Corn silage for Dairy Cattle: Past, Present & Future

Randy Shaver, Ph.D., PAS, ACAN

Dairy Science Department

THE UNIVERSITY of WISCONSIN MADISON

UW Extension

DEPARTMENT OF DAIRY SCIENCE University of Wisconsin-Madison

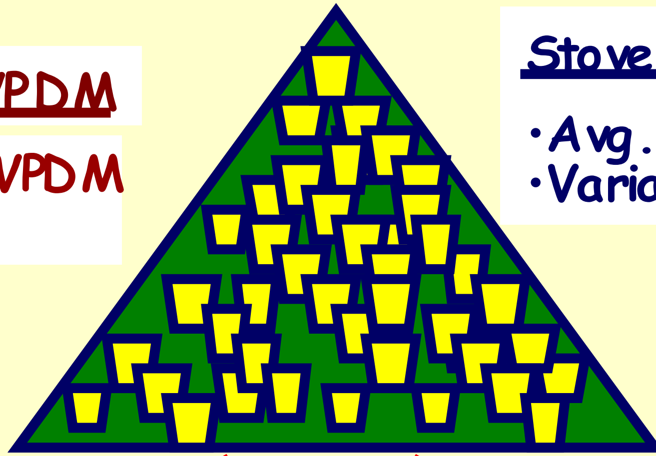
Corn Silage's Past
(30-35 years ago)

- "Well-eared" 51% NDF in (US Canadian Feed Tables, 1982) & "Normal" 45% ± 5% NDF in (Dairy NRC, 2001 Feed Tables)
- No Corn Silage hybrid selection programs
- Neither starch nor ivNDFD assayed by commercial labs
- At least for Wisconsin, generally
  - Worst fields of corn chopped for silage
  - Targeted to replacement heifers and dry cows
  - Only up to 25% of forage DM if fed to milking cows
- Fine chopping (1/4th-3/8th" or 6-10 mm TLOC)
  - No kernel processing
  - No peNDF focus
- Use of uprights so tendency to chop drier (>40% DM)
- Very limited use of microbial inoculants

Today's Corn Silage

- 41% ± 5% NDF, 54% ± 5% $ivNDFD_{30}$, 32% ± 7% Starch
- Corn Silage hybrid selection programs with Starch, ivNDFD, & Quality Index focus
- BMR & other "silage specific" commercial hybrids
- Starch, ivNDFD, & uNDF assayed by commercial labs
- Predominant forage in milking cows rations
- Kernel processing the norm
    - StarchD focus
    - Longer chop lengths (3/4th-1" or 19-26 mm TLOC)
        - peNDF focus
- Custom harvesters more the norm
- Horizontal silos, 35% harvest DM target, & use of microbial inoculants typical

