On the Road to a New Sweet Sorghum Industry in the USA

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Presentation Outline

- Key value added products from sugar feedstocks – the “Sugar Platform”

- Advantages of sweet sorghum over other crops

- USDA-ARS New Orleans research on sweet sorghum

- Largest operational sweet sorghum biorefinery in USA: Heckemeyer Mill, Sikeston, Missouri, USA

- Overcoming processing problems with help of USDA scientists
Sugar Platform
Biomass Conversion Technologies

- **BIOCHEMICAL**
  - Sugar Fermentation Platform

- **CHEMICAL**
  - Oleochemical/Chemical Platform

- **THERMOCHEMICAL**
  - Gasification Platform

- Fuels, Chemicals, Energy & Co-products
Key Value Added Products from Sugar Feedstocks
“Sugar Platform”
– From Chemical or Biocatalytic Processes

C6 or C5 Sugars

C6
Citric acid → Food preservative
Gluconic acid → Food acidulant
Lysine → animal feed
HMF → plastics
Glucaric acid
Sorbitol

C6 or C5 Sugars

C5
Furfural → Industrial solvents
Levulinic acid → Rubber/resins
Xylitol → low calorie sweetener
Glutamic acid
Itaconic acid

C2
Ethanol → Liquid fuel
Acetic acid → Wood glue
Glyoxylic acid → skin care products

C3
Lactic acid → PLA
Biodegradable plastic
1,2-Propanediol
3-Hydroxy Propionic acid
Acrylic acid

C4
Butanol → Liquid fuel
Succinic acid → Polymers/surfactants/adhesives

Aspartic acid
Butanediol
The Development of the **Sugar Platform** Will Depend On:

- Application of chemical and bio-catalysts to transform sugars into useful biobased chemical intermediates and downstream products
- Successful scaling up of biocatalysts from “proof-of-concept” experiments on a laboratory scale to commercial industrial process scale - *only beginning to emerge*
- Availability of economic, readily-available source or sources of sugar feedstocks (expected to transition to ligno-cellulosic derived sugars)
  - At present mainly focused on corn, cassava starch, and sugarcane molasses
- Availability of stable, transportable, and storable feedstocks for year-round use
Sweet Sorghum
Advantages of Sweet Sorghum over Other Crops for Biofuels and Bioproducts

- Adapts well to adverse environments
  - Requires relatively low inputs

- Very high energy balance
  - Comparable efficiency as sugarcane

- Can be used in existing ethanol factories
  - Much easier to ferment than corn with higher ethanol output potential

- 1 - 2 crops per year (Temperate)
  - Improves economics immensely

- Can be processed with a dual feed stock
  - Makes it a low cost seasonal crop
    - Sugarcane and sugar beet

- Genetic improvement potential is HUGE
  - Hybrid and tailor made sweet sorghum cultivars

Can be processed with a dual feed stock
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World Map Depicting Approximate Areas Where Sweet Sorghum, Sugarcane, and Sugar Beet can be Grown

Adapted from Debor (2009).
USDA-ARS Sweet Sorghum Research
Objectives of the New Sugar & Energy CRIS Project
2014-2019

- All objectives and sub-objectives are focused on solving industry problems after discussions with numerous industrial stakeholders
Interrelationships of New Project Objectives

Develop Technologies That Enable Growth and Profitability in the Commercial Conversion of Sugarcane, Sweet Sorghum, and Energy Beets into Sugar, Advanced Biofuels, and Bioproducts

Sugarcane for Sugar Manufacture

Objective 1. Develop commercially-viable technologies that reduce undesirable effects of starch and color on processing and end-product quality.

Objective 2. Develop commercially-viable technologies that reduce or eliminate undesirable effects of high viscosity on sugar processing and end-product quality.

Objective 3. Develop commercially-viable technologies to increase the stability and lengthen storage of sugar feedstocks.

Sweet Sorghum and Energy Beets for Advanced Biofuels and Bioproducts Manufacture

Objective 4. Develop commercially-viable technologies for the biorefining of sugar crop feedstocks into advanced biofuels and bioproducts.

Objective 5. Identify and characterize field sugar crop traits that affect sugar crop refining/biorefining efficiency, and collaborate with plant breeders in the development of new cultivars/hybrids.

Objective 6. Develop, in collaboration with commercial partners, technologies that enable production of marketable products from residues and by-product streams.

Develop Technologies That Enable Growth and Profitability in the Commercial Conversion of Sugarcane, Sweet Sorghum, and Energy Beets into Sugar, Advanced Biofuels, and Bioproducts
Largest Sweet Sorghum Biorefinery in USA
Sikeston, Missouri, USA

- Poultry
- Cattle
- Timber
- Row crop sweet sorghum
HECKEMEYER MILL

2015
Row-cropped sweet sorghum
- Multiple Cultivars: e.g., M81E, Honey Drop, Dale, and KN Morris

- Plant late May/Early June

- Stagger the rotation for timely harvest

- Process from Mid August (depends on Juice Brix)

- Modified Forage Harvesting - up to 2.5 inch billets
Double Tandem 4 ft Wide Roller Mill
Overcoming Processing Problems with Help of USDA Scientists

Aim: Large, Commercial Scale Manufacture of Food Grade and Non-Food Grade Syrup
August to October, 2014
Major Starch Problem

Eggleston et al (2015.). Sugar Tech
Heated, De-aerated Sweet Sorghum Juice

Scum formed on surface

Formation of Flocs (Light Color) which are Starting to Precipitate

Clarified (Clean) Juice

92% Turbidity Removal over 1 hr

Eggleston Clarification Process
New Late Season Problem

Light Green Scum Formation on Surface of Clarification Tank

- Has to be skimmed off or filter pressed
- Highlights seasonal variations that warrant further investigation

7.93 ± 0.52% protein on a dry wt basis
Syrup (Long-Term) Storage
Overall Process and Supply Chain for Syrup Production at Heckemeyer Mill

Extraction → De-aeration → Settling → Heating → Clarification → Evaporation

ensiled bagasse → sediment → mud

High Value Cattle Feed

V. minimal waste processing
Capacity of Mill is 90 tons/hr which is approx. 120 acres/day or 24,000 gals of 80 Brix syrup/day
Thank You