Strategies to improve nutritive value of corn and sorghum silage

Luiz F. Ferraretto, Ph.D., PAS
Department of Animal Sciences
University of Florida

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Objectives

- Introduce indicators of corn silage nutritive value
- Highlight the use and application of these indices
- Discuss practical strategies to enhance these quality indices

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Starch quality indicators

Indicator	Practical Implication
Starch (% DM)	▪ Alter energy density ▪ Impact milk yield or feed efficiency
StarchD (% starch)	
Prolamin (% DM)	
Corn silage / Berry processing score (% of starch below 4.75 / 1.70 mm sieve)	

Methods may vary across laboratories and may include calculation of rates of digestion.

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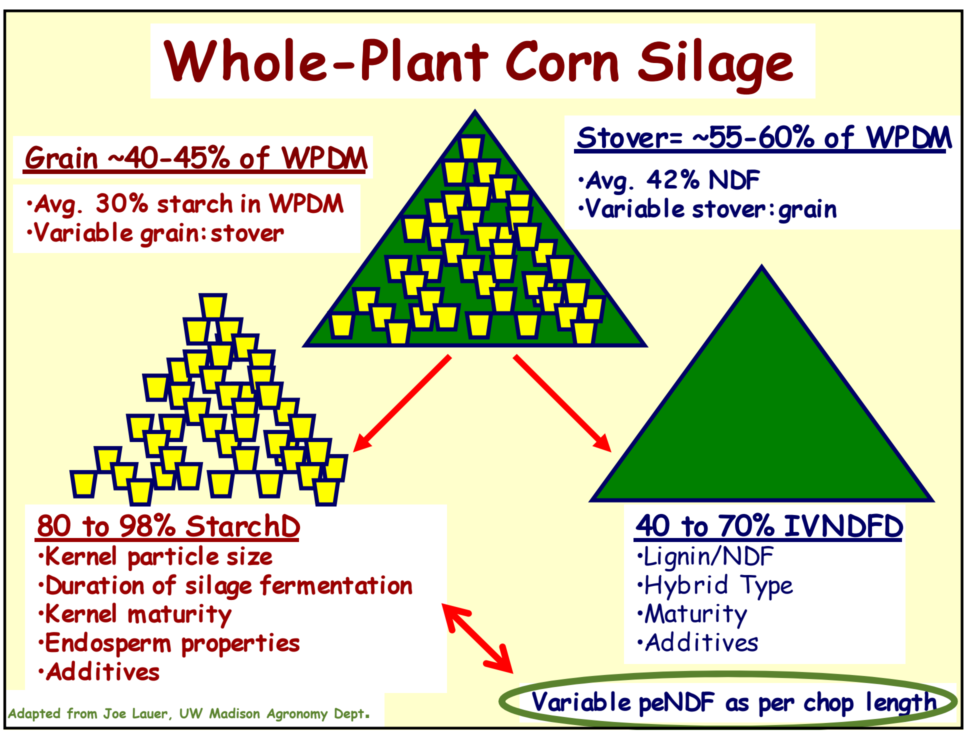

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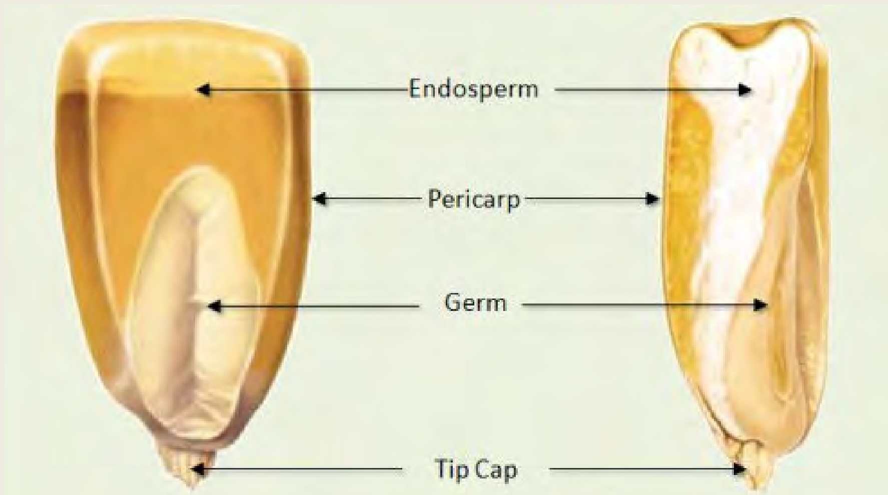
Corn Kernel



