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

Mention of companies, labs, trade names, products or assays solely for the purpose of providing specific information or examples and does not imply recommendation, endorsement or exclusion.

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

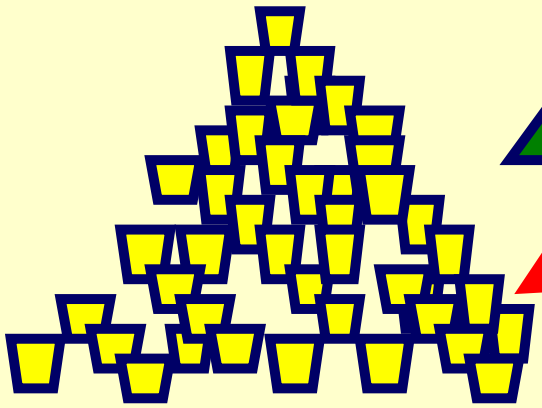
Whole-Plant Corn Silage

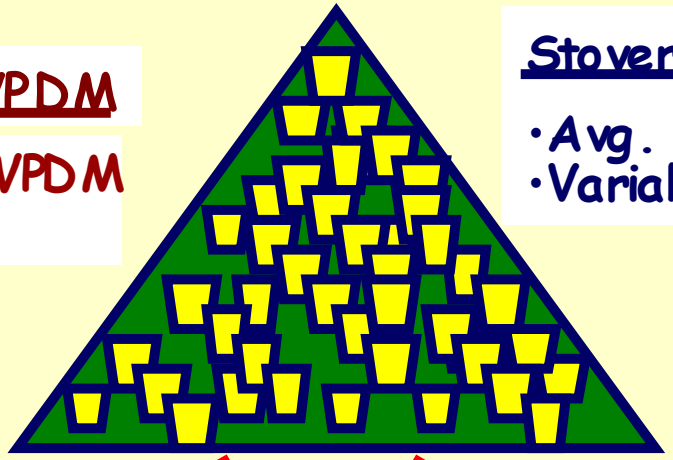
Grain ~40-45% of WPDM

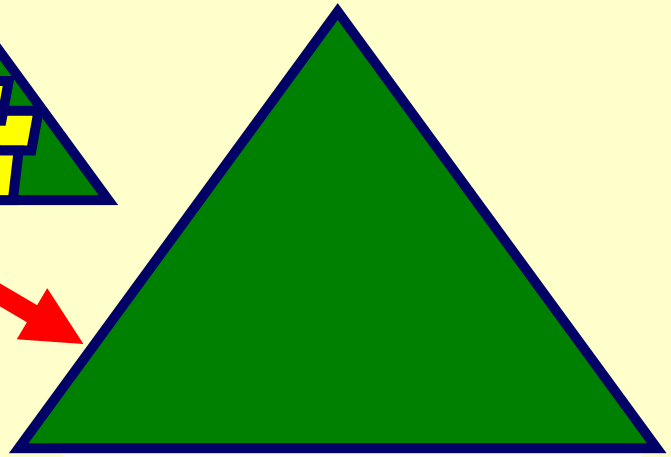
- Avg. 32% starch in WPDM
- Variable grain:stover

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% TVNDFD

- 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**

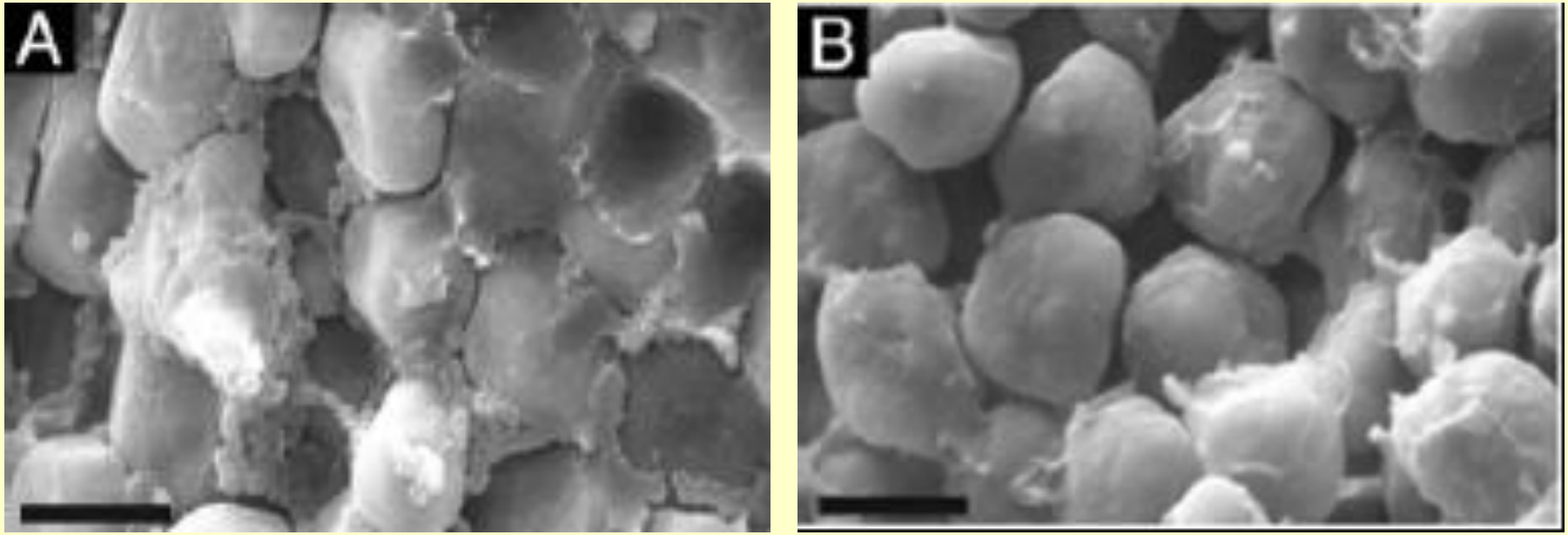
- **15-year data summary from UW-Madison Agronomy Dept. hybrid performance trials**
  - bm_3 ivNDFD 6%- to 11%-units greater than trial averages
  - Milk per ton consistently greater than trial averages
  - Starch % & DM yield per acre trended lower for the bm_3 hybrids included in those trials

