genetics	Hybrid Genetics - BMR
Harvest %DM	Harvest %DM	Chop Height
Chop Height	Chop Height	Plant Health

You have control over the hybrid(s) you purchase

While not the only influencer, <u>hybrid genetics</u> set the "potential"

What TO Focus on When Selecting Silage Genetics

1. **Basic Agronomic Traits (Yield Stability)**
   Heat units to silk and maturity, technology traits, stress emergence, drought tolerance, disease resistance (e.g. NLB, ear molds)
2. **Dry Matter Yield**
   Influenced by plant height at the ear (biomass yield) and starch (grain) content
3. **Starch Content**
   – Most energy dense component of the plant
   – Influenced heavily by harvest maturity of the kernel
   – Short statured plants can be high in starch but may lack overall biomass (tonnage).

What NOT To Focus on When Selecting Silage Genetics
(but certainly important when feeding the silage)

1. Fiber Digestibility

- **Not a selection trait - little genetic variation between non-BMR's**
  - Why BMR hybrids have been commercialized
  - Wet conditions during vegetative growth equals lower fiber digestion
  - Growing environment is 3-times more influential than genetics

2. Starch Digestibility

- **No significant differences among hybrids at silage maturity**
- **Not a selection trait but important to know for feeding silage**
  - Highly influenced by growing environment, kernel maturity, degree of kernel processing and time in fermented storage

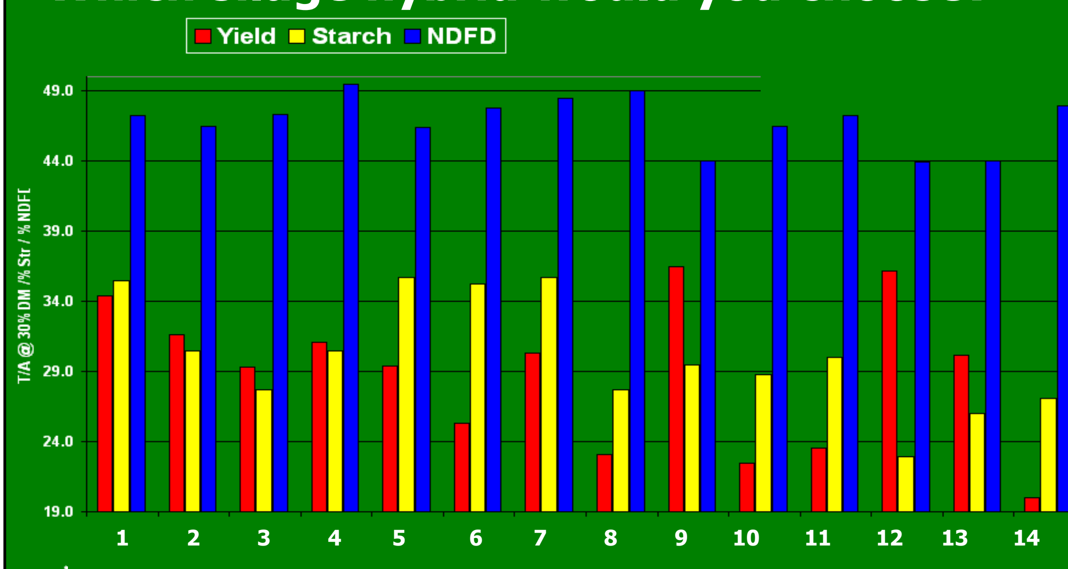
Factors Influencing Corn Silage Value

Yield	% Starch	Fiber Dig
Growing Environment	Growing Environment	Growing Environment
Hybrid Genetics	Hybrid Genetics	Hybrid Genetics - BMR
Harvest %DM	Harvest %DM	Chop Height
Chop Height	Chop Height	Plant Health

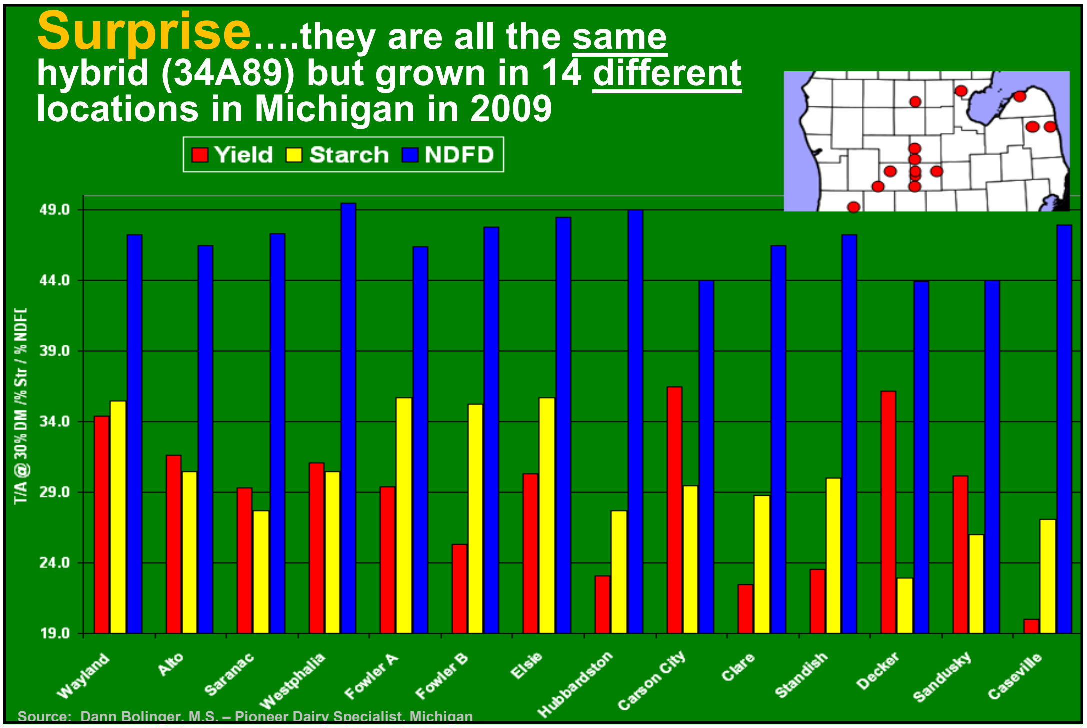
Growing Environment is important but something you have LIMITED control over!

Effect of Environment

Which silage hybrid would you choose?



Source: Dann Bolinger, M.S. – Pioneer Dairy Specialist, Michigan



Factors Influencing Corn Silage Value

Yield	% Starch	Fiber Dig
Growing Environment	Growing Environment	Growing Environment
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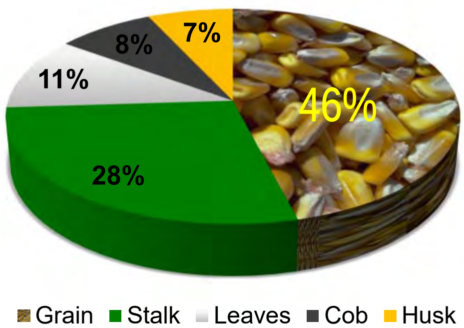
Harvest %DM	Harvest %DM	Chop Height
Chop Height	Chop Height	Plant Health

We will discuss yield and starch together because they are so closely related

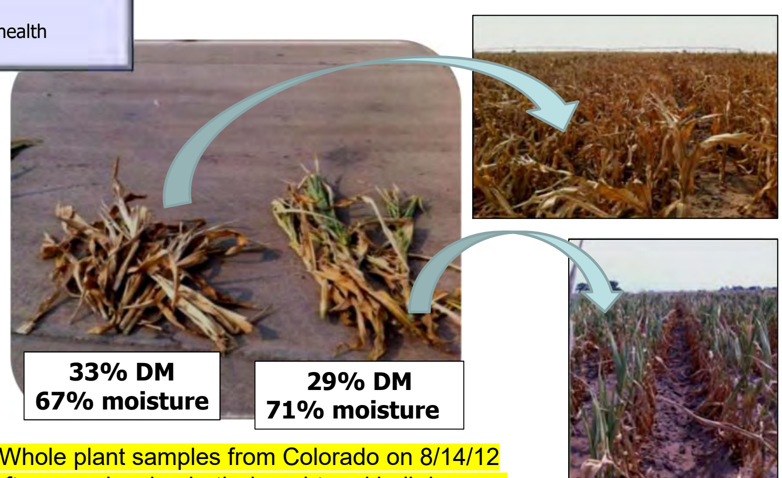
Corn Silage Yield is Highly Influenced by Grain (Starch) Content

- ❑ Grain typically makes 45-50% of silage yield



Starch Deposition is also the Main Reason for Increasing DM as Corn Silage Matures

Other reasons DM increases:
- ❑ Disease
- ❑ Poor plant health
- ❑ Frost



Whole plant samples from Colorado on 8/14/12 after experiencing both drought and hail damage with essentially no ear development

Plant Population Drives Yield

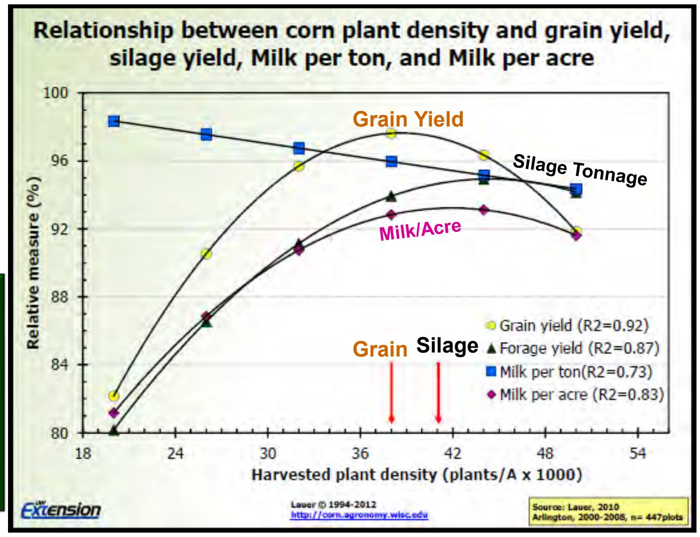
…….And you have control over plant populations

Dr. Joe Lauer
UW Corn Extension Specialist

In general, managing corn for optimum grain yield will optimize silage yield and quality. Modest changes are required for maximum silage yield and quality.