Whole-Plant Corn Silage

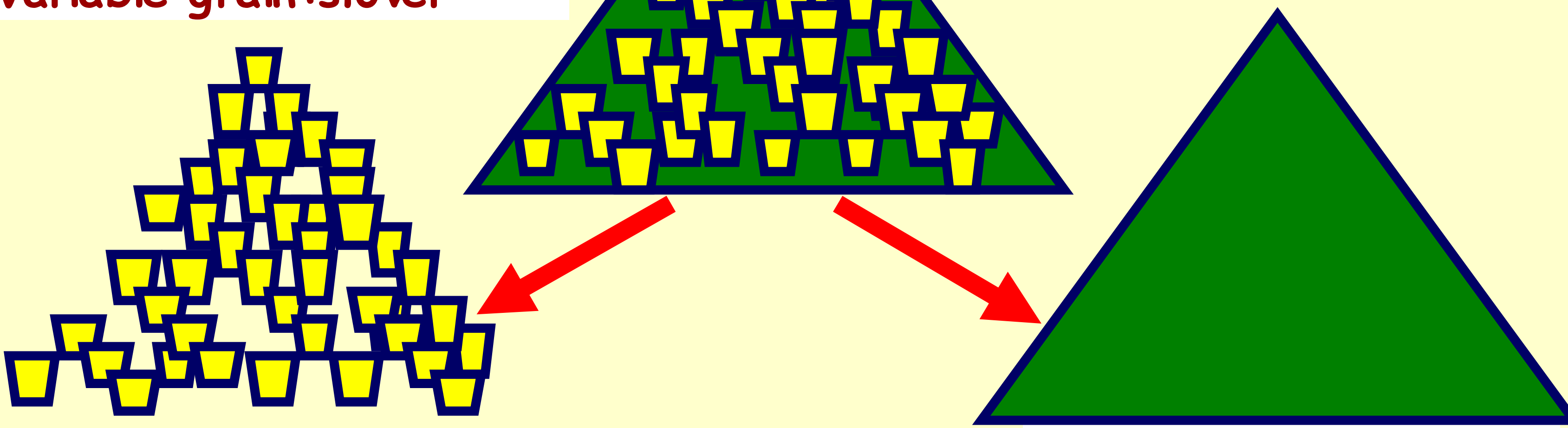


Grain ~40-45% of WPDM

- Avg. 32% starch in WPDM
- Variable grain:stover

Stover= ~55-60% of WPDM

- Avg. 41% NDF in WPDM
- Variable stover:grain



80 to 98% StarchD

- Processing, particle size
- Fermentation
- Maturity
- Endosperm properties
- Additives (exp.)

40 to 70% IVNDFD

- Lignin/NDF
  - ✓ Hybrid Type
  - ✓ Environment; G × E
  - ✓ Maturity
- Cutting height
- Additives (exp.)

Variable peNDF as per chop length

Adapted from Joe Lauer, UW Madison Agronomy Dept.

Corn Silage Quality Indicators for High-Producing Dairy Herds

Parameter	Indicates Better Quality	Primary Reason
NDF	↓	↓ Rumen Fill Limitation of DMI Potential for production response or feeding of higher-forage diets
Lignin	↓	
$uNDF_{240}$	↓	
$NDFD_{30}$	↑	
Starch	↑	↑ Energy Density Potential for production response or feeding less corn grain

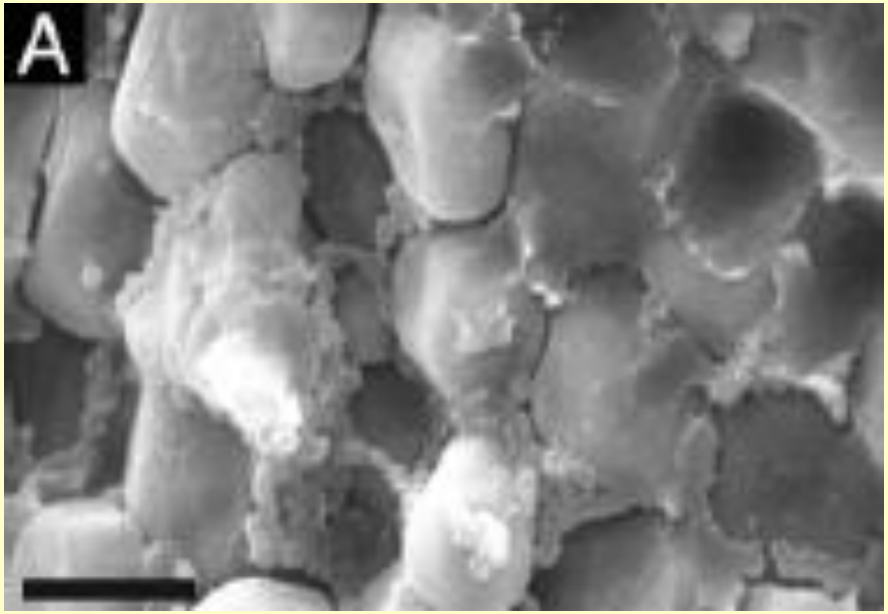
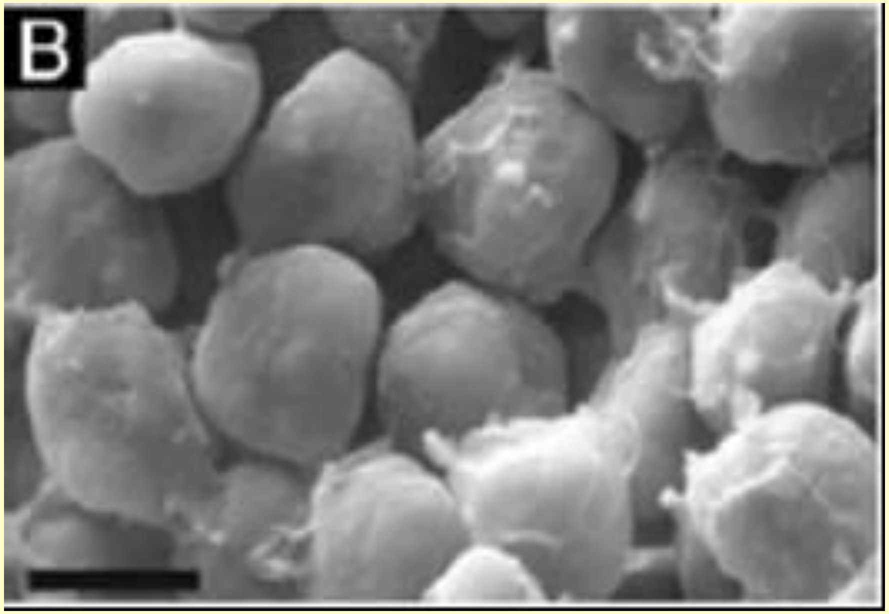
Corn Silage Starch (or NDF) %