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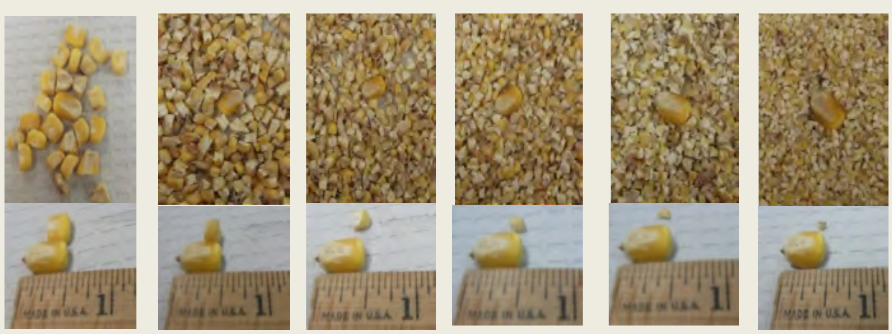
Kernel particles

2P	4P	8P	16P	32P	64P



P = pieces

Dias Junior et al., 2016

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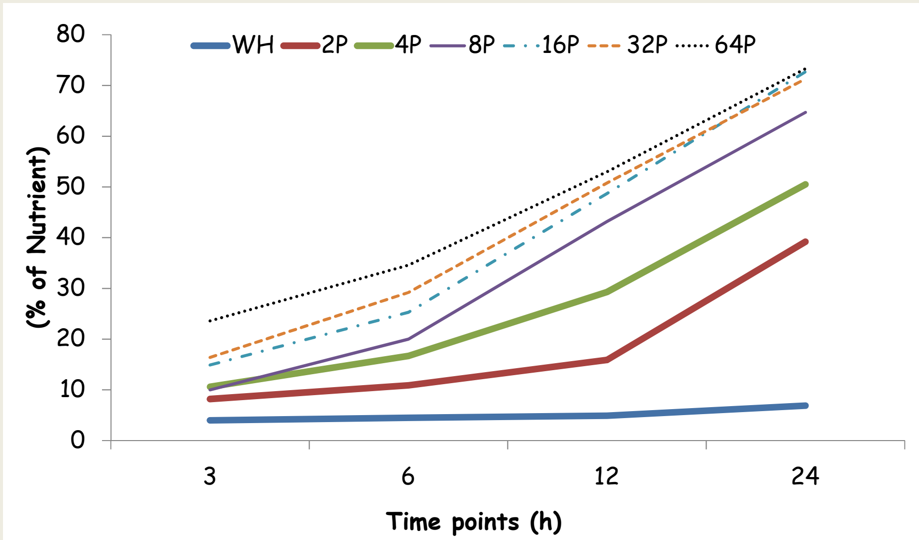
Ruminal in situ DM digestibility of unfermented kernels



Dias Junior et al., 2016

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Corn silage processing score and fecal starch

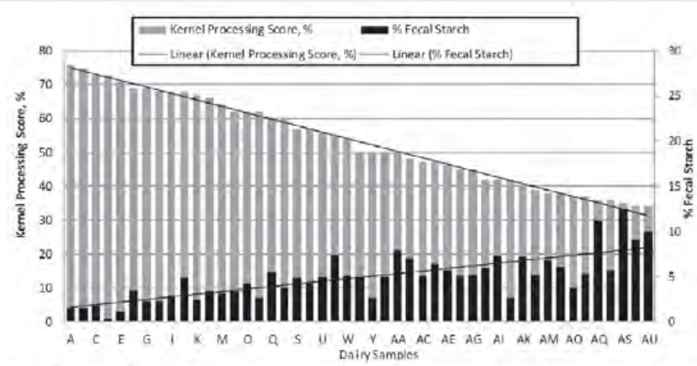

Figure 1 Percent fecal starch plotted against respective corn silage kernel processing score (%) for each dairy sample (n=47).