Ask the recommended population for grain and increase only 2-3,000 PPA more for silage or you will "drop" off the grain yield curve and loose starch content.

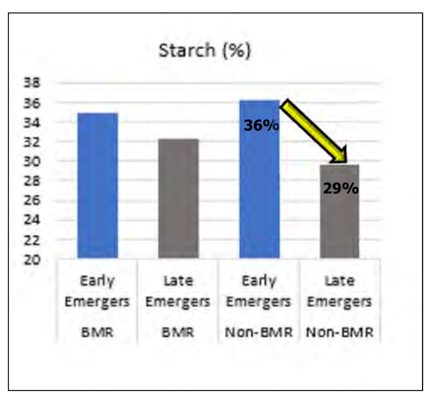
You could push higher if silage intended for heifers/dry cows not requiring so much starch



Source: Dr. Joe Lauer, UW State Corn Extension Specialist, Pioneer Corn Silage presentation January 31, 2012, Johnston, IA

Starch Content is Negatively Impacted by Late Emergence <u>Due to Poor Planting</u>

…..you have control over tillage and planter set-up



- ❑ In fields from a 2016 Wisconsin study on late emerging plants, 19% of plants were 12-72 hours later in emerging.
- ❑ 2017 showed similar numbers of late emerging plants in a repeat of the 2016 study.
- ❑ This is the silent "environmental thief" robbing the hybrid of its true potential

Harvest Timing Influences Yield

You have (some) control over planting date and harvest timing

Dr. Joe Lauer
UW Corn Extension Specialist

- ❑ The drivers of Corn Silage Yield are:
  - #1 harvest timing
  - #2 hybrid genetics
  - #3 planting date
- ❑ Harvest timing is #1 because grain typically makes 50% of the yield (and 65% of the energy)

Range and Relative Impact (%) of Management Decisions on Silage Yield and Quality

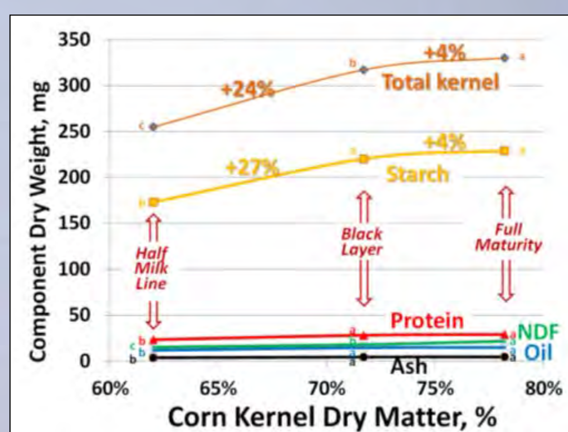
Factor	N Trials	Yield T/A	Milk per Ton Lb milk/T	Milk per Acre Lb milk/A
Hybrid Top v. Bottom Entry	204	3.1 (39%)	477 (14%)	11,500 (43%)
Plant density 22K v. 40K	31	1.2 (14%)	-130 (-4%)	2900 (10%)
Planting date April 24 v. June 16	28	2.2 (27%)	110 (3%)	7800 (30%)
Row Spacing 30" v. 15"	13	0 (0%)	8 (0%)	70 (0%)
Rotation CC v. CS v. CSW	--	?	?	?
Soil Fertility 160 v. 0 lb N/A	--	20 to 50% change		
Pest Control Poor v. Good	--	"Do for silage what you do for grain." Economic thresholds tend to be lower.		
Harvest timing Wet (R3) v. Dry (R5.5)	5	4.4 (40%)	490 (15%)	12,000 (38%)

Source: Dr. Joe Lauer, UW State Corn Extension Specialist, Pioneer Corn Silage presentation January 31, 2012, Johnston, Iowa

Extension Lauer © 1994-2012 http://corn.agronomy.wisc.edu Lauer, 1995-2007 (unpublished)

You Have Control over Harvest Timing

- Maturity at harvest
  - Prior to black-layer (R6 stage), starch is still being produced and deposited in the kernel



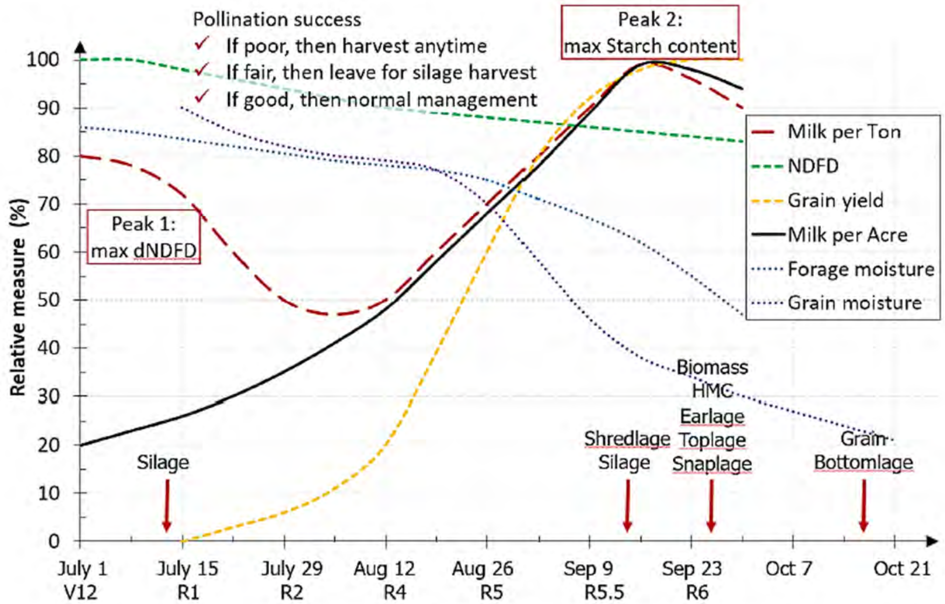


Figure 1. Normal Pattern of Corn Forage and Grain Development in Wisconsin.

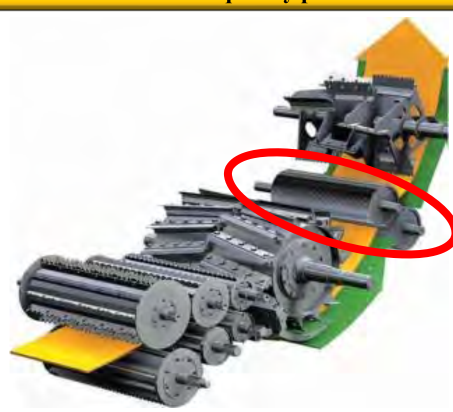
August 2019 — Field Crops 28.5 - 132

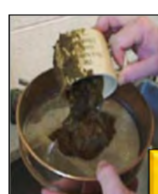
The "Normal" Pattern of Corn Forage and Grain Development

Joe Lauer, Corn Agronomist

You Have Control over Kernel Processing

If <u>chopping longer</u> and/or <u>harvesting more mature</u> (to capture more starch), it is important to have the kernels adequately processed





It is becoming increasingly popular to test for fecal starch levels (goal is <3%) to help determine if grain and corn silage kernel processing was adequate.

