Commercial Application of Switchgrass as Renewable Alternative Bedding for Broilers in a Single-Cycle Production System

Amy Barkley\textsuperscript{1}, Paul Patterson\textsuperscript{1}, R. Michael Hulet\textsuperscript{1}, and Jude Liu\textsuperscript{2}

\textit{Department of Animal Science\textsuperscript{1} and the Department of Agricultural and Biological Engineering\textsuperscript{2}, The Pennsylvania State University, University Park, PA}
THE PROBLEM:

- Increase in diversion of wood shavings
- Variability and uncertainty in shavings market
- Availability of renewable, alternative bedding products
INTRODUCTION TO SWITCHGRASS

- 20 years continuous production (Wurzbacher, 2014)
- Produce biomass
  - 8.97-13.45 Mg/ha (Wurzbacher, 2014)
- Can be grown on marginal land (Hall, 2008)
  - Poor drainage
  - Poor fertility
- Native species
- Dries down in field (<20% moisture) (NRCS, 2011)
HISTORICAL PERFORMANCE OF SWITCHGRASS AS POULTRY BEDDING

• Mississippi State (Davis et al., 2010)
  • Replicate pen trial
  • Live performance and carcass wt not affected
  • Foot pad dermatitis lower for birds on switchgrass

• University of Delaware (Brown and Thomas, 2012)
  • 2 commercial scale switchgrass studies
    • Smaller particles prevent caking
    • 25 mm

• Mississippi State & Auburn (Davis et al., 2015)
  • Switchgrass performed equally to pine shavings in pen trial
  • No difference in performance over 3 flocks
    • Exception: 42 d FCR (Pine shavings > switchgrass)
  • Ammonia flux not different
Particle classification strongly influences potential litter performance

- **Switchgrass of 3 particle sizes vs softwood shavings** (Barkley et al., 2017)
  - Small switchgrass particles (5.3mm) perform similarly to softwood shavings
  - Longer switchgrass treatments (31.4 mm and 62.8mm) performed similarly to each other
- Bird performance not impacted
  - Day 56 BW: Softwood shavings and 5.3 mm switch best
- Footpad and breast feather cleanliness scores not different among treatments
HYPOTHESIS

Switchgrass with a larger particle size will not impact bird performance and welfare when compared to a smaller particle size, though it may impact litter performance.
**EXPERIMENTAL DESIGN**

- Two barns - Cooperator’s farm
  - Replicate cells bedded to 8.3 cm
- White organic broilers (Ross x Ross)
- December 2016-January 2017
  - 7 weeks
- SAS 9.4 - One-way ANOVA - Blocked by house - \((P \leq 0.05)\)

<table>
<thead>
<tr>
<th>Front</th>
<th></th>
<th></th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2</td>
<td>S2</td>
<td>S2</td>
<td>House 9</td>
</tr>
<tr>
<td>Cell 1</td>
<td>Cell 3</td>
<td>Cell 5</td>
<td>(non-trial region)</td>
</tr>
<tr>
<td>S1</td>
<td>S1</td>
<td>S1</td>
<td></td>
</tr>
<tr>
<td>Cell 2</td>
<td>Cell 4</td>
<td>Cell 6</td>
<td></td>
</tr>
</tbody>
</table>
MATERIALS AND METHODS
BEDDING ANALYSIS

• 3 samples of each bedding type before bird placement
  • Percent moisture
  • pH
  • Particle distribution
  • Density
  • Water holding capacity : evaporative loss (Spiehs et al., 2013)
  • Nutrient profile
    • Total N, Ammonium N, Organic N, P₂O₅, K₂O, Carbon
  • Energy density
MATERIALS AND METHODS
LITTER ANALYSIS

- Parameters evaluated at days 12, 35, and 45
  - Litter sampled from each cell for pH and moisture
  - Litter score (0-3)
  - Litter surface temperature
  - Ambient ammonia
- Nutrient analyses and energy density – day 46
  - Total N, Ammonium N, Organic N, P₂O₅, K₂O
- Ammonia flux – day 46 (Burley, 2009)
  - Dynamic flux chamber and INNOVA
MATERIALS AND METHODS

BIRD PERFORMANCE

• Bodyweight – days 12, 35, 45
  • 25 birds evaluated per cell
• Mortality – days 1-9
MATERIALS AND METHODS
BIRD WELFARE

- Days 12, 35, 45
  - 25 birds evaluated per cell
  - Breast cleanliness scores: (0-2)
    - Amount of adhering debris to breast feathers
  - Footpad scores: (0-2)
    - 2 feet evaluated separately

SWITCHGRASS PROCESSED VIA TUB GRINDER

<table>
<thead>
<tr>
<th>Down Screen diameter</th>
<th>Up Screen Diameter</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.27cm</td>
<td>2.54cm</td>
<td>S1</td>
</tr>
<tr>
<td>2.54cm</td>
<td>5.08cm</td>
<td>S2</td>
</tr>
</tbody>
</table>
BEDDING PROPERTIES

