Improving the Value and Utilization of Distillers Grains

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SYs Involved

- **1 SY**
  - Kurt A Rosentrater
    Lead Scientist
    Agricultural and Bioprocess Engineer

- **OSQR Review**
  - Approved July, 2006

North Central Ag Research Lab

- Brookings, SD
  - Staff
    - 12 SYs
    - 25 technical and support
    - Various undergraduate/graduate students (SDSU)
  - Research
    - 3 projects
      - Entomology ecology
      - Agronomic cropping systems for sustainable agriculture
      - Utilization of byproducts from biofuels manufacturing

North Central Ag Research Lab

- Eastern South Dakota Soil and Water Research Farm
  - 140 acres

Capabilities/Instrumentation

1) Analytical balances
2) Bench-scale centrifuges
3) Colorimeter/spectrophotometer
4) Cone-plate viscometers
5) Constant temperature water baths
6) Constant-humidity tempering chambers
7) Differential scanning calorimeter
8) Fiber analyzer
9) Forced air convection ovens
10) Freezers
11) Helium pycnometer
12) Inductively-coupled plasma optical emission spectrometer
13) Instron material properties tester
14) Jenike shear cell
15) Leco C-N analyzer
16) Light microscopes
17) Melting point meter
18) Mixing, blending, and milling machines
19) Penetrometer
20) Ph meters
21) Powder characteristics and flowability tester
22) Refrigerators
23) Rotap shaker with standard sieving screens
24) Stainless steel vessels and reactors
25) Stationary and shaking constant temperature incubators
26) Surface tensiometer
27) Thermal properties meter
28) Top loading balances
29) Water activity meter

ARS Bioenergy & Energy Alternatives

Bioenergy & Energy Alternatives

National Goals

- Energy Security
- Environmental Quality
- Rural Economy

Program Goals

- Sustainable Energy From Agriculture
  - Energy efficient
  - Economic
- Understand Recalcitrance Of Biomass
- Exploit Potential Of Molecular Biology
  - Plant quality and quantity
  - Conversion organisms
- Match Feedstock Characteristics With Conversion Requirements
- Devise Value-Added Biofuel Coproducts
- Meet Rural Energy Needs
  - Liquid fuel
  - Electricity
  - Heat

Feedstock To Fuel

Feedstock

Starch, Lipid, and Cellulosic

- Crops
- Crop residues
- Byproducts
- Wastes

- Design
- Produce
- Harvest
- Characterize
- Enhance
- Deliver

Conversion

Biological and Thermochemical

- On-farm
- Local community
- Biorefinery

- Processes
- Organisms
- Product separation
- Efficiency

Fuel

- Ethanol
- Biodiesel
- Biogas
- Hydrogen

- Quality
- Performance
- Uses

Coproducts

- Food
- Feed
- Biobased industrial

- Devise
- Quality
- Functionality
- Uses

Partnership to Address Coproducts

- CRIS # 5447-41000-001-00
  - Fiber Extrusion to Improve Use and Production of Ethanol Byproducts – USDA ARS NCARL
- CRIS # 5447-41000-001-01
  - Improved Uses and Values for Dried Distillers Grains and C4 Grass Feedstocks – MBI
- CRIS # 5447-41000-001-02
  - Assess Utility and Value of Modified Dried Distillers Grains – SDSU

MBI Objectives

- Assess the value of distillers dried grains in a biorefinery system, specifically:
  - Develop high protein distillers dried grains using germ removal
  - Establish a pretreatment laboratory for C4 grass feedstock processing
  - Develop ammonia fiber explosion (AFEX) pretreatment process for corn stover and C4 grass feedstocks
  - Develop beef rations from distillers dried grains and ammonia fiber explosion (AFEX) treated corn stover
  - Establish a pilot plant for C4 grass feedstocks processing