Braman and Kurtz, 2015

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Sorghum Kernel particles

1P 2P 4P

McCary et al., 2019; ADSA Abstract

P = pieces

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Ruminal in situ incubation

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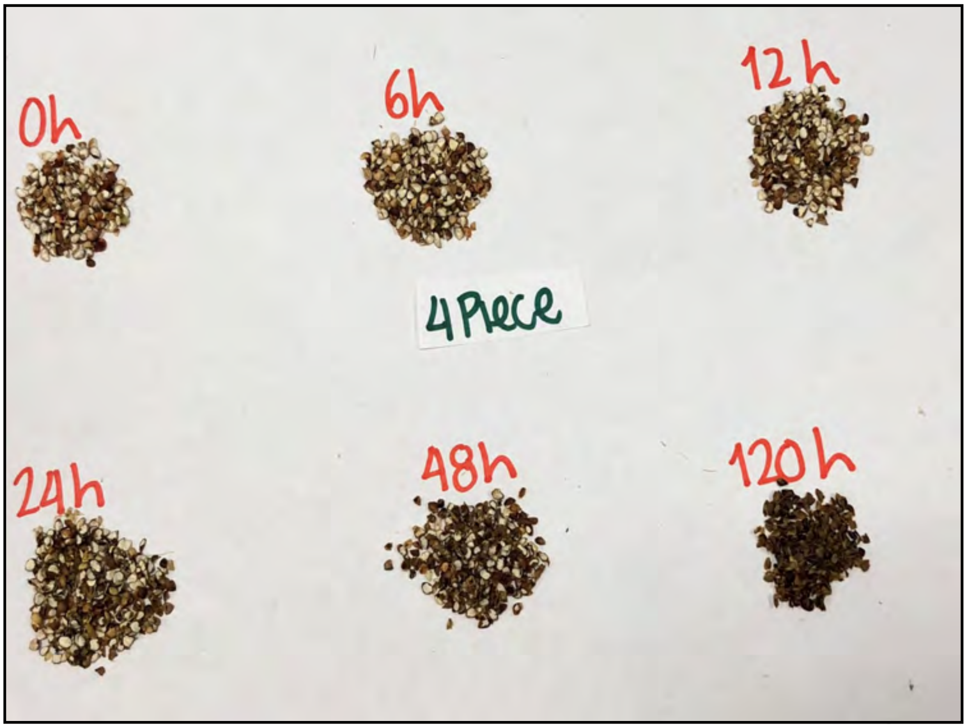

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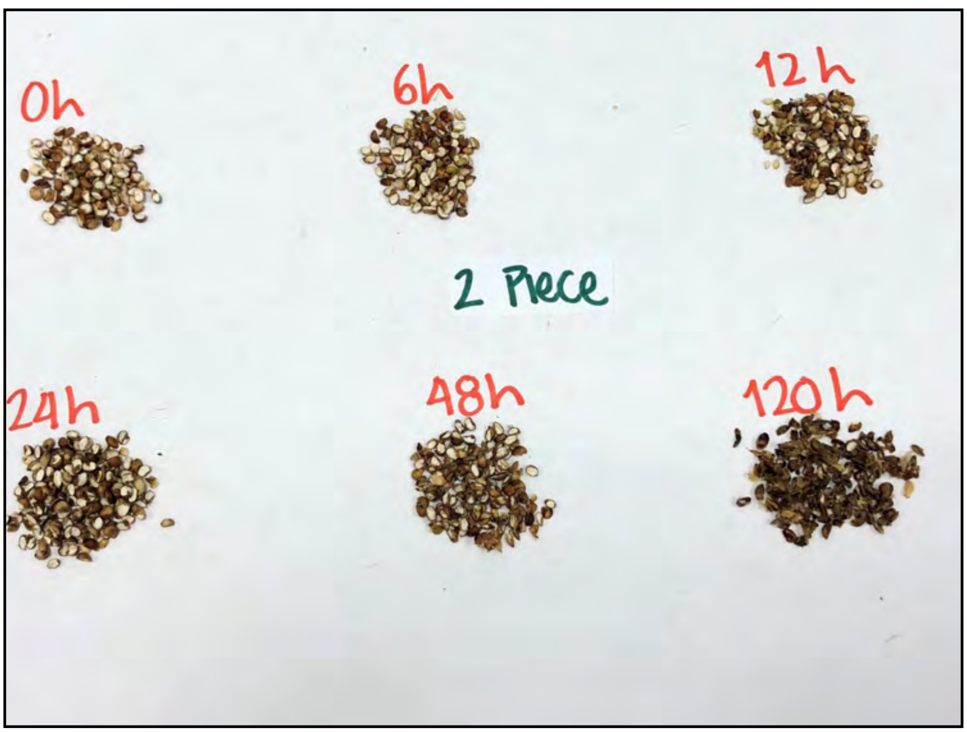

