Effectiveness of diet modification and manure additives for poultry operations

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Background

- Focus has been on odor and ammonia
- Considerable diet work conducted, emphasizing reducing dietary protein
  - Odorants are protein metabolites
- Additive work is less documented but again targeting N (ammonia)
Diet approaches

• Balance nutrients
  • Principle: reduce the source of precursors to air emissions
    • Reduced total dietary N (protein)
      – Feeding more supplemental amino acids
        » Met, Lys, Thr, Trp….Val, Lys, Arg, Cys
    • Feed more phases or group animals more extensively
    • Reduce feed waste/loss
Diet approaches

• Alter excreta pH
  • Principle: by changing excreta pH, specific compounds are less (more) likely to volatilize
    • Decreasing pH below 7 retain more N
      – Tradeoff is that S is more likely to volatilize
Diet approaches

• Bind nutrients (N)
  • Principle: similar to altering excreta pH but use of compounds that tie up nutrients in another form
    • Humic acid
    • DeOdorase
Increasing number of phases in broilers

- Conducted study over multiple flocks
  - Consider used litter effect
### Dietary Treatments

<table>
<thead>
<tr>
<th>Trt</th>
<th>Control</th>
<th>Reduced CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, days</td>
<td>Phase</td>
<td>% CP</td>
</tr>
<tr>
<td>H - 6</td>
<td>Starter</td>
<td>22.1</td>
</tr>
<tr>
<td>7 - 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 - 23</td>
<td>Grower</td>
<td>20.0</td>
</tr>
<tr>
<td>24 - 29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 - 35</td>
<td>Finisher</td>
<td>17.2</td>
</tr>
<tr>
<td>36 - 42</td>
<td>Withdrawal</td>
<td>16.6</td>
</tr>
</tbody>
</table>
Findings

• As a result of feeding the 6-phase program, NH₃ emissions (mg kg⁻¹ bodyweight) was reduced from 41%, from 131 to 76 mg kg⁻¹ bodyweight.

• Emission reductions were observed for NO, NO₂, H₂S and non-methane total hydrocarbon as well.
Cumulative flock NH3 emissions

mg NH3 per flock

Flock
Amino acid formulation and supplementation in turkeys

• 2 x 2 factorial
  • 100 or 110% or NRC-recommended AA formulation
  • Containing 2 (Lys, Met) or 3 (Lys, Met, Thr) AA
• First conducted on a commercial scale
Findings

• Feeding 100% diets
  • Decreased cumulative ammonia loss (14%)
  • Decreased cumulative hydrogen sulfide loss (12%)
  • Losses consistent with reduced nutrient intake

• Feeding 3 AA diets
  • Decreased N excretion (12%)
  • Decreased cumulative ammonia loss (23%)
  • Less ammonia emitted as percent of N excretion
Feeding diets containing zeolite, gypsum and reduced CP to laying hens

- In trials 1, 2, and 3, respectively hens were 21-, 38-, and 59-wk
- C diet contained 18.0, 17.0, and 16.2% CP and 0.25, 0.20, and 0.20% S
- R diet contained 17.0, 15.5, and 15.6% CP and 0.99, 1.20, and 1.10% S
Findings

• Average daily egg weight (ADEW; 57.4 g), average daily egg production (ADEP; 82.5%), average daily feed intake (ADFI; 92.6 g) were unaffected by diet

• In trials 1, 2, and 3, daily NH$_3$ emissions from hens fed the R diets (185.5, 312.2, and 333.5 mg bird$^{-1}$) were less than those of hens fed the C diet (255.0, 560.5, and 616.3 mg bird$^{-1}$)
## Results of performance—diet effect

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADEW, g</td>
<td>57.4</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>ADEP, %</td>
<td>82.5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>ADFI, g</td>
<td>92.6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>BWC, g</td>
<td>24.3</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

- ADEW - Average daily egg weight
- ADEP - Average daily egg production
- ADFI - Average daily feed intake
- BWC - BW change
Results of daily NH$_3$ emissions

<table>
<thead>
<tr>
<th>Weeks</th>
<th>R Diet (mg bird$^{-1}$ day$^{-1}$)</th>
<th>C Diet (mg bird$^{-1}$ day$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 wks</td>
<td>185.5</td>
<td>255</td>
</tr>
<tr>
<td>38 wks</td>
<td>312.2</td>
<td>333.5</td>
</tr>
<tr>
<td>59 wks</td>
<td>560.5</td>
<td>616.3</td>
</tr>
</tbody>
</table>

Diet P < 0.01  Age P < 0.01  Diet $\times$ Age P > 0.05
Results of daily H$_2$S emissions

<table>
<thead>
<tr>
<th></th>
<th>R diet</th>
<th>C diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 wks</td>
<td>0.5</td>
<td>1.6</td>
</tr>
<tr>
<td>21 wks</td>
<td>0.8</td>
<td>1.9</td>
</tr>
<tr>
<td>38 wks</td>
<td>7.1</td>
<td>3.7</td>
</tr>
<tr>
<td>59 wks</td>
<td>3.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>

4-fold increase; 6 million hens to trigger EPCRA
Feeding reduced S diets

- Hy-line W36 laying hens from 47 to 50 wk of age
- C, RedS, and LowS diets were formulated to contain 0.19%, 0.11%, and no supplemental DL-Met
  - Analyzed S contents (2,602; 2,540; and 2,460 ppm) corresponded to S intakes of 244.6, 236.6, and 217.0 mg/bird/d in hens fed C, RedS and LowS diets
  - Methionine intake of 274.7, 361.6, or 406.7 mg/hen/d resulted in increasing egg weights of 61.1, 63.9, and 65.1 g (P < 0.01) for the LowS, RedS and C diets
Findings