Kernel Processing Scoring

This is the Ro-Tap lab method to quantify kernel damage

Jointly developed by Pioneer, Dave Mertens and Dairyland Labs (Arcadia, WI)

- **Quantifies percent of starch in damaged vs. undamaged kernels. Available commercially from Dairyland Labs (Arcadia, WI) and Cumberland Valley Lab (Hagerstown, MD) for ~ $18.00**

This is the most important sieve, the 4.75mm screen (0.187 in)

Starch not as available in kernels on or above the 4.75mm screen (traps ¼ kernel pieces and greater)

4.75mm screen

Starch passing this screen is more available and what is reported as “damaged” or “% passing coarse screen” on lab results

Sieve (mm)	Fiber and starch separations
19	coarse
13	coarse
9.5	coarse
6.7	coarse
4.75	coarse / starch sieve
3.35	medium
2.36	medium
1.18	Medium/peNDF sieve
0.6	fine
pan	fine

Can also be used to calculate peNDF using fiber above 1.18mm screen as the pe factor (wet sieving using the Penn State Separator does not give valid peNDF values)

Pioneer Field Test to Assess Degree of Kernel Processing During Harvest

Best field test is a 1 liter cup….if you see more than 2-4 half or whole kernels in this volume of silage, then chopper adjustments may be called for:

Ideal = 2 whole kernels or less
Adequate = 2 to 4 kernels
Inadequate = more than 4 kernels

Much faster and simpler than “floating the fiber” method

Figure 1. Chopped whole-plant corn placed into water.

Figure 2. Gently agitating material to help the kernels sink to the bottom of the container.

Figure 3. Skimming and removing the floating stover.

Figure 4. Carefully draining the water so only the kernels remain in the container.

Source: www.uwex.edu/ces/crops/uwforage/KernelProcessing-FOF.pdf

Absolutely **perfect** ensiling management

But the cows will suffer production because the roller mill was 3 years old (4500 engine hours) and it had never been changed

Factors Influencing Kernel Damage

1.Chop Length

- ❑ Shorter chop length will process kernels better if you do not have a great need for peNDF (scratch) coming from the corn silage
- ❑ Some processors can chop as long as 30mm and still processes kernels

2.Roller mill wear

- ❑ Typical life of chromed roller mills ~60,000 tons of corn silage

3.Roller mill gap

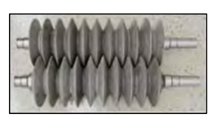
- ❑ set at 1-3mm

4.Roller mill differential

- ❑ typically desire >40% differential depending upon processor and desired kernel damage

John Deere KernelStar

Conventional rolls



Krone Disc Processor

Claas Shredlage

Industry Makes Advances in Corn Silage Processing Past 10 YRS

(CVAS Data, 2006 - 2016)

Crop Year	Number	Average	Percent Optimum	Percent Poor
2006	97	52.8	8.2	43.3
2007	272	52.3	9.2	37.9
2008	250	54.6	5.2	34.8
2009	244	51.1	6.1	48.0
2010	373	51.4	5.9	43.4
2011	726	55.5	12.3	33.1
2012	871	60.8	14.8	19.9
2013	2658	64.6	26.2	22.1
2014	4634	62.2	25.8	10.4
2015	3231	61.1	24.2	17.5
2016	3598	63.5	30.8	11.5

Source: Ward, Ralph. 2017. Starch Digestibility: How It's Measured, Reported and Used. Penn State Dairy Cattle Nutrition Conference Workshop 11/15-16/17

Starch Digestibility
Fact vs. Fiction

What NOT To Focus on When Selecting Silage Genetics

(but certainly important when feeding the silage)

Starch Digestibility

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      - whether the grain is being fed dry or fermented
      - degree of grinding of dry corn
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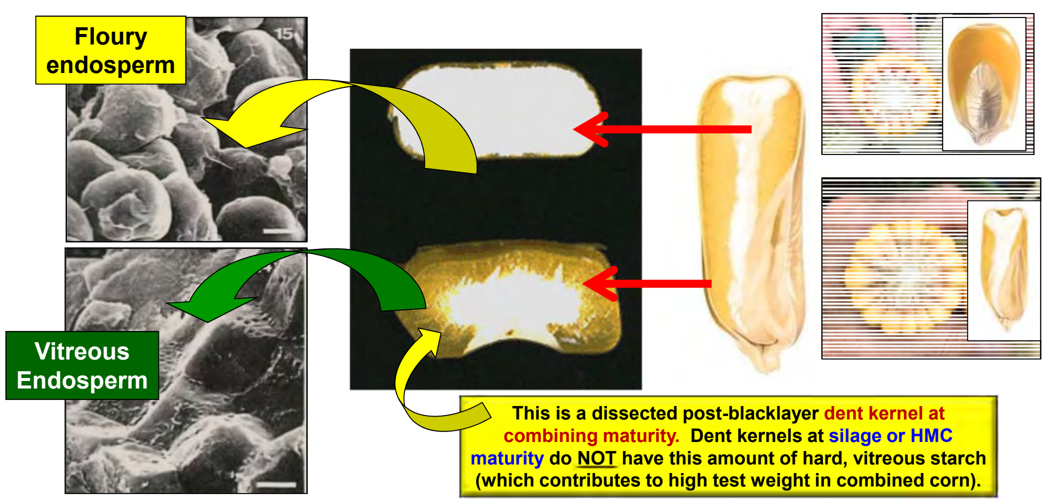
    - time in fermented storage

Definitions: Floury (dent) vs. Vitreous (flinty) Endosperm



This is a dissected post-blacklayer dent kernel at combining maturity. Dent kernels at silage or HMC maturity do NOT have this amount of hard, vitreous starch (which contributes to high test weight in combined corn).

During fermentation, the protective zein proteins are slowly solubilized away over time in storage.

- ❑ **There are essentially no flint corn hybrids in North America, other than popcorn and Indian corn, because it yields so poorly.**

Review of Starch Digestion

Rumen vs. Total Tract

- Too little starch digested in the rumen reduces microbial protein flow to the intestines.
- Too much starch digestion in the rumen can lead to subacute ruminal acidosis (low pH from acid production) causing off-feed, low production, and production of CLA's from corn linoleic acid resulting in low butterfat

7 hour STRD analysis only accounts for starch digested in the rumen

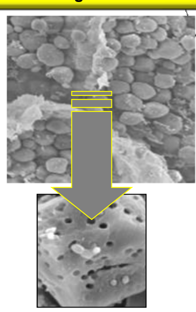
Rumen

CS/HMC Starch

dry corn Starch

small intestine

Fecal starch analysis give the best indication of total tract starch digestion. Goal is <3% fecal starch



Rumen bacteria attacking a starch granule

	Rumen	Small Intestine
1. Acidosis potential	Yes	No
2. Grow Bacterial protein	Yes	No
3. Absorbed nutrients	VFA	Glucose
4. Methane loss	Yes	No
5. Energy value	80%	100%

Notice higher energy value when starch is digested in the intestines due to less gaseous losses

Do we really want floury corn to deliver higher ruminal starch digestion?

- SARA (rumen upset due to low pH) is a major challenge in herd pushing for high production
- We will continue w/ high corn-based diets
- Fecal starch levels on most well-managed herds are already below 3% so improvement in total tract starch digestibility, especially if accompanied by any reduction in yield, seems of little value.
- Nutritionists appear more concerned with reducing, rather than increasing, ruminal starch digestibility in high corn grain/silage based diets exemplified by the move away from high-moisture corn to dry corn in many dairy diets.

Subacute ruminal acidosis (SARA) is a major challenge in dairy nutrition strategies aimed at fulfilling the energy needs of a high-producing cow. SARA is a prevalent and widespread metabolic disorder in intensive ruminant agriculture systems, including the dairy industry. It's initiated when the equilibrium of the rumen pH goes below 5.6 for more than 3 hours over the course of a day, causing the rumen to be more acidic. But what causes this to happen? How do you identify it? What are the negative effects this disorder has on the animals?

SARA is more likely when the ration contains an imbalance of starch and fiber. Increased amounts of metabolic energy are commonly provided in the cow's diet by adding rapidly fermentable carbohydrates, usually in the form of starch, to meet her high nutritional demands during lactation. This lends itself to increase the risk of SARA, by the rapid fermentation of the carbohydrates which stimulates microbial growth. With increased

Both BMR and starch reduces rumen pH affecting intakes and potentiates linoleic acid => CLA

Linoleic acid
(*cis*-9,*cis*-12 C18:2)

normal rumen fermentation

Conjugated linoleic acid (CLA)
(*cis*-9,*trans*-11 C18:2)
(Also known as Rumenic Acid. A desirable CLA accounting for 90% of CLA in milk and linked to anti-carcinogenic activity)

Vaccenic acid
(*trans*-11 C18:1)

Stearic acid
(C18:0)

altered rumen fermentation
(e.g. low rumen pH)

Conjugated linoleic acid (CLA)
(*trans*-10,*cis*-12 C18:2)
(Undesirable CLA linked to milk fat depression)

Only 3-4 grams of trans-10, cis-12 CLA flowing to the intestines can dramatically drop fat test
Source: Overton et al; 2003. Proc 4-States Conf. P 89

(*trans*-10 C18:1)

Stearic acid
(C18:0)

Source: Mahanna, B. 2009. Milk fat depression involves many factors. Feedstuffs Vol. 81, No 42 October 12, 2009

What NOT To Focus on When Selecting Silage Genetics

(but certainly important when feeding the silage)