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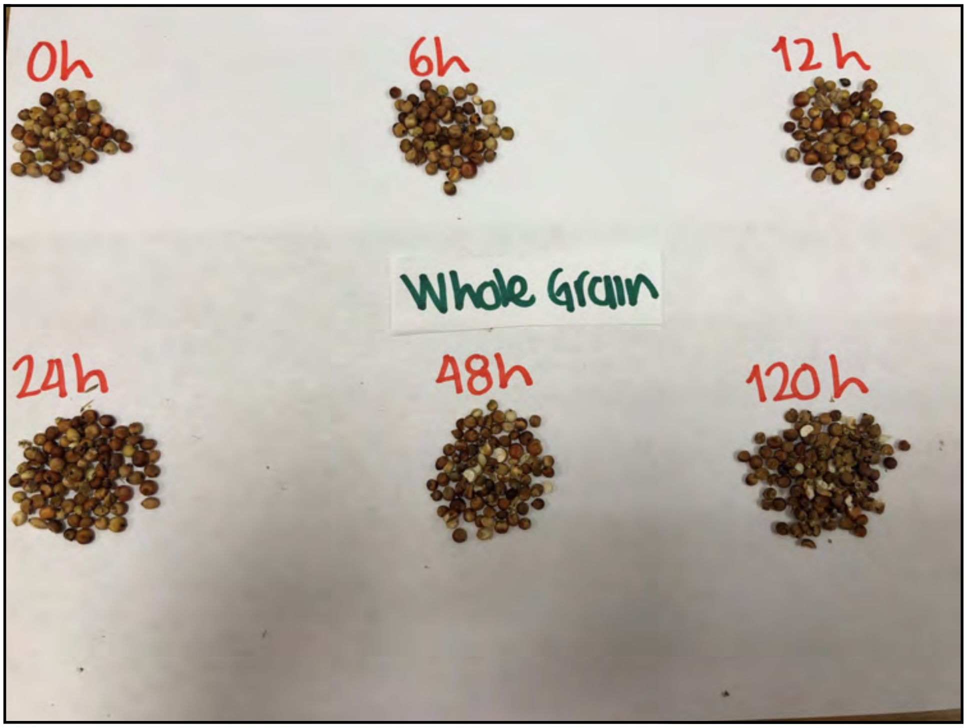

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Particle size and BPS

Item	1P	2P	4P
Sieves, mm			
6.70	0.00	0.00	0.00
4.75	0.00	0.00	0.00
3.35	19.64	3.52	0.00
2.36	77.81	45.06	14.11
1.70	2.54	48.39	59.77
1.18	0.00	2.89	23.79
0.59	0.00	0.13	1.45
0.30	0.00	0.00	0.56
Pan	0.00	0.00	0.32
GMPS, µm	2,152	1,695	1,277
Surface area, cm^2/g	19	22	27

McCary et al., 2019; ADSA Abstract

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UF Sorghum Processing Trial

- 5 hybrids planted during the spring were used as replication
- 2 theoretical length of cut – 15 and 22 mm
- 2 roll gap settings – 1 and 3mm
- 2 storage length – 30 and 90 d