- **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

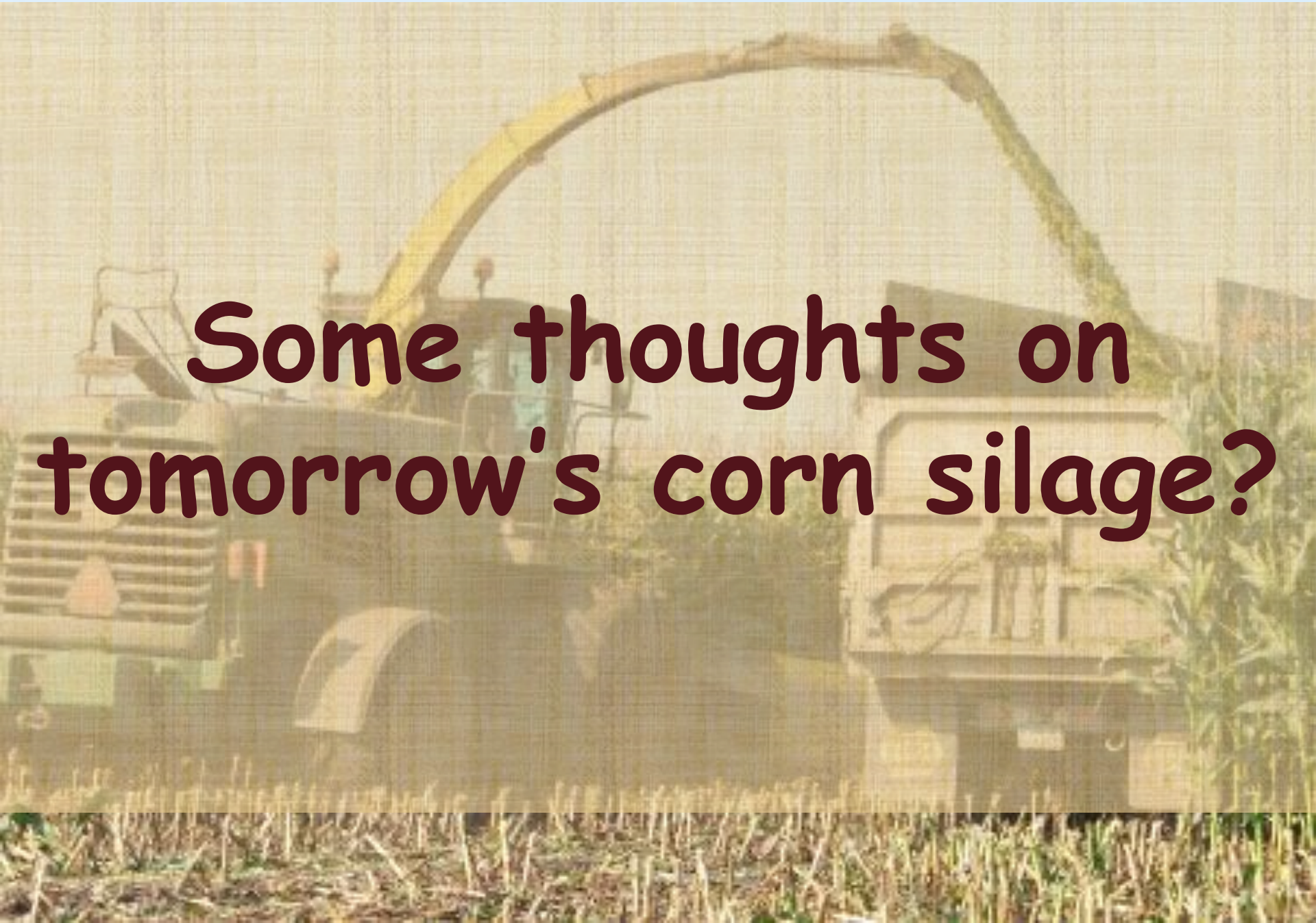
- **Conventional Processors**
  - 17-22 mm TLOC
  - ≈20% Roll speed differential
  - 1-2 mm Roll Gap
- **Contemporary Processors**
  - 17-26 mm TLOC
  - 40-50% Roll speed differential
  - 1-3 mm Roll Gap
  - Alternative processor type
    - Cross-grooved rolls
    - Intermeshing discs