2. Starch Digestibility

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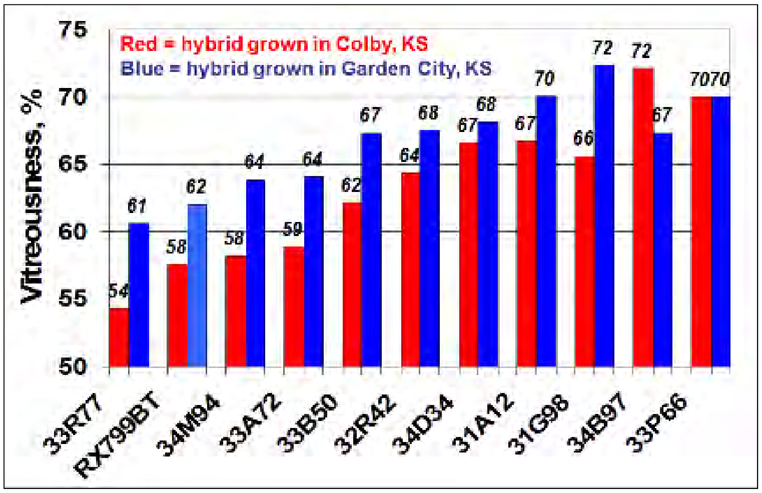
  - Highly influenced by:
    - growing environment
    - kernel maturity
    - degree of kernel processing in corn silage
    - whether the grain is being fed dry or fermented
      - degree of grinding of dry corn
    - time in fermented storage

Growing environment impacts level of vitreous starch (just like it impacts NDFD)

Hybrids grown in Garden City had more
vitreous starch than when grown in Colby, KS



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Silage Kernels (pre-blacklayer) vs. Dry Corn (post blacklayer)

Starch Digestibility of Corn - Silage and Grain

Jeffrey L. Firkins[1]
Department of Animal Sciences
The Ohio State University

Presented at the Tri-State Nutrition Conference
April 25, 2006

Conclusions

Taken together with other studies described, I conclude that there should be an optimum NSC availability in the rumen that is consistent with efficient rumen microbial metabolism. Clearly, the amount of RDS depends on the maturity, DM percentage, and processing of corn silage. Some silages might be lower in RDS than others, so we still need to develop or improve methodology to predict starch availability in silages in a systematic laboratory analysis that will help nutrition advisors to better account for varying RDS. Until more work is done, the Wisconsin index (Ferreira and Mertens, 2005) for particle size should be considered to predict total tract starch digestibility. Vitreousness of corn grain in silage seems to be of relatively little value. In contrast, vitreousness or perhaps gelatinization of dry corn grain should be considered, particularly to help users know when to grind corn more finely. Using these considerations for coarse adjustment of rations, the amount of RDS can be fine-tuned with more slowly available byproducts or increased moderately with small amounts of sugars according to individual herd or group needs. As ration balancing and feeding systems continue to improve in reliability and repeatability, nutrition advisors will still have to use their knowledge of nutrition to continue to keep pace with other feeding management practices.

Univ. of WI FeedGrainV2.0

Primary Factors Influencing Starch Digestibility in Feed Grains

This is what is tested if kernel fed fermented
(e.g. corn silage or HMC at or before blacklayer)

Processing
Particle size

Mean Particle Size (MPS)

Harvest/Storage
Dry vs. HMC
DM of HMC/Maturity
Silo Fermentation Time

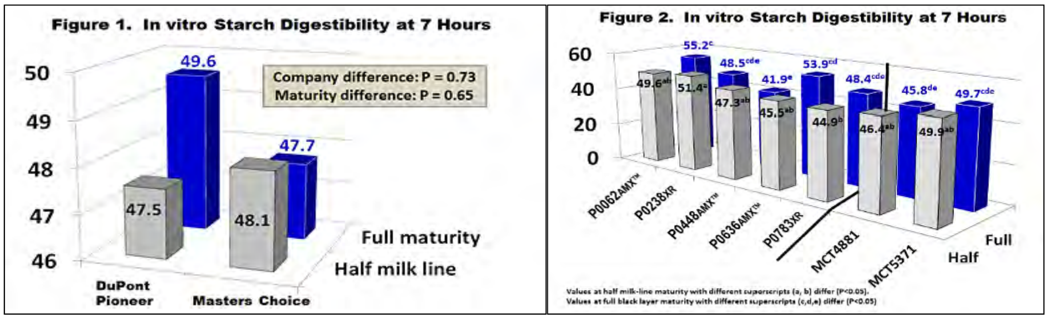
Ammonia Level (% of CP)
(higher values indicate a longer, more extensive fermentation)

Endosperm Type
Starch-Protein Matrix
Hardness
Vitreousness
For Dry Corn only

Prolamin

For HMC, snaplage or corn silage, only particle size and ammonia level (indicator of extent of fermentation) are used in FeedGrain V2.0 calculations. Vitreousness is considered only for dry corn (although fine grinding effectively reduces any negative impact of hard vitreous starch).

No difference in 7-hour STRD when kernels at silage (or HMC) maturity



Univ. of WI FeedGrainV2.0

Primary Factors Influencing Starch Digestibility in Feed Grains

This is what is tested
If kernels fed as dry corn
(past blacklayer)

Processing
Particle size

Mean Particle Size (MPS)

Harvest/Storage
Dry vs. HMC
DM of HMC/Maturity
Silo Fermentation Time

Ammonia Level (% of CP)
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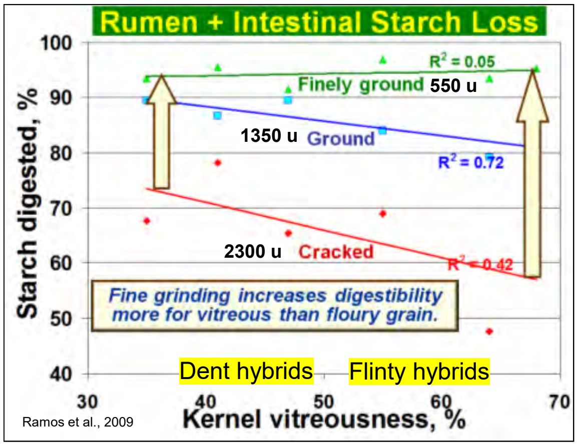
Research from INRA (France) Showing that Fine-Grinding of Dry Corn Grain Removes any Negative Effect of Endosperm Type on Total Tract Starch Digestion



Negative effects of vitreous starch are overcome with processing explaining why we feed fine-ground dry corn to dairy cows (e.g. 400-700 microns).

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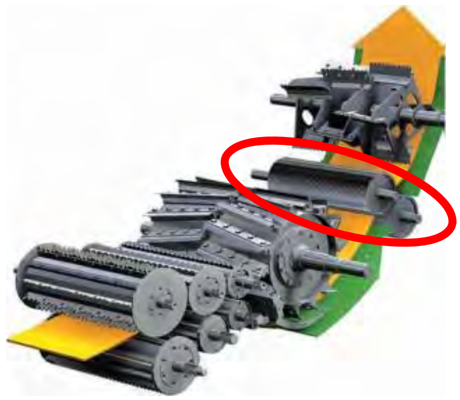
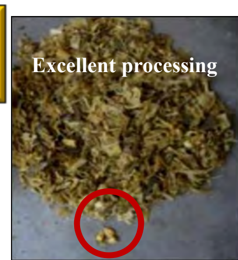
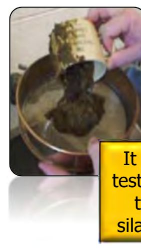
Key Factors Influencing Starch Digestion

Degree of kernel processing

If chopping longer and/or harvesting more mature (to capture more starch), it is important to have the kernels adequately processed







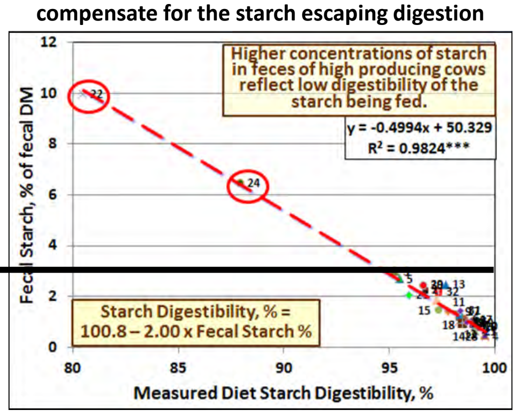
It is becoming increasingly popular to test for fecal starch levels (goal is <3%) to help determine if grain and corn silage kernel processing was adequate.

2015 Pioneer/Wisconsin Field Study

Herds: 32 dairies in the Upper Midwest.
Cows: Top strings from each herd (106#)
Diets: Kernel processed corn silage fermented 8 months; corn grain (Dry rolled, HMC, or earlage)
TMRs averaged 26% starch 31% NDF.
Samples: Corn silage, grain, TMR, feces.