Moisture Holding Capacity

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Density</th>
<th>(n)</th>
<th>Moisture</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>3</td>
<td>0.1039a</td>
<td>6</td>
<td>11.09</td>
<td>7.79</td>
</tr>
<tr>
<td>S2</td>
<td>3</td>
<td>0.0728b</td>
<td>6</td>
<td>11.18</td>
<td>8.03</td>
</tr>
<tr>
<td>P-Value</td>
<td>---</td>
<td>&lt;0.0001</td>
<td>---</td>
<td>0.8268</td>
<td>0.0997</td>
</tr>
</tbody>
</table>

Evaporative Loss

* indicates statistical significance.
LITTER PARAMETERS

- Litter temperature, pH, ambient ammonia, and flux not different by treatment
  - Did differ by house
    - Temperature (°C) higher in house 9 on day 35 (27.77 vs 24.52)
    - Ambient ammonia (ppm) higher for house 9 on day 35 (64.89 vs 49.64)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Day 12</th>
<th>Day 35</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>16.66</td>
<td>32.88</td>
<td>30.55</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>17.23</td>
<td>33.60</td>
<td>33.30</td>
</tr>
<tr>
<td>P-Value</td>
<td>---</td>
<td>0.5674</td>
<td>0.7230</td>
<td>0.2981</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Day 12</th>
<th>Day 35</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>0.26</td>
<td>0.80</td>
<td>1.47</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>0.24</td>
<td>0.69</td>
<td>1.20</td>
</tr>
<tr>
<td>P-Value</td>
<td>---</td>
<td>0.2522</td>
<td>0.3893</td>
<td>0.1446</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Day 12</th>
<th>Day 35</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>0.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.38&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.75&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>1.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.96&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>P-Value</td>
<td>---</td>
<td>0.0017</td>
<td>0.0035</td>
<td>0.0203</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Day 12</th>
<th>Day 35</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>0.09</td>
<td>0.48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.22&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>0.17</td>
<td>1.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.64&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>P-Value</td>
<td>---</td>
<td>0.3425</td>
<td>0.0013</td>
<td>0.0087</td>
</tr>
</tbody>
</table>
**BIRD PERFORMANCE**

- Mortality 1 – 9 days not affected overall
  - Day 1 – S2 > S1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(n)</th>
<th>Day 12</th>
<th>Day 35</th>
<th>Day 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>0.25(^b)</td>
<td>1.71</td>
<td>2.42</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>0.26(^a)</td>
<td>1.68</td>
<td>2.35</td>
</tr>
</tbody>
</table>

P-Value:
- 0.0056
- 0.3265
- 0.1232
## LITTER NUTRIENT AND ENERGY ANALYSES

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture (%)</th>
<th>Total N (g/kg)</th>
<th>NH$_4$ (g/kg)</th>
<th>P$_2$O$_5$ (g/kg)</th>
<th>K$_2$O (g/kg)</th>
<th>Carbon (g/kg)</th>
<th>C:N</th>
<th>GJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>36.21</td>
<td>20.99</td>
<td>4.81</td>
<td>14.40</td>
<td>12.91$^b$</td>
<td>273.67$^a$</td>
<td>13.23$^a$</td>
<td>20.05</td>
</tr>
<tr>
<td>S2</td>
<td>39.35</td>
<td>22.77</td>
<td>5.43</td>
<td>16.73</td>
<td>16.52$^a$</td>
<td>247.20$^b$</td>
<td>10.91$^b$</td>
<td>18.08</td>
</tr>
<tr>
<td>P-value</td>
<td>0.1713</td>
<td>0.0734</td>
<td>0.2378</td>
<td>0.0888</td>
<td>$0.0155$</td>
<td>$0.0149$</td>
<td>$0.0257$</td>
<td>$0.0786$</td>
</tr>
</tbody>
</table>

n = 6

2.55-2.87 kg of single cycle switchgrass litter to 8.3cm = energy in 1 L propane (21.3-24 lbs of litter to 1 gallon propane)
SUMMARY AND CONCLUSIONS

• Litter scores strongly affected by treatment
  • Footpad scores
• Litter moisture not affected by treatment
  • Breast cleanliness scores
• Bird performance was not affected by treatment
• Carbon in spent litter was highest for S1 (higher density bedding)
WHERE TO GO FROM HERE?

- Determine equipment to consistently processes switchgrass to particle specifications
  - Catalogue of particle size distributions from varying equipment types
- Conduct trial again in summer months
  - Is this product better for summer production
THANK YOU!

- NE-SARE
  - Graduate student grant
- Ernst Biomass
- Cooperating grower
QUESTIONS?

Amy Barkley
209 Henning Building
University Park, PA 16802
amm6255@psu.edu