SDSU Objectives

- Assess the value of distillers dried grains and modified distillers dried grains in livestock diets, specifically:
  - Beef cattle diets
    - Develop and assess delivery systems to provide ethanol co-products to range cattle
    - Assess ruminal characteristics of protein, fiber and carbohydrate components of current and future ethanol co-products
  - Dairy cattle diets
    - Conduct preliminary and in-depth investigations on nutritional characteristics and nutrient flux of ethanol co-products fed to dairy cattle

ARS NCARL Research

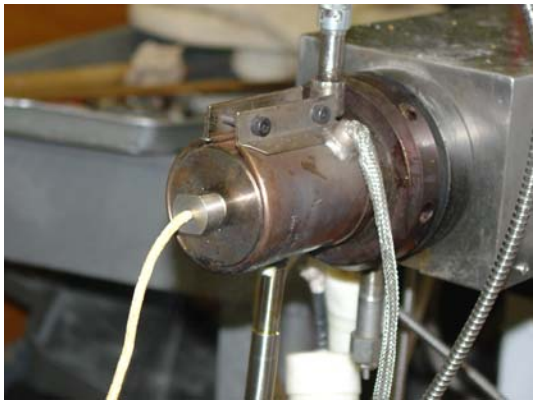
- Objective #1 – Storability & Flowability
  - Identify, characterize, and determine
    - Physical and chemical properties of DDGS
      - Cause bridging & caking
      - Currently result in economic losses

ARS NCARL Research

ARS NCARL Research

ARS NCARL Research

- Objective #2 – Value-Added Feeds
  - Develop and evaluate processes for
    - Converting DDGS into high-value feeds
      - Extrusion processing
        - » Aquaculture feeds (tilapia)
        - » Pet foods



ARS NCARL Research

- Objective #2 – Value-Added Feeds
  - Develop and evaluate processes for
    - Converting DDGS into high-value feeds
      - Pellet mill processing
      - Beef & dairy rations

ARS NCARL Research

- Objective #3 – Value-Added Bio-Materials
  - Develop and evaluate processes for
    - Converting DDGS into other products
      - » Foods
      - » Industrial composites

Collaborations

- Expanding partnership base

Flowability

- SDSU
  - ABE Department
- Bay State Milling
- Dakota Ethanol
- FWS Design Builders
- Iowa State Univ.
- National Corn-to-Ethanol Pilot Plant
- Purdue Univ.
- Todd & Sargent, Inc
- USDA-ARS ERRC
- VeraSun

Value-Added Feeds

- SDSU
  - ABE Department
  - Animal Science Dept.
  - Dairy Science Dept.
  - Fisheries & Wildlife Biology
- Andritz-Sprout
- California Pellet Mill
- Dakota Ethanol
- Insta Pro International
- USDA-ARS ERRC
- VeraSun

Bio-Materials

- SDSU
  - ABE Department
  - Food Science Dept
  - Rapid Prototyping Consortium
- Dakota Ethanol
- Northern Illinois Univ.
- Rotex Corp.
- USDA-ARS ERRC
- USDA-ARS HNRC
- USDA-ARS US DFRC
- VeraSun

Recent Accomplishments

- Conclusions thus far…
  - Flowability problems appear to be impacted by
    - Moisture content, storage pressure, temperature, time
  - DDGS appears to be a promising protein alternative compared to fish meal
    - But the lack of starch poses challenges with durability and cohesion
  - DDGS appears to be a promising biodegradable filler
    - But inclusion does lead to decreased mechanical strength
  - DDGS appears to be a promising substitute for flour
    - But as inclusion level increases, baking functionality, flavor, and color are negatively impacted