The two herds (#22 and 24) with high fecal starch had poor silage kernel processing scores. Their high string was still producing well but likely it was costing them more in added starch to compensate for the starch escaping digestion

Most under the 3% goal



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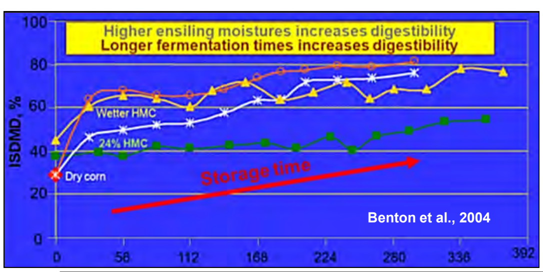
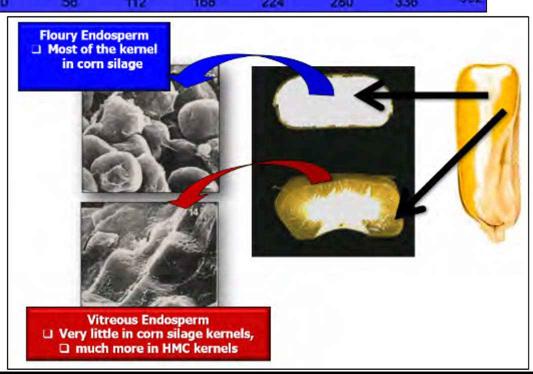
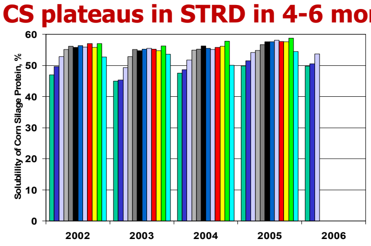
Ruminal Starch Digestion Increases Over Time In Fermented Storage Due to Increased Prolamin (zein) Solubility

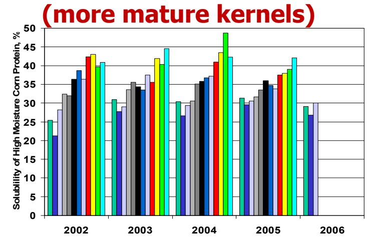




CS plateaus in STRD in 4-6 months



HMC increases for a full 12 months (more mature kernels)



Ruminal Starch Digestion Increases Over Time In Fermented Storage Due to Increased Prolamin (zein) Solubility

J. Dairy Sci. 100:9048–9051
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Short communication: Influence of various proteolytic sources during fermentation of reconstituted corn grain silages

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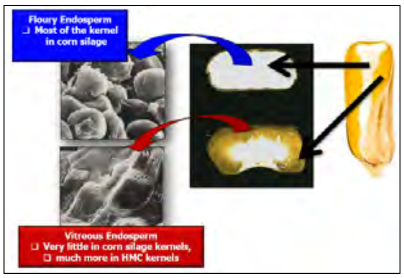
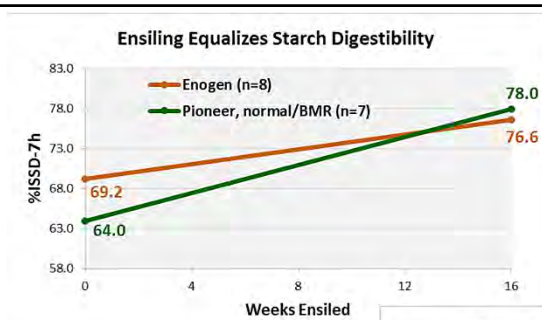
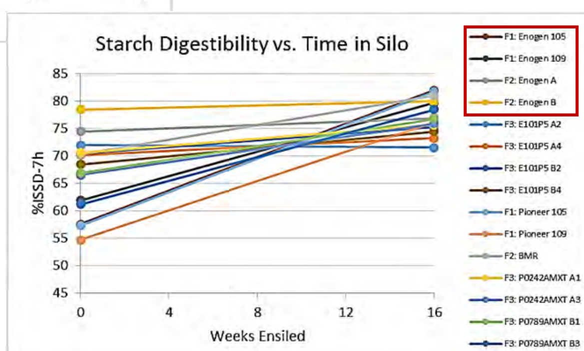


ABSTRACT

The objective of this study was to determine the contribution of corn kernel enzymes, bacteria, fungi, and fermentation end-products (main acids and ethanol) to protein solubilization during fermentation of reconstituted corn grain silage. Flint corn kernels were ground (5-mm sieve), rehydrated to 32% of moisture, and treated with no additives (control), gamma irradiation (32 kGy), gamma irradiation + fermentation end-products (1% of lactic acid, 0.3% of acetic acid, and 0.7% of ethanol, as fed), and natamycin (1% as fed). Treated grains were ensiled in nylon-polyethylene bags and stored for 90 d. Protein solubilization was calculated for each treatment and the contributions of proteolytic sources were determined. Bacterial activity was the main contributor to proteolysis (60%) followed by corn kernel enzymes (30%), whereas fungi and fermentation end-products had only minor contributions (~5% each).



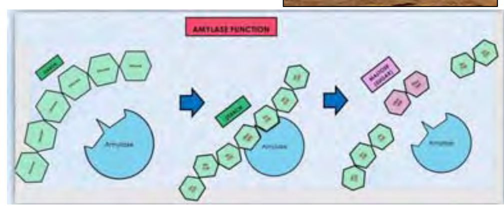
Fermentation is the GREAT EQUALIZER



**3 on-farm comparisons, Michigan 2017-2018*

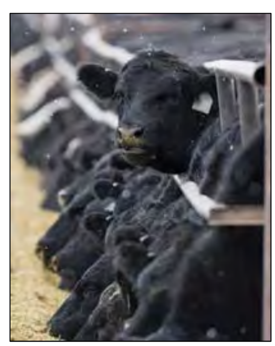
What is Enogen Corn?

- Enogen feed corn hybrids contain alpha amylase, an enzyme that breaks down corn starch into sugar
  - Transgenic trait
  - Exclusively marketed by Syngenta
- Designed for the dry grind ethanol industry to replace enzymes used in ethanol production
  - Very little demand



Enogen for Feed?

- Repurpose of this GMO corn
  - Due to large investment, poor demand from ethanol
  - Stewarded product – needed to be used for ethanol or fed to animals
- Research at UNL feeding dry cracked grain to feedlot steers showed "some" promise in improving feed efficiency
- Syngenta marketing ran with this data and additionally promoted for corn silage



Comments by Dr. Fred Owens

- Direct infusion of amylase into the small intestine failed to increase total tract starch digestion by steers in Colorado State trials by Rumpler and Johnson about 25 years ago.
- That also supports the concept that enzyme activity within the ruminant digestive tract typically is sufficiently high to fully digest all available starch.
- Instead, coarseness of particles within dry rolled grain, particularly when compounded by high grain vitreousness, limits accessibility of starch for attack by microbial or animal amylases within the digestive tract.

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Beef Cattle Trial Summary

	Inclusion Rate (%DM)	Protein Source	DOF	ADG	DMI	F:G Ratio	HCW	Marbling
ISU 2014	Dry Corn 10%	WDGS	131	NSD*	NSD*	NSD*	NSD*	NSD*
ISU 2014	Dry Corn 20%	WDGS	131	NSD*	NSD*	NSD*	NSD*	NSD*
UNL 2018	Dry Corn 68%	MDSG	172	NSD*	NSD*	NSD*	NSD*	NSD*
UNL 2018	Dry Corn 34%	MDSG	172	NSD*	NSD*	NSD*	NSD*	NSD*
UNL 2018	Dry Corn 58%	Sweet Bran	172	+ 0.24 #/d	NSD*	+ .033 G:F	NSD*	NSD*
UNL 2018	Dry Corn 64%	WDGS	148-181	+ 0.24 #/d	NSD*	+ .020 G:F	+ 28.6 #	NSD*
UNL 2018	Dry Corn 32%	WDGS	148-181	+ 0.22 #/d	NSD*	+ .024 G:F	+ 26.4 #	NSD*
KSU 2018	Corn Silage 8%	Sweet Bran	138-166	NSD*	- 0.39 #/d	+ .009 G:F	NSD*	N/A
KSU 2018	Flaked Corn 74.5%	Sweet Bran	138-166	NSD*	NSD*	- .005 G:F	+ 11.3#	N/A
KSU 2019	Corn Silage 40%	Hay/Supplement	91	+ 0.18 #/d	NSD*	+ .005 G:F	NSD***	N/A
KSU 2019	Dry Corn 38.5%	Hay/Supplement	91	NSD*	NSD*	NSD*	NSD***	N/A
NSD* = No Significant Differences (p>.05)								
NSD*** = No Significant Differences (p>.05) ***study used live weight instead of HCW								

- Results are very inconsistent
- Results varied with protein source, type of corn, and inclusion rate of Enogen corn
- Most results are either not significant or show slight improvements in outcome
  - Very similar to data in feeding amylase directly

Dairy Cattle Trials

- No peer-reviewed studies available
- Several "research reports" presented
  - Descriptions of methods limited or flawed
    - Example of flawed methods:
      - Feeding study where Conventional fed Nov/Dec and switched to Enogen Jan-March – *Starch digestibility gradually increases over time so it would be expected that silage fed later will have greater results*
  - No statistical analysis presented
    - Example:
      - "Milk yield & feed efficiency were numerically greater during ON period" – *note the use of the word "numerically" and not "statistically"*

Dairy Cattle Trials (cont)

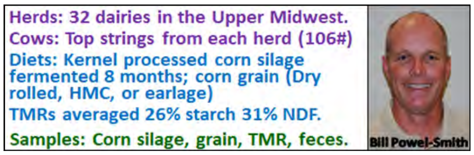
- *"Research by Penn State University found a 4% increase (6% increase uncorrected) in ECM feed efficiency with Enogen® Feed corn silage – with no negative effect on rumen fermentation."*

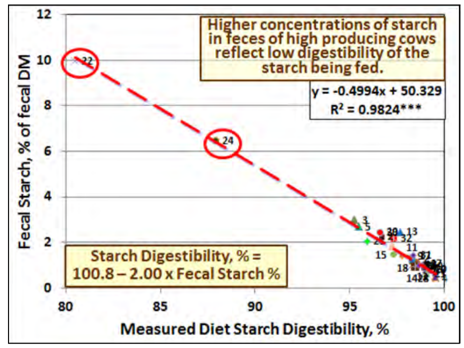
The rest of the story….