- Hybrid impacts grain yield potential, possibly grain:stover ratio, & thus the potential starch %
- But actual starch % largely uncontrolled since varies depending on:
  - Crop growing conditions (i.e. rainfall amounts & timing)
  - Harvest timing relative to kernel maturity
  - Cutting height
- Survey of 4 commercial labs; over 300k samples
  - Normal range was 25% to 39%

Corn Silage NDFD

- **Reduced lignin & corresponding greater ivNDFD, DMI & milk yield have consistently been reported for bm_3-type corn silage hybrids in research trials**
- **15-year data summary from UW-Madison Agronomy Dept. hybrid performance trials**
  - bm_3 ivNDFD 6%- to 11%-units greater than trial averages
  - Milk per ton consistently greater than trial averages
  - Starch % & DM yield per acre trended lower for the bm_3 hybrids included in those trials
- **For conventional-type hybrids, progress in improving ivNDFD has been slow & small relative differences among hybrids often observed**

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).

Corn Silage StarchD

- Hybrid selection for kernel endosperm properties to improve StarchD very slow to evolve
- Genetic effects on StarchD tempered in corn silage
  - Harvest should be completed pre-blacklayer
  - Kernel processed during harvest
  - Prolonged silo storage increases StarchD
- No standardized agreed upon method for assessing differences in StarchD among samples
- When altering kernel endosperm properties in WPCS cannot ignore potential for negative changes in Starch (NDF) %, ivNDFD or agronomics

Corn Silage Harvesting

- **Conventional Processors**
  - 17-22 mm TLOC
  - ≈20% Roll speed differential
  - 1-2 mm Roll Gap

- **Contemporary Processors**
  - 17-26 mm TLOC
  - 40-50% Roll speed differential
  - 1-3 mm Roll Gap
  - Alternative processor type
    - Cross-grooved rolls
    - Intermeshing discs