Recent Accomplishments

- Relevant publications – flowability

- Ganesan, V., K. A. Rosentrater, and K. Muthukumarappan. 2006. Methodology to determine soluble content in dry grind ethanol coproduct streams. *Applied Engineering in Agriculture* 22(6).
- Rosentrater, K. A. 2006. Understanding distillers grains storage, handling, and flowability challenges. *Distillers Grains Quarterly* 1(1): 18-21.
- Rosentrater, K. A. 2006. Understanding flowability – Part 2: Some key parameters. *Distillers Grains Quarterly* 1(2): 20-23.
- Rosentrater, K. A. 2006. Understanding flowability – Part 3: Some physical properties of DDGS. *Distillers Grains Quarterly* 1(4): 14-17.
- Rosentrater, K. A. and K. Muthukumarappan. 2006. Corn ethanol coproducts: generation, properties, and future prospects. *International Sugar Journal* (in press).
- Ganesan, V., K. Muthukumarappan, and K. A. Rosentrater. 2006. Effect of flow agent addition on the physical properties of DDG with varying moisture content and soluble percentages. 2006 ASABE Annual International Meeting, Portland, OR. Paper No. 066076.
- Ganesan, V., K. A. Rosentrater, and K. Muthukumarappan. 2005. Effect of temperature and relative humidity on the physical properties of DDGS with varying solubles. 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 056110. St. Joseph, MI: ASAE.
- Ganesan, V., K. A. Rosentrater, and K. Muthukumarappan. 2005. Flowability and Handling Characteristics of Bulk Solids and Powders – A Review. 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 056023. St. Joseph, MI: ASAE.

Recent Accomplishments

- Relevant publications – feed

- Chevanan, N., K. A. Rosentrater, and K. Muthukumarappan. 2006. Viscosity modeling of dough containing distillers grains in a single screw extruder. Transactions of the ASABE (in review).
- Chevanan, N., K. Muthukumarappan, and K. A. Rosentrater. 2006. Effect of Die Dimensions on Extrusion Processing Parameters and Properties of DDGS Based Extrudates. Cereal Chemistry (in review).
- Chevanan, N., K. A. Rosentrater, and K. Muthukumarappan. 2005. Effect of whey protein as a binder during the extrusion of fish feed pellets. 2005 North Central ASAE/CSBE Conference, Brookings, SD. ASAE Paper No. SD05-100. St. Joseph, MI: ASAE. Presented September 30, 2005.
- Chevanan, N., K. A. Rosentrater, and K. Muthukumarappan. 2005. Utilization of Distillers Dried Grains for Fish Feed by Extrusion Technology – A Review. 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 056025. St. Joseph, MI: ASAE. Presented July 18, 2005.
- Chevanan, N., K. A. Rosentrater, and K. Muthukumarappan. Physical properties of extruded tilapia feed with distillers dried grains with solubles. 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 056169. St. Joseph, MI: ASAE. Presented July 19, 2005.

Recent Accomplishments

- Relevant publications – composites

- Rosentrater, K. A. and A. W. Otieno. 2005. Considerations for manufacturing bio-based products. Journal of Polymers and the Environment 14(4): 1-12.
- Tatara, R. A., S. Suraparaju, and K. A. Rosentrater. 2006. Compression molding of phenolic resin/corn-based DDGS blends. Polymers and the Environment (in review).
- Otieno, A., R. Tatara, S. Suraparaju, and K. A. Rosentrater. 2006. Analytical and experimental studies of properties of ethanol coproduct-filled plastics. 2006 IJME/Intertech International Conference. Kean University, Union, NJ. Presented October 21, 2006.
- Rosentrater, K. A. and J. Visser. 2006. Parametric simulation modeling of injection molding plastic composites with bio-based fillers. 2006 IJME/Intertech International Conference. Kean University, Union, NJ. Presented October 21, 2006.

- Relevant publications – food

- Rosentrater, K. A. and P. Krishnan. 2005. Incorporating distillers grains in food products. Cereal Foods World 51(2): 52-60.
- Rosentrater, K. A. and P. Krishnan. 2005. Update on Utilizing Ethanol Processing Residues in Food Products. 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 056026. St. Joseph, MI: ASAE. Presented July 18, 2005.

Thank You

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