- ❑ Enogen isoline silage had 3 points higher starch that the control. In this study diets were held the same for both sets of dairy cattle, in other words they didn't adjust the rations for the differences in starch among the corn silage samples.
- ❑ This difference alone could create about a 2.1 pound increase in milk.
- ❑ It would appear that a higher starch level would account for the increased milk, not the Enogen isoline

- Why do you feel you need increased starch digestibility?

Most herds have fecal starch <3% which indicates starch
the majority of starch is digested – amylase not needed





- **If you feel like amylase is of value to your ration, why not just feed it directly?**

  - ❑ Feed grade amylase has been available years – not utilized by nutritionists as results are inconsistent

  - ❑ Adequate starch digestion obtained with appropriate kernel processing (silage) and fine grinding (dry grain)

Enogen's enzyme was developed for a high-temp (65C) ethanol fermenter,

NOT the temperature in the cows rumen (40C)

***Short communication:* In vitro ruminal fermentability of a modified corn cultivar expressing a thermotolerant α-amylase**

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J. Dairy Sci. 93:4846–4849
doi:10.3168/jds.2009-2321

The fermentability of a corn cultivar that expresses a thermostable α-amylase (CA3272) was evaluated under various in vitro conditions. The CA3272 corn was developed as a replacement to microbial enzyme additions during the high-temperature processing of corn to produce ethanol. The α-amylase activity in the corn might have the potential for positive effects on ruminant performance if incorporated into the ration.

In a third in vitro experiment, there was a small but significant difference in starch degradation of CA3272 compared with IC (90.6 vs. 89.7%) but this difference is most likely not biologically relevant.

In a fourth in vitro experiment, CA3272 and IC were incubated in water at 40 and 65°C for 24 h. Degradation of starch from native amylase activity at 40°C was 1.99 and 1.60% for CA3272 and IC, respectively, but when they were incubated at 65°C, starch degradation was 10.56 and 0.85% for CA3272 and IC, respectively. These data demonstrate that amylase activity in CA3272 is expressed at a high temperature (65°C) but at the physiological temperature expected in a rumen of a cow (39–40°C), expression of amylase activity does not appear to be sufficient to have any positive (or negative) effects on ruminal metabolism.

Enogen Feed Trial Summary

1. Results are very inconsistent
   - There are some positive results – not worth arguing against – just need to point out the times it did not work
2. Marketing is "cherry-picking" positive results to fit their narrative
   - The same trial used in their marketing handouts had a separate experiment that showed no significant advantage
3. No discussion of yield performance in the field
   - The biggest issue with Enogen is not the feeding performance it is the agronomic performance

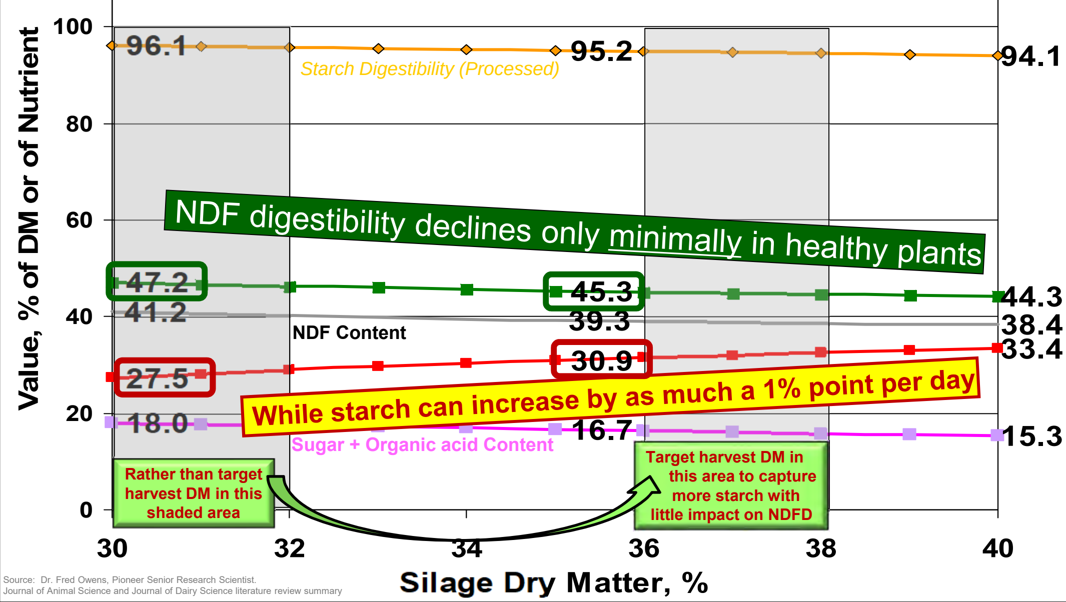
Factors Influencing Corn Silage Value

Yield	% Starch	Fiber Dig
Growing Environment	Growing Environment	Growing Environment
Hybrid Genetics	Hybrid Genetics	Hybrid Genetics - BMR
Harvest %DM	Harvest %DM	Chop Height
Chop Height	Chop Height	Plant Health

Moisture is the most important environmental factor affecting NDFD

Irrigation is great for yield and starch but may be a limiting factor for NDFD

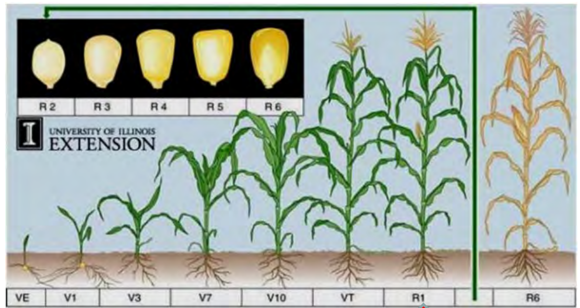
Harvesting at Closer to ¾ Milk Line to Capture More Starch Does Not Significantly Reduce Fiber Digestibility in Healthy Plants

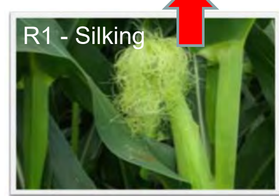


Source: Dr. Fred Owens, Pioneer Senior Research Scientist.
Journal of Animal Science and Journal of Dairy Science literature review summary

Growing Environment Impact on NDFD

- The growing environment **before and after silking (R1)** will affect final corn silage nutritive value
  - **Before silking**, environment affects plant **height (and yield) and NDFD**
    - Dry conditions => higher NDFD
    - **Wet conditions => lower NDFD**
      - but not as much if heat units are lagging behind normal
  - **After silking,** primarily impacts starch deposition but poor late-season plant health can lower NDFD

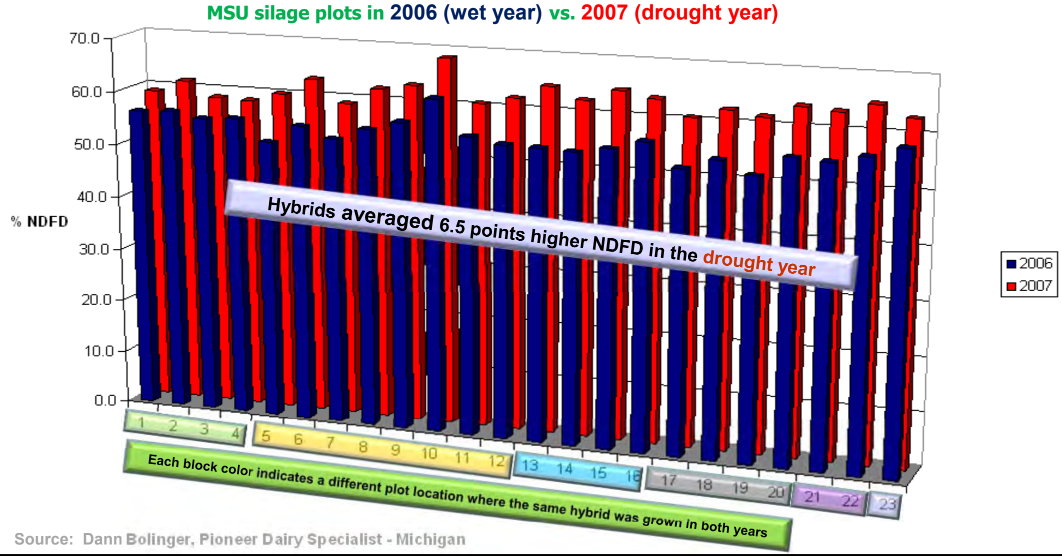




❑ **Fiber digestibility does NOT change over ensiling time like starch digestibility does!**