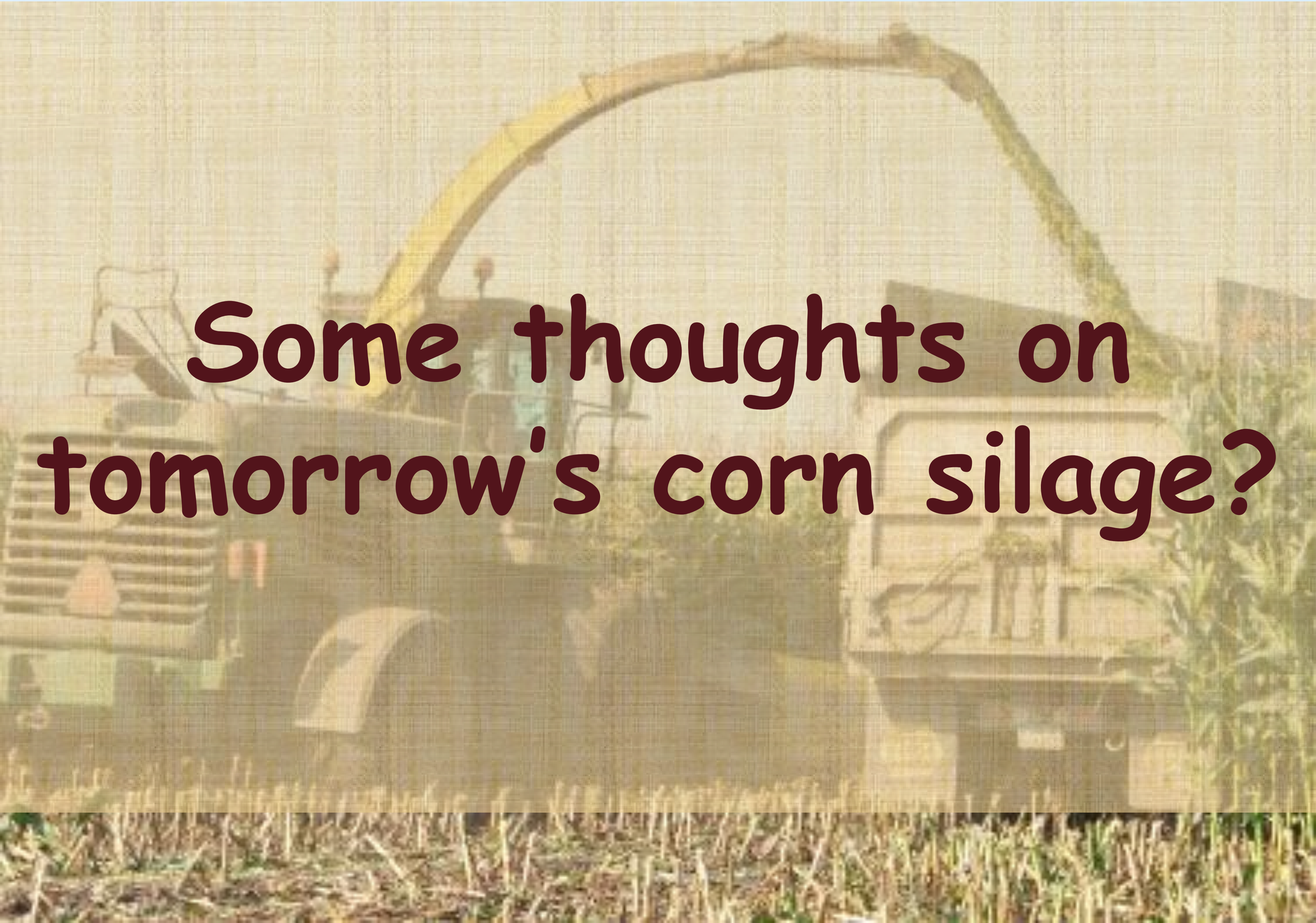
Corn Silage Harvesting

- On-the-go TLOC & inoculant rate adjustments to SPFH using on-board NIRS DM measurements
- Earlage/Snaplage heads on SPFH