McCary et al., 2019; ADSA Abstract

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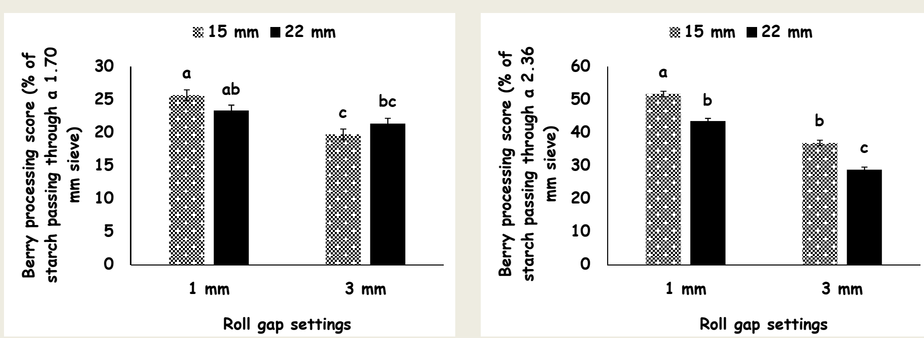
BPS – 1.70 vs. 2.36 mm sieve



McCary et al., 2019; ADSA Abstract

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How to obtain excellent processing?

- The key: adequate and constant monitoring

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Focus on Forage

Wisconsin TEAM Forage

Making Sure Your Kernel Processor Is Doing Its Job

by Kevin J. Shinners and Brian J. Holmes

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

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.

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Figure 3. Skimming and removing the floating stover.

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

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Fecal Starch Economics

- Dietary starch – 25%
- Dry matter intake (55 lb/cow/d)
- Corn grain starch – 70% starch (1lb corn = 0.7 lb starch)
- Corn grain ivStarchD – 70% ivStarchD (1 lb corn = 0.49 lb digestible starch)
- Corn grain price – 140 US$/ton (0.07 $/lb)

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Fecal Starch Economics

CSPS, %	30	55	80
Starch intake, lb/d	13.75	13.75	13.75
Fecal starch, %	8.40	4.65	0.90
TTSD, % Starch	89.5	94.2	98.9
Starch loss, lb/d	1.45	0.80	0.15
Corn grain, lb/d	2.96	1.63	0.31
Corn grain, $/d	0.19	0.11	0.02

Starch intake = (55 lbs DMI * 25% starch)/100
Fecal starch = 12.9 – (0.15 * CSPS) Braman and Kurts (2015)
TTSD = 100 – (1.25 * fecal starch) Fredin et al. (2014)
Starch loss = starch intake – ((starch intake * TTSD)/100)

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Silage Fermentation Increases Starch Digestibility!

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Response across multiple trials

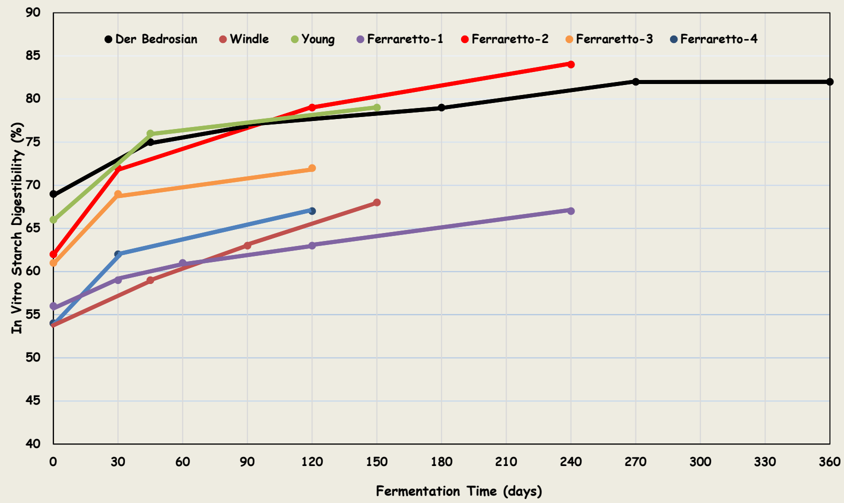

Figure 1. Effect of days of ensiling on ruminal in vitro starch digestibility. Data from Der Bedrosian et al., 2012; Windle et al., 2014; Young et al., 2012; Ferraretto-1, Ferraretto et al., 2015a; Ferraretto-2, Ferraretto et al., 2015b; Ferraretto-3,4, Ferraretto et al., 2016.

