USDA Ongoing Research with Dietary Fiber

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Current Research at USDA
- Enhance nutrient utilization and animal health to increase production efficiency and minimize nutrient release to environment.
- Multidisciplinary/collaborative approach.
  - Integration of physiological, molecular, and whole animal studies.
  - Gene expression analysis
  - Physiological biomarkers
  - "Feed & weight"
  - Proteins

Fiber in Swine Diets
- Increase endogenous protein loss
- Decrease absorption of dietary N and lipids
  - Decrease urea excretion
  - Lipid metabolism and meat quality
- Increase in intestinal mass (some cases)
  - Maintenance requirements
  - Increased O2 consumption by portal drained organs
- Increased heat increment
- Variable effects
- Dealing with fiber in swine diets
  - Feed little to none
  - Enzymes
  - Genetics

Dietary Fiber-holistic approach
- Nutrient utilization;
  - Effects of fiber on intestinal and whole body energy metabolism, gene expression, and inflammation.
- SCFA effects on growth, energy metabolism, body composition and immune function.

The fiber source
<table>
<thead>
<tr>
<th>Fiber Source</th>
<th>NDF</th>
<th>ADF</th>
<th>HC</th>
<th>Cell.</th>
<th>Lignin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>10</td>
<td>3</td>
<td>7</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td>SBM</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>DDGS</td>
<td>26</td>
<td>10</td>
<td>16</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>CGM</td>
<td>53</td>
<td>12</td>
<td>41</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>HP-DDG</td>
<td>20</td>
<td>12</td>
<td>9</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Alfalfa Meal</td>
<td>45</td>
<td>35</td>
<td>10</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Wheat midds</td>
<td>37</td>
<td>10</td>
<td>27</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Hemicellulose Dose Response
- Objectives: 1) Corn fiber (NDF, HC) tolerance by growing pigs; 2) Physiological adaptations to high fiber.
- n = 48 growing gilts (30.8 ± 0.9kg), individually penned
- 4 dietary fiber/hemicellulose levels
  - 6.2-16% HC, ME allowed to float.
- BW and ADFI measured weekly
- Plasma energy metabolites on lowest and highest fiber levels.
- Small intestine, colon, and liver tissue collected for enzyme, mRNA, and proteins.
  - Genes involved in oxidative metabolism.
  - Intestinal and hepatic AMPK activation.
  - Tissue abundance of mitochondrial respiratory protein (COXII).
**Diet Composition**

<table>
<thead>
<tr>
<th>HC level</th>
<th>6.2%</th>
<th>10.0%</th>
<th>14.0%</th>
<th>18.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, %</td>
<td>71.04</td>
<td>62.60</td>
<td>63.76</td>
<td>44.94</td>
</tr>
<tr>
<td>SBM, %</td>
<td>25.70</td>
<td>21.65</td>
<td>17.50</td>
<td>13.30</td>
</tr>
<tr>
<td>CGM, %</td>
<td>--</td>
<td>12.55</td>
<td>25.60</td>
<td>38.69</td>
</tr>
<tr>
<td>NDF, %</td>
<td>9.67</td>
<td>14.57</td>
<td>19.67</td>
<td>24.79</td>
</tr>
<tr>
<td>ADF, %</td>
<td>3.50</td>
<td>4.56</td>
<td>5.67</td>
<td>6.78</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3.31</td>
<td>3.26</td>
<td>3.21</td>
<td>3.16</td>
</tr>
<tr>
<td>CP, %</td>
<td>17.8</td>
<td>18.7</td>
<td>19.7</td>
<td>20.7</td>
</tr>
<tr>
<td>Lys, %</td>
<td>1.05</td>
<td>1.03</td>
<td>1.02</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Growth Performance**

![Graph showing growth performance with ADG (kg) over weeks for different HC levels](image)

**Feed Intake**

![Graph showing feed intake with ADF (kg) over weeks for different HC levels](image)

**Feed Efficiency**

![Graph showing feed efficiency with Gain:Feed over weeks for different HC levels](image)

**Energy metabolites**

- **Liver weight**
- **Liver glycogen**
- **Liver TGs**
- **Plasma glucose**
- **Plasma TGs**

**Intestinal enzyme and mitochondrial proteins**

- **Alkaline phosphatase**
- **Sucrase**
- **Cytochrome c oxidase II (COXII)**

![Graph showing enzyme and protein levels](image)
Colonic gene expression

Study Outcomes

Growing pigs can tolerate relatively high levels of fiber from CGM.
- Model for feed efficiency?
- Balance for energy or will pig compensate?
- Part of adaptive response includes increased serum TGs and decreased hepatic energy stores.
- Intestine adapts by increased enzyme production and oxidative metabolic capacity.
- Mechanisms for increased mitochondrial protein?

Future Directions

- Evaluating impact of other fiber sources on whole body energy metabolism and molecular pathways.
  - Cellulose, pectin, resistant starch
  - “Modern” genetic lines.
- Impacts of dietary fiber and other nutrients on inflammation and animal health.
  - Fiber may impact translocation of bacteria and endotoxin.
  - Systemic inflammation due to alterations in energy metabolism.

Questions?