Corn Silage Microbial Inoculants

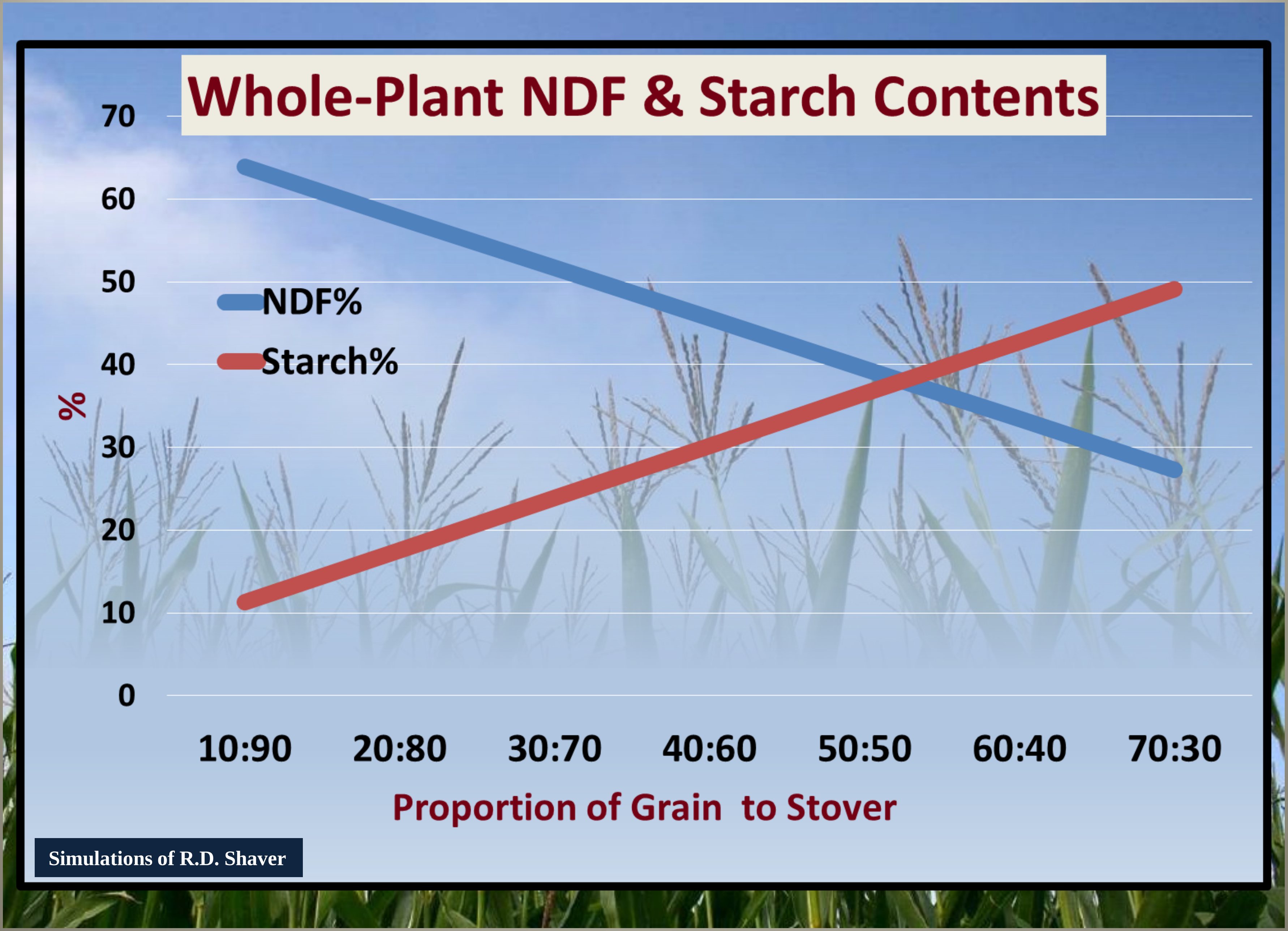
- Back-end feedout stability focus versus front-end pH drop focus
- Lactobacillus buchneri use to increase acetate relative to lactate
- Use of L. plantarum/L. Buchneri combo products
- Experimental interest in potential effects on ivNDFD & StarchD

Some thoughts on tomorrow's corn silage?