Kung et al., 2018

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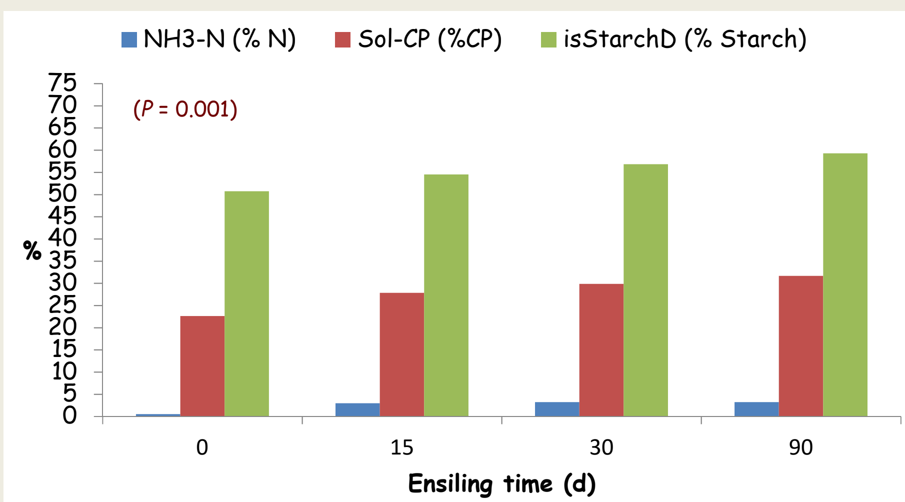
Storage length effect – sorghum silage



Fernandes et al., unpublished

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Initial research

- Research supports the use of inventory planning so a newly harvest crop would be fed only after 90-120 days in storage
- Ensiling time does not attenuate differences in starch digestibility caused by hybrids or maturity
- It requires proper management during filling, packing and covering

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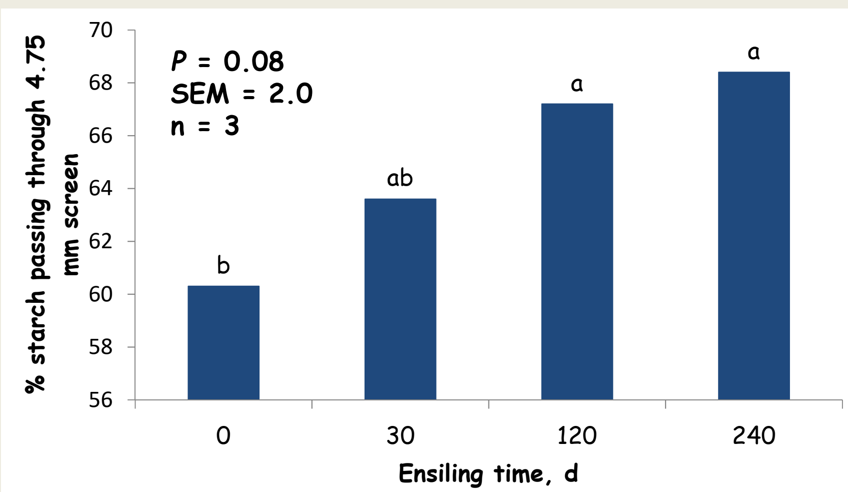
Corn Silage Processing Score



vacuum sealed experimental mini silos

Ferraretto et al., 2015c

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Is this the case if silage is poorly processed?

Item	0 d	120 d	*P*-value
DM, % as fed	36.6	35.6	0.29
pH	5.74	4.00	0.001
Lactate, %DM	0.03	7.74	0.001
Acetate, %DM	0.01	1.01	0.001
Starch, %DM	31.4	31.1	0.89
CSPS, % starch < 4.75 mm	28.8	28.8	0.97

Agarussi et al., 2018

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US Fiber Quality Summary

Parameter	Indicates Better Quality	n	Normal Range
NDF (% DM)	↓	384,715	36 - 46
Lignin (% DM)	↓	344,134	3 - 4
$uNDF_{240}$ (% DM)	↓	81,418	8 - 13
$NDFD_{30}$ (% NDF)	↑	170,634	48 - 60
TTNDFD (% NDF)	↑	27,954	36 - 46

Summary of combined multi-year, multi-lab (CVAS, DairyOne, RRL, DLL) data, except TTNDFD only from RRL

Adapted from slide courtesy of Dr. Randy Shaver, UW-Madison

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Corn Silage Quality Indicators

Indicator	Practical Implication
NDF (% DM)	▪ Intake limitation through rumen fill ▪ Impact milk yield and the establishment of high-forage diets
Lignin (% DM)	
$uNDF_{240}$ (% DM)	
$NDFD_{30}$ (% NDF)	
TTNDFD (% NDF)	

Methods vary across laboratories and may include calculation of pools and rates of digestion.