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

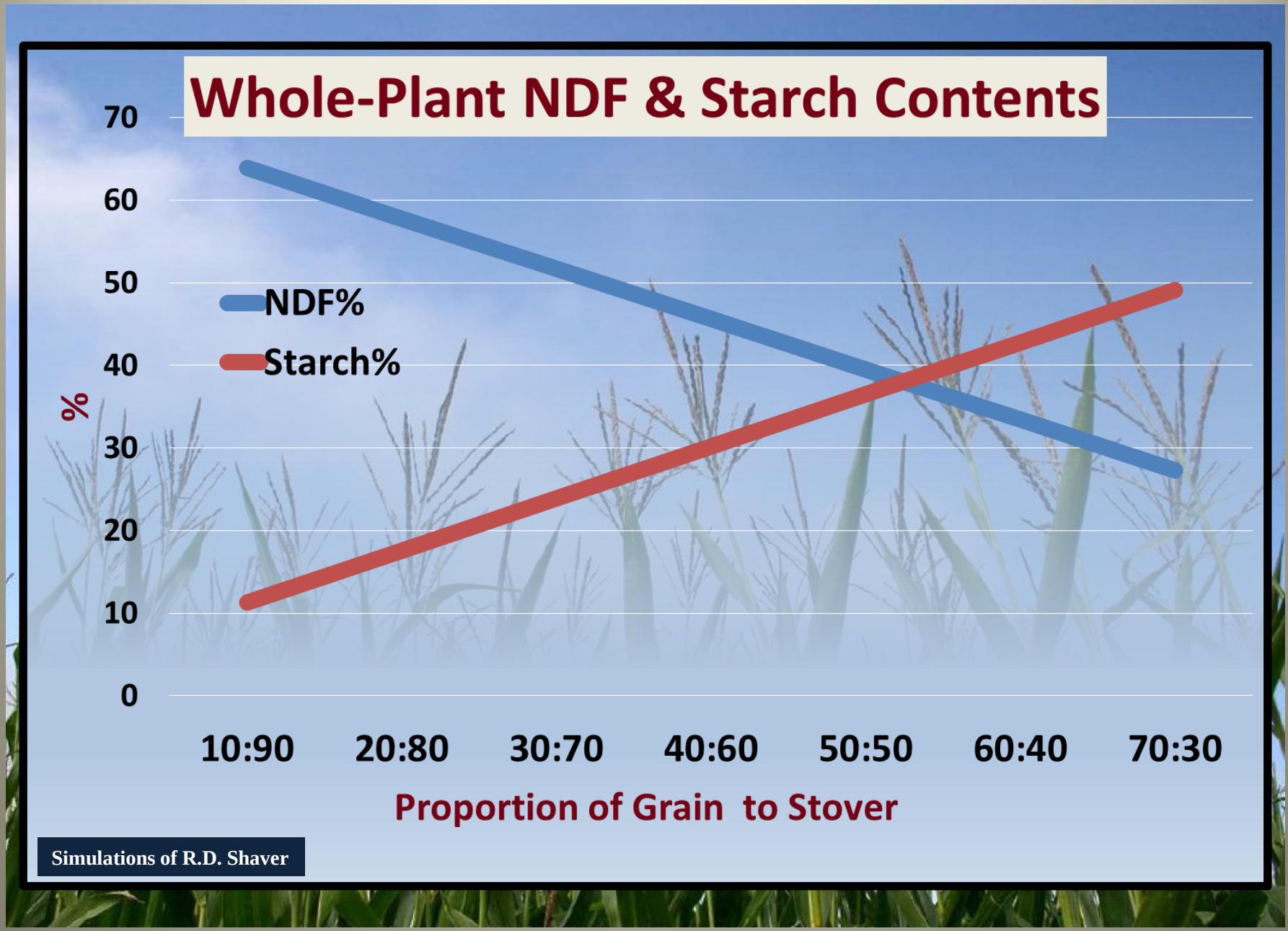
- Back-end feedout stability focus versus front-end pH drop focus
- Lactobacillus buchneri use to increase acetate relative to lactate
- Use of L. plantarum/L. Buchneri combo products
- Experimental interest in potential effects on ivNDFD & StarchD



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