Dietary Effects on Air Emissions: Beef Cattle

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Feedyard Emissions of Concern

Ammonia, Hydrogen Sulfide
Methane, Odors
Particulates, Pathogens
Nitrogen, Carbon, Sulfur, etc.

How Does Diet Affect Emissions?

Pen Surface
Stockpiles
Cattle
Retention Pond
Roads
Feedmill

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Diet & Particulates

- To our knowledge – no studies
- Does supplemental fat in diet decrease?
- PM emissions - affected by pen surface moisture
  > As the organic matter content of the pen surface manure increases, the quantity of moisture required to control dust may increase (Miller & Woodbury, 2003)
  > Ammonia – a precursor of PM$_{2.5}$

Ammonia Losses

Most ammonia is produced rapidly from urine spots on the pen surface

Possible Exception - “burst” during warm-up after an extended cold (< 45°F) period

Emissions increase with days on feed (increased urinary N)

Dietary Crude Protein (CP) Effects on NH$_3$ Emissions

(Cole & Todd, preliminary data)

Assumes Ruminally Degradable Protein: Ruminally Undegradable Protein ratio remains fairly constant

Note: These values should not be used to calculate emission factors

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Seasonal Effects of Dietary CP on Ammonia Emissions
(Todd & Cole, preliminary data)

Note: These values should not be used to calculate emission factors

Phase Feeding & Nitrogen Emissions
Cole et al., 2006

Note: Similar results in Nebraska studies

Steam Flaking & Wet Distiller’s Grains with Solubles: N Volatilization Losses
MacDonald & Cole, 2008 (preliminary data)

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Sorghum Wet Distiller’s Grains with Solubles: N Volatilization Losses
Brown & Cole, 2008 (preliminary data)

<table>
<thead>
<tr>
<th>% Nitrogen Intake</th>
<th>Pounds / head</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
</tr>
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<td>3</td>
</tr>
<tr>
<td>25</td>
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</tr>
<tr>
<td>55</td>
<td>-4</td>
</tr>
<tr>
<td>60</td>
<td>-5</td>
</tr>
</tbody>
</table>

- 10% SWDGS
- 15% SWDGS

- No effect on urine N excretion
- Increased fecal OM excretion
- Decreased fecal (7.1 vs. 6.9) and manure (6.3 vs. 8.1) pH

NH₃: Summary

- Daily ammonia emissions from beef feedyards may be decreased by
  - Decreasing dietary crude protein concentration
  - Limiting Ruminally Degradable Protein (i.e. urea) percentage
  - Phase feeding of protein

NH₃: Summary

- Effects of feeding Distiller’s Grains
  - In general – NH₃ losses increase with increasing diet crude protein
  - May be affected by
    - Dietary concentration of distiller’s grain (DG)
    - DG grain source (corn vs. sorghum)
    - Season
    - Grain processing method
    - Crude protein of forages fed
    - Alfalfa vs. grass hay vs. silage?

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Hydrogen Sulfide and Odors

Most odorous compounds (Volatile organic compounds – VOC) are produced by anaerobic fermentation of carbohydrates and proteins.

Hydrogen sulfide \( (\text{H}_2\text{S}) \) – from dietary sulfur sources.

Dietary Sulfur Sources

- Forages and grains (mostly amino acids)
  - Sulfur fertilization effects?
- By-products (amino acids & sulfates)
  - Distiller’s grains
  - Gluten feed
  - Mineral sources (sulfates)
  - Water (sulfates)

Distiller’s Grains (WDG) & Feedlot

\( \text{H}_2\text{S} \) Concentrations (Benson et al., 2005)

Note: concentrations are not necessarily indicative of actual emissions.

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**Distiller’s Grain & In Vitro \( \text{H}_2\text{S} \)**  
(Varel et al. 2008)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
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<tbody>
<tr>
<td>Dry Rolled Corn Control</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>20% WDG</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>40% WDG</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>60% WDG</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

**Distiller’s Grain & Odor Units**  
(Benson et al., 2005)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>26</th>
<th>28</th>
<th>30</th>
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<tbody>
<tr>
<td>Dry Rolled Corn Control</td>
<td>22</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>15% WDG</td>
<td>23</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>25% WDG</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>35% WDG</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>33</td>
<td>35</td>
</tr>
</tbody>
</table>

**Grain Processing & Odorants**  
(Archibeque et al. 2006)

<table>
<thead>
<tr>
<th>Component</th>
<th>0</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
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</thead>
<tbody>
<tr>
<td>Volatile Fatty Acids</td>
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<td>120</td>
<td>180</td>
<td>240</td>
<td>300</td>
<td>360</td>
<td>420</td>
</tr>
<tr>
<td>Butyrate</td>
<td>2</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Cresol</td>
<td>3</td>
<td>15</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>Fecal Starch (mg/g)</td>
<td>4</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>120</td>
<td>140</td>
</tr>
</tbody>
</table>

Dry Rolled Corn  
High Moisture Corn

In vitro concentrations

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Odors: Summary

- Odor Emissions
  - Decreased by decreasing fecal starch
  - Grain processing method
  - Distiller’s grains effects are not clear

- Hydrogen Sulfide Emissions
  - Increased by increased dietary S
    - High S byproducts – Distillers grains, gluten feed
    - High sulfur water

Greenhouse Gases

Methane is produced from both enteric fermentation in the animal and fermentation in pen surface and stockpiled manure, etc.

Methane production from shallow retention ponds is minimal during the day

Dietary Effects on Methane Production: Rules of Thumb

- Increasing dietary fiber concentration increases enteric methane production
  - Greater ruminal acetate:propionate ratio

- Supplementing with fat decreases enteric methane production
  - Decreased ruminal fermentation
  - Selective effects on methanogenic bacteria
  - Biohydrogenation of fatty acids

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Dietary Effects on Methane Production: Rules of Thumb

- More intensive grain processing tends to decrease enteric methane production
  - Effects on ruminal fermentation
    - Lower pH decreases methanogenesis
    - Decreased acetate:propionate ratio
    - Decreased dry matter intake
- More intensive grain processing may also decrease manure methane production
  - Less fecal starch

In Vitro CH₄ Production: Replacing Corn + Oil With Distiller’s Grains

(Behlke et al., 2008)

CH₄: Summary

- **Enteric emissions**
  - Decreased by more intensive grain processing
  - Effects of Distiller’s Grain & Gluten Feed are not clear
    - Basal fat level of diet?
    - Roughage level of diet?
- **Manure emissions**
  - Theoretically – decreased by more intensive grain processing and lower roughage levels

Similar results by Varel et al., (2008)

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**Additional Conclusions**

- Feeding and management technologies that increase production efficiency
  - Ionophores, beta-agonists, implants, etc.
  - Tend to decrease emissions per unit of production

- Effects on performance need to be considered –
  - g/day vs. g/lb ADG or g/lb beef produced

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**Thank You**

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**References & Additional Reading**


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