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Forage NDF digestibility and cow performance

For every 1 percentage-unit increase in NDF digestibility

- +0.40 lb/d DMI
- +0.55 lb/d 4%FCM (Oba and Allen, 1999)

>40% corn silage in diet

- +0.26 lb/d DMI
- +0.31 lb/d 3.5%FCM (Jung et al., 2010)

Slide courtesy of Dr. Rick Grant, Miner Institute

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Fiber digestibility and chewing behavior

Study	Intake	Eating time
Grant et al., 1994	88.3	120.7
Aydin et al., 1999 Exp. 1	85.0	117.9
Aydin et al., 1999 Exp. 2	95.6	105.6
Oliver et al., 2004	95.5	114.9

Data presented as percentage of control treatment

Grant and Ferraretto, 2018; JDS

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Effect of eating time on lactation performance

Item	n	Intercept	Slope	*P*-value
Milk, kg/d	415	39.2	-0.024	0.001
3.5% FCM, kg/d	415	35.8	-0.011	0.03
ECM, kg/d	405	38.0	-0.016	0.001
Milk protein, %	405	3.28	-0.0005	0.04
Milk protein, kg/d	405	1.27	-0.0009	0.001

Krentz et al., 2018; ADSA Abstract

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Brown mid-rib mutant hybrids

- BMR mutation reduces forage lignin
- Characteristic brown mid-rib color
- Improved digestibility outweighs lower yields?
- No. reflects genes encoding enzymes in the lignin synthesis pathway

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Nutrient composition of corn hybrids

Item	BMR	CONS	*P*-value
DM, % as fed	33.7	33.9	0.27
CP, %DM	8.1	7.8	0.07
NDF, %DM	43.0	42.8	0.34
Lignin, %DM	2.0[b]	2.9[a]	0.001
ivNDFD, % NDF[1]	58.1	46.7	0.001
Starch, %DM	28.7[ab]	29.7[a]	0.05

[1]Ruminal in vitro NDF digestibility after 30 or 48 h of incubation

Ferraretto and Shaver, 2015

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Effect of BMR corn silage on lactation performance

Item	Control	Difference
DMI, lb/d	53	+2
Milk, lb/d	82.2	+3.3
Fat, %	3.63	-0.11
MUN, mg/dL	15	-1
NDFD, % NDF	42.3	+2.5
TTSD, % Starch	92.7	-1.4

Adapted from Ferraretto and Shaver, 2015

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Effect of BMR sorghum silage on lactation performance

Item	Difference to conventional
DMI, lb/d	0.69
Milk, lb/d	1.83
Fat, %	0.34
Fat, lb/d	1.70
Protein, %	0.17
Protein, lb/d	1.39

Adapted from Sanchez-Duarte et al., 2019

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BMR sorghum effects on yield, NDFD, and lodging

Item	NON-BMR	BMR
Yield, DM tons/acre	6.2	5.1
ivNDFD, % NDF	39.2	48.2
uNDF 240 h, % DM	18.7	15.9
Lodging score	1.1	1.0