Growing Environment NOT Genetics Is the Main Influencer of Fiber Digestibility

Growing Environment Effect on the Same Hybrids Grown in MSU silage plots in 2006 (wet year) vs. 2007 (drought year)



Source: Dann Bolinger, Pioneer Dairy Specialist - Michigan

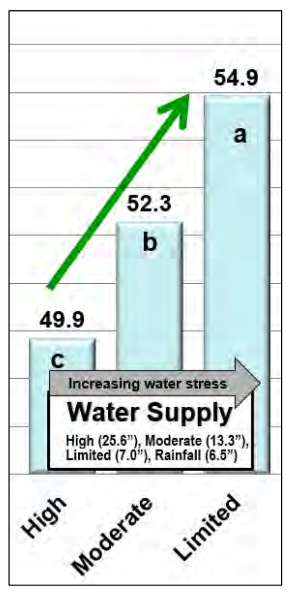
Effects of Moisture Stress….

Irrigation: High (25.6″)
Moderate (13.3″)
Limited (7.0″)
Rainfall (6.5″)

Source: Soderlund, S., F. N. Owens and C. Fagan. 2013. Field experience with drought-tolerant corn. Presentation at the Joint Annual Meeting of the American Dairy Science Association (ADSA) and American Society of Animal Science (ASAS), Indianapolis, Indiana, July 2013.

What Effect Did Moisture Timing Have on NDFD?

Source: Soderlund, S., F. N. Owens and C. Fagan. 2013. Field experience with drought-tolerant corn. Presentation at the Joint Annual Meeting of the American Dairy Science Association (ADSA) and American Society of Animal Science (ASAS), Indianapolis, Indiana, July 2013.



Late-Season Plant Health Can Also Influence NDFD (and Plant DM)

Plants that develop late-season plant diseases drop significantly in fiber digestibility. In the example below, both plants **equal in NDFD on Sept 19** but NLB infesting the susceptible hybrid **significantly lowered** its NDFD, compared to the hybrid which maintained plant health

Hybrid	Detail	Date Sampled	NDFD30
X	**healthy stalks – field A**	**9/19/2017**	**61.7**
X	**healthy stalks – field A**	**9/27/2017**	**60.9**
Y	**diseased stalks – field B**	**9/19/2017**	**59.3**
Y	**diseased stalks – field B**	**9/28/2017**	**46.4**

How Does a Frost Impact Fiber Digestibility

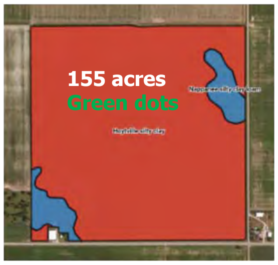

EFFECT OF FROST DAMAGE AND FUNGAL GROWTH OF CORN LEAF NDFD

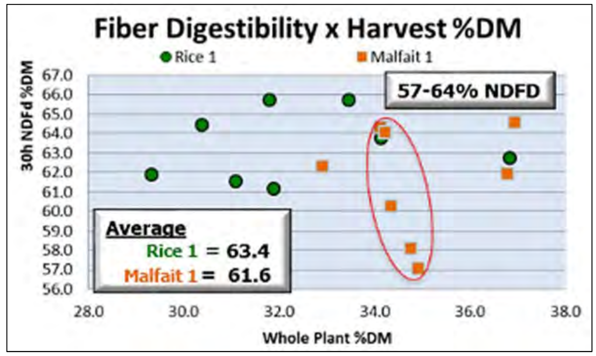
2014 corn silage data from Miner Institute indicates similar effect of disease on lowering NDFD and increasing uNDF (non-BMR hybrids)

Forage Sample	Condition	DM%	NDF, %DM	NDFD30, %NDF	uNDFom30, %DM	
Frost & fungal corn leaves	Fresh	32.9	64.6	58.7	26.2	Frosted
Green healthy corn leaves	Fresh	39.3	60.1	64.6	21.1	Healthy
BMR	Silage	41.6	45.1	72.3	12.6	
CS 2014	Silage	41.1	47.0	62.0	18.0	
CS 2013	Silage	32.4	46.4	62.5	17.5	

Source: Miner Institute Farm Report. March 2015.

Field Variability Also Exists for NDFD





Source: Dann Bolinger, 2016 DuPont Pioneer Michigan/Ohio Dairy Specialist

8 samples representing 8 random loads from a single field for <u>each</u> Green and Orange dot hybrid

Today, we understand NDFD is <u>not</u> an important hybrid selection criteria because growing environment is much more important than genetics in determining NDFD….but it is still very important to diet formulation.

- **Growing environment is 3X more influential on NDFD than genetics.**
  (Dr. Fred Owens, Retired Pioneer Research Scientist

- **Moisture the plant receives is 7-times more influential on fiber digestibility (and uNDF) than heat units.**
  (Dr. Mike VanAmburgh, Cornell University)

BMR Genetics to Improve NDFD

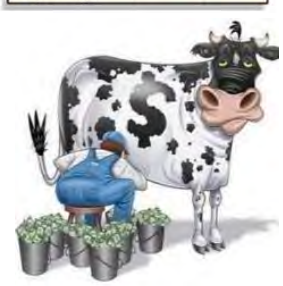
You have control over the hybrid(s) you purchase

Higher NDFD with BMR Hybrids

Higher NDFD impacts:

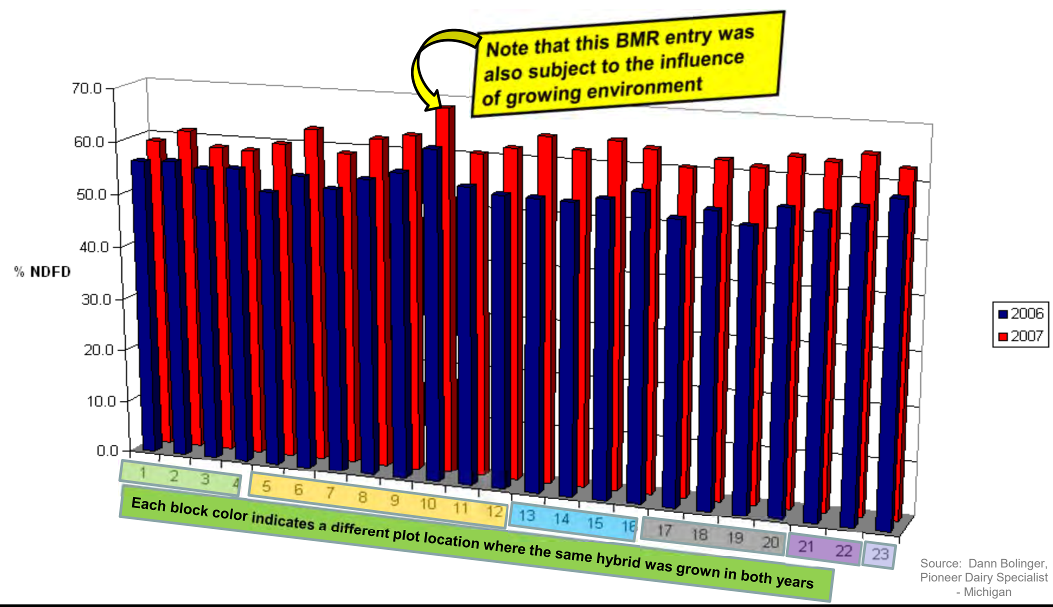
– **The amount of forage in the diet (typically more forage = a cheaper ration)**
– **The energy obtained from the silage**
– **The amount of forage cows can eat per day because BMR fiber is more fragile and exits the rumen faster than fiber from non-BMR hybrids**

	uNDF 240h, % of DM	
Feed type	Goal	Avg.
Alfalfa hay or haylage	< 13	18
Corn silage	< 7	9
Sorghum, sudan or small-grain hay or silage	< 9	14



The main nutritional advantage of BMR silage is higher intakes from lower uNDF and higher cell wall fragility due to less lignin (which interferes with rumen bacteria degradation of cell walls)

Example of Growing Environment Effects on the Same Hybrids Grown in MSU silage plots in 2006 (wet year) vs. 2007 (drought year)