Will continued grain yield increases cease being our friend?

i.e. we are already seeing 30% NDF, 40% starch sample analyses on corn silage from dairy farms


Whole-Plant NDF & Starch Contents
70
60
50
40
30
20
10
0
%
NDF%
Starch%
10:90
20:80
30:70
40:60
50:50
60:40
70:30
Proportion of Grain to Stover
Simulations of R.D. Shaver

Corn Silage Hybrid Considerations

- >Stover Yield to balance >Grain Yields
- Earlage quality
- Replacement Heifers & Dry Cows
  - Low Grain, Starch Contents
- Output trait focus?
  - NDFD; StarchD;
  - Linloleic Acid; Amino Acids

Corn Silage NDFD

- **Brown midrib mutation**
  - 1st discovered in 1924 at UMN
  - 4 mutants identified; bm1 (1931) – bm4 (1947)
  - Some agronomic & yield drag constraints inherent to mutants remain
- **Low-Ferulate corn mutant**
  - Published on recently by Hans Jung's group at USDA/UMN
  - Similar lignin % but altered lignin chemistry
- **Transgenics or CRISPR?**

Corn Silage StarchD

- **Genetic or transgenic modifications studied**
  - **Comparisons of Flint, Dent, Reduced-Vitreousness Dent, Floury, Opaque, Waxy Endosperm in Conventional Hybrids** (numerous citations but few feeding trials)
  - **Floury-Leafy Hybrid** (Ferraretto et al., 2015, JDS; Morrison et al., 2014, JDS abstr)
  - **Floury-BMR Hybrid** (Morrison et al., 2016 JDS abstr)
  - **α-Amylase expressed in kernel** (Hu et al., 2010, JDS; trials in progress)

Floury BMR

Grant et al., 2017, CNC

	CCS[1]Starch (TMF2R447)	bm_3[1] (F2F498)	EXP bm_3[1] (FBDAS3)
DMI, lb/d	59[b]	62[a]	61[ab]
Milk, lb/d	96[b]	104[a]	106[a]
Fat, %	4.00[a]	3.85[b]	3.87[b]
ECM, lb/d	104[b]	111[a]	114[a]
ECM/DMI	1.76[b]	1.79[b]	1.87[a]
MNE, %	35[c]	38[b]	40[a]
Total Tract Digestiblity, %			
OM	74	75	74
NDF	58	58	58
Starch	99	99	99

[1]Fed in TMR containing 49% corn silage and 6% haycrop silage (DM basis) in 5x replicated 3 × 3 Latin Square design with 28d periods

High-Amylase Corn Hybrids

- Syngenta
  - Enogen Feed Corn (EFC)
- GMO
  - Greater kernel amylase as kernel matures
- Developed for ethanol industry
  - Conversion of starch to sugars prior to yeast fermentation
- Recent approval for feeding to livestock
- Animal performance benefits?; WPCS Yield drag?; Seed/Trait Costs?

Corn Silage Harvesting

- TLOC & KPS
  - Fiber Shredding?
  - KPS by image analysis (Luck's app)
- Earlage/Snaplage
- Toplage/Stalklage?
- Use of on-board NIRS & GPS to better manage harvest for more consistent quality

Corn Silage Microbial Inoculants

- Nutrient digestibility focus
- Mold/Yeast inhibition

Corn Silage
Feeding Considerations

- Supplementing higher corn silage diets
  - peNDF
  - Soluble Fiber
  - Rumen buffering
  - Protein/Amino Acids
- Feeding all reduced lignin, high NDFD forages
- Better incorporation of digestion kinetics into forage evaluation & development of feeding programs

Questions?

DEPARTMENT OF DAIRY SCIENCE
EXCELLENCE IN EDUCATION AND DISCOVERY
UNIVERSITY OF WISCONSIN - MADISON
www.wisc.edu/dysci

THE UNIVERSITY of WISCONSIN MADISON

UW Extension