Adapted University of Florida Variety Trials, Spring 2018

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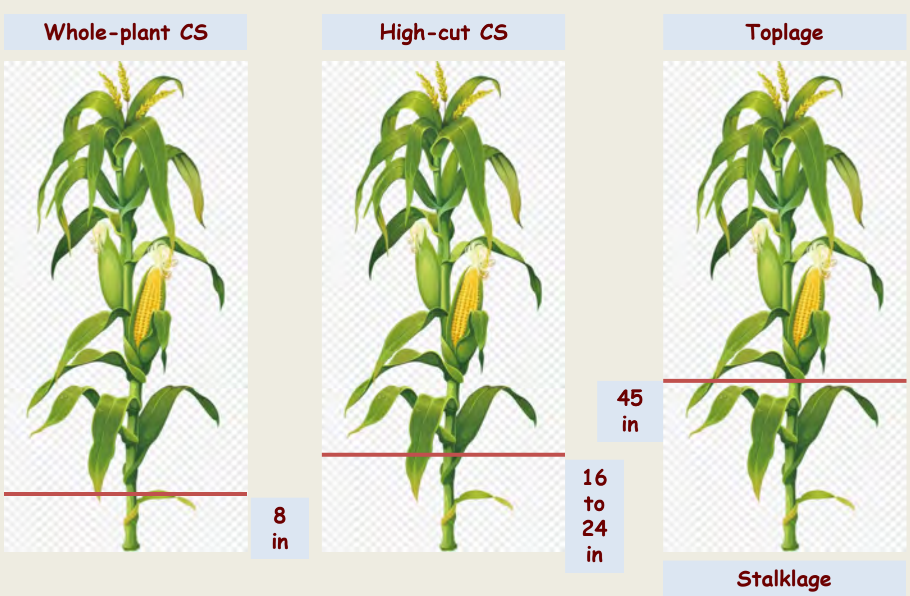
Whole-plant material



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Whole-plant material

	Whole-plant CS	High-cut CS	Toplage	Snaplage
Cutting height, inches	10	40	45	51
DM, %	37.7[c]	40.6[b]	42.2[b]	53.3[a]
CP, % of DM	8.2[b]	8.9[a]	8.9[a]	8.8[a]
NDF, % of DM	40.3[a]	34.5[b]	32.1[b]	19.5[c]
Lignin, % of DM	4.0[a]	3.4[b]	3.1[c]	2.2[d]
Starch, % of DM	33.9[d]	38.8[c]	43.0[b]	58.6[a]
Ash, % of DM	3.7[a]	3.4[ab]	3.1[b]	1.7[c]
Yield, DM ton/acre	10.3[a]	9.14[b]	7.85[c]	5.58[d]

Nigon et al., 2016

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Normal vs. high cutting height

Average of 7 studies		
Cutting height, inches	7	21
NDF, %	40	37
ivNDFD, % of NDF	52	56
Starch, %	32	35
Yield, ton of DM/ac	7.7	6.8
Milk, lb/ton	3291	3422
Milk, lb/ac	21407	19917

Ferraretto et al., 2018

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Take-home message

- Cutting height improves quality but at the expense of reduced yield
- Cutting height may be a feasible option to improve forage quality when area is not a limiting factor
- Perhaps the combination of greater plant population and cutting height could lead to improved quality without compromising yields

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Predicting the benefits of CH

- Several studies have evaluated the influence of cutting height corn silage yield and quality
- However, an evaluation across multiple studies has yet to be conducted
- Our objective was to assess the influence of cutting height on nutrient composition and yield of whole-plant corn silage through a meta-analysis

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Cutting Height Equations

Item	n	Intercept	Slope	P - value
DM, % of as fed	62	32.50	0.218	0.02
Starch, % of DM	55	27.70	0.208	0.01
NDF, % of DM	64	43.54	-0.248	0.001
Lignin, % of DM	25	3.65	-0.029	0.08
NDFD[1], % of NDF	49	50.31	0.202	0.01
DM yield, t/ha	52	17.82	-0.122	0.001

[1]NDFD = ruminal in vitro or in situ NDF digestibility at 30 or 48 h

Paula et al., 2019; ADSA Abstract

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Simulation

	CS	High-cut CS	High-cut simulation
Cutting height, inches	6	24	24
NDF, % of DM	37.7	33.8	33.2
Starch, % of DM	37.5	41.7	41.1
NDFD, % of NDF	49.6	52.7	53.2
Yield, DM ton/acre	8.9	8.1	8.0

Data adapted from Ferraretto et al., 2017
Simulation performed with equations by Paula et al., 2019

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Conclusions

- Many factors alter nutrient digestibility of whole-plant corn and sorghum silage
- Processing and maturity at harvest remains the most important factors to improve digestibility
- Storing feedstuffs for longer or increasing cut height may be viable options but inventory planning is required

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Questions

lferraretto@ufl.edu

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