Set Realistic BMR Expectations

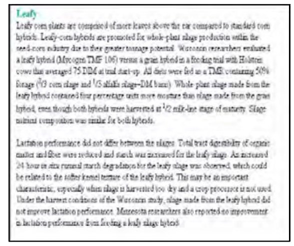
vs. standard corn silage hybrids

- Potential for more agronomic risk
  (standability, need for fungicides etc.)
- Slightly reduced yields
  (5-15% depending upon growing conditions)
- Extra inventory needed due to
  slightly reduced yields and higher feed intake of BMR silage
- **Biggest value is to transition and early lactation cows** to drive intakes (1 lb extra dry matter intake equates to 1.5 lbs more milk/cow/day)
- First time BMR growers should discuss their decision
  to plant BMR with their nutritionist

What About Leafy Hybrids

(extra leaves above the ear, shades the ear leaf responsible for driving starch deposition)


Comparison of Feeding Corn Silages from Leafy or Conventional Corn Hybrids to Lactating Dairy Cows



Although small differences in nutrient content and digestibility existed among corn silage hybrids, inclusion of these leafy hybrids in lactation cow diets at 40% of the dietary dry matter did not have a significant impact on lactation performance of dairy cattle. Source: 2003, University of Minnesota Research – Journal of Dairy Science 86:2932-2939

"Under the harvest conditions of the Wisconsin study, silage made from the leafy hybrid did not improve lactation performance. Minnesota researchers also reported no improvement in lactation performance from feeding a leafy silage hybrid. Source: 1999. Dr. Randy Shaver Dairy Nutrition Specialist University of Wisconsin

Harvest Management Options to Increase Fiber Digestibility (NDFD)

Starch and Fiber Digestibility Can Sometimes be Increased by High Chopping

Table 1. Average nutrient content and production of corn silage harvested at low or high levels of height (summarized from 11 studies)[1].

Increasing chop height from ~7" to 20"

Item	Low height (6.8 ± 2.5")	High height (19.3 ± 2.8")	Change (%)
DM, %	38.1	40.3	6.0
CP, %	7.0	7.1	2.0
ADF, %	24.2	21.8	-10.2
NDF, %	41.6	38.6	-7.4
Starch, %	30.6	32.4	5.9
NEL, Mcal/lb	0.71	0.74	4.2
NDF digestibility, %[2]	50.6	54.0	6.7
DM digestibility, %[2]	78.6	80.6	2.5
Yield, ton/ac, DM	8.1	7.5	-7.4
Milk equivalent[3]			
lb/ton	3014	3162	5.2
lb/ac	20990	20610	-1.7

Review of 11 Scientific and Popular Press articles on high-chopping by Wu and Roth at Penn State

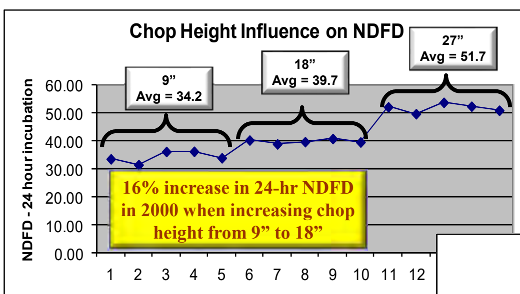
Starch is concentrated

Fiber Dig increased by 6.7% or 3.4 percentage units

These trials showed that whole plant yield decreased about 0.4 as fed tons for every 4" increase in chop height (0.17 ton of DM) .....Pioneer data suggests closer to 1 ton of as fed silage lost per every 4" increased chop height....but keep in mind that the silage yield loss is indigestible fiber from the lower plant internodes...not leaves, ear or upper (more digestible) stalk internodes.

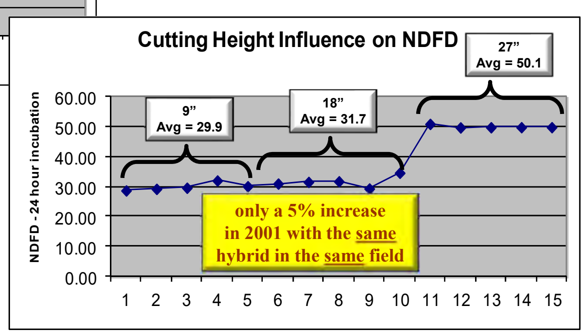
Source: http://www.das.psu.edu/user/publications/pdf/das03-72.pdf

Example of How Hybrids Respond Differently to High-Chopping Depending upon the Growing Season

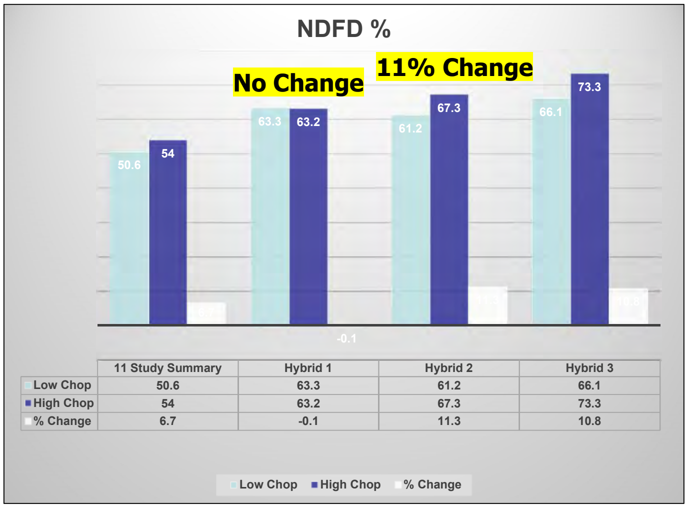


The only way to know if high-chopping will significantly increase fiber digestibility is to sample whole plants just prior (~2 weeks) to harvest and rapidly analyze with a NIR for fiber digestibility (NDFD)

Trial Background: Fiber digestibility data from 5 plants harvested at 3 different chop heights from the same hybrid (34B23) sampled from same section of same field in 2000 and again in 2001



2018 High Chop Data from S. Wisconsin

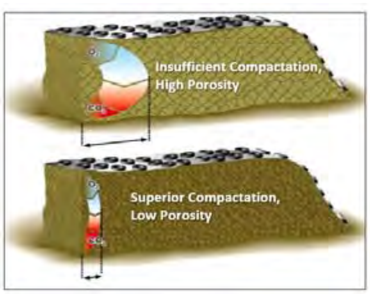


	11 Study Summary	Hybrid 1	Hybrid 2	Hybrid 3
Low Chop	50.6	63.3	61.2	66.1
High Chop	54	63.2	67.3	73.3
% Change	6.7	-0.1	11.3	10.8

Notice variation in response to high chopping depending upon hybrid (and location). From essentially 0 to an 11% improvement in NDFD

Finally, You Have Control Over Corn Silage Storage

- Compaction
- Feed-out Management
- And using technologies like *L. buchneri* inoculants, oxygen barrier film and facers.



What Happens with Frozen Corn Silage

- You lose epiphytic LAB's (less so with commercial inoculant strains.
- Optimum growth rate for LAB fermentation is 90F. As temperatures decrease from optimum, fermentation will proceed but more slowly until temperature reaches about 32F when fermentation ceases.
- Yeast will survive freezing
  - Cellular damage allows for fast yeast growth when silage warms up
- Expect reduced stability because of yeast survival
- OK to feed this silage but recognize the differences compared to normally fermented silage:
  - Feeds like green chop
  - Higher sugar content
  - No change in starch digestibility due to lack of microbial activity that occurs in normally fermented silage
- When warms up, fermentation proceeds but recognize that lower DM, densely compacted, larger volume silage piles/bunkers will warm up at a slower rate. As silage warms and slowly ferments:
  - Sugar levels are reduced
  - Fermentation acids are increased
  - If inoculated with a buchneri-containing inoculant, stability in feed-bunk should improve
  - No known studies on how much ruminal starch digestibility might improve given the alteration in microbial activity compared to normally fermented silage. Best to conduct 7-hour ruminal starch digestibility analysis.

Conclusion: Managing the Manageable
What Is Under Your Control

Silage Yield

- **Hybrid Genetics**
- **Planting Date**
- **Planting Population**
- **Kernel Maturity at Harvest**
- **Chop Height** (concentrates starch)

Conclusion: Managing the Manageable
What Is Under Your Control

Silage Yield

- Hybrid Genetics
- Planting Date
- Planting Population
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- Chop Height (concentrates starch)

Silage Starch Content

- Hybrid Genetics
- Planting Date
- Planting Population
- Kernel Maturity at Harvest
- Chop Height (concentrates starch)

Conclusion: Managing the Manageable
What Is Under Your Control

Silage Yield

- Hybrid Genetics
- Planting Date
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- Planting Date
- Planting Population
- Kernel Maturity at Harvest
- Chop Height (concentrates starch)

Fiber Digestibility

- Hybrid Genetics – BMR
- Harvest Timing / Fungicides
- Chop Height
(lower internodes less digestible)

Conclusion: Managing the Manageable
What Is Under Your Control

Silage Yield
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Silage Starch Content
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Silage Starch Digestibility
- Degree of Kernel Processing
- Amount of Time in Fermented Storage

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Storage and Feeding
- Compaction/Face Management
- Inoculation


Thank You……
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