• Daily H₂S emissions from hens fed C, RedS, and LowS diets were 0.83, 0.62, and 0.44 mg/bird (P<0.01)

• Completely eliminating DL-Met supplementation resulted in less cumulative egg mass
Reducing S emissions

• Hy-line W-36 hens from 50 to 53 wk of age
• Diets were arranged in a 2 × 2 factorial design
  • DDGS (0 or 20% of diet dry matter)
  • Source of minerals (common inorganic sources; In or organic mineral sources from Pancosma, Geneva, Switzerland; Org).
• Egg weight (65.12g) and egg production (88%) were not affected by diet (P>0.05)
• Feeding DDGS decreased mass of NH$_3$ emitted daily (592 vs. 512 mg/hen/d for 0% and 20% DDGS)
• Feeding DDGS increased daily CH$_4$ emissions by 13 to 15% (39.3 vs. 45.4 mg/hen/d)
Findings

• Mass of excreta (27.3 vs. 31.5 kg DM) and mass of N excreted (1.25 vs. 1.52 kg N) from 56 hens over a 3-wk period were increased as a result of feeding DDGS

• Substitution of inorganic trace mineral sources with organic sources did not alter air emissions
Feeding DDGs to laying hens

- Roberts et al. (2007) indicated that a diet containing 10% DDGS lowered NH₃ emission from laying hen manure.
Feeding laying hens commercial diets containing 0, 10, or 20% DDGS

- Diets were formulated to contain similar CP levels (18.3%), non-phytate P (0.46%), and Ca (4.2%).
- On an analyzed basis, the 0, 10, and 20% DDGS diets contained 0.22, 0.27, and 0.42% S.
- Hyline W36 hens aged 21 to 25 wk
Hen performance and apparent nutrient digestibility

- No diet effect on hen performance
  - Egg weight (50.9 g)
  - Egg production (85%)
  - Feed intake (87.9 g/hen/d)
- No diet effect on apparent nutrient digestibility
  - Apparent N digestibility (57.7%)
  - Apparent P digestibility (29.5%)
  - Apparent DM digestibility (75.1%)
Including 20% DDGS in layer diet resulted in lower NH$_3$ emissions compared with the 0% or 10% DDGS diet.

A decrease in NH$_3$ emissions was observed as the amount of DDGS increased from 0 to 20%.

The diet containing 20% DDGS can decrease NH$_3$ emissions by 24%.

Lacking common superscripts differ (P < 0.05)
A decrease in H₂S emissions was observed as the amount of DDGS increased from 0 to 20%.

The diet containing 20% DDGS can decrease H₂S emissions by 58%.

Including 20% DDGS in layer diet resulted in lower H₂S emissions compared with the 0% or 10% DDGS diet.

* Lacking common superscripts differ (P < 0.05)
Manure approaches

- Bind nutrients
  - Humic acid
- Alter excreta/litter pH
  - PLT (sodium bisulfite)
  - Gypsum (calcium sulfate)
Ingredient formulation on excreta pH in broiler chicks

- Diets containing different levels of DDGS, meat and bone meal, adipic acid, and combinations of these ingredients were fed for 9 d prior to a 4-h excreta collection
- Excreta were stored at room temperature in open containers for 48 h after collection
- No initial or 48-h pH effects were noted
Effects of excreta storage and Alum

• Potential N volatilization was affected by additive and Alum addition
• Inclusion of adipic acid as well as CaCl₂ reduced potential N volatilization
• Samples with Alum lost 24.8% of the N in the samples after 14 d of storage while those with no Alum lost 63.3% N
• We concluded that low CP diets (20.8%) and inclusion of CaCl₂ impairs broiler performance
Protein source effects

- Both MM and DDGS (43.2 and 39.4% N loss, respectively) decrease the potential N volatilization over 14 d of storage vs. the SBM diet (47.9% N loss)
- Alum addition to excreta reduced potential N volatilization by a factor of 2.2
- Substitution of part of the SBM with MM or DDGS and the use of Alum reduced the potential N volatilization from stored broiler excreta
Manure amendment work at MSU

• Liquid and solid manure work
• Manure generated from animals on diet studies
• Additives applied at manufacturer’s recommendations
Manure amendment treatments
pH modifiers

- PoultryGuard™ on broiler chicken litter (granulated sulfuric acid)
  - PoultryGuard™ addition:
    - 0 (no addition, control)
    - Manufacturer rate = 0.366 kg/m²
    - ½ Manufacturer rate = 0.183 kg/m²

- Litter not mixed during the 38 d storage period
Least squares means of gas concentration and emissions from broiler litter treated with a pH amendment (PoultryGuard™)

<table>
<thead>
<tr>
<th></th>
<th>NH₃ ppm</th>
<th>NH₃ mg d⁻¹</th>
<th>H₂S ppm</th>
<th>H₂S mg d⁻¹</th>
<th>N₂O ppm</th>
<th>N₂O mg d⁻¹</th>
<th>CH₄ ppm</th>
<th>CH₄ mg d⁻¹</th>
<th>NMTHC ppm</th>
<th>NMTHC mg d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amendment effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84.51c</td>
<td>669.98c</td>
<td>0.0768</td>
<td>1.07</td>
<td>1.91</td>
<td>8.79</td>
<td>3.11</td>
<td>13.2</td>
<td>0.65</td>
<td>2.8</td>
</tr>
<tr>
<td>Half dose</td>
<td>75.45b</td>
<td>591.49b</td>
<td>0.0741</td>
<td>1.02</td>
<td>1.88</td>
<td>8.13</td>
<td>2.89</td>
<td>11.8</td>
<td>0.67</td>
<td>3.0</td>
</tr>
<tr>
<td>Full dose</td>
<td>67.70a</td>
<td>524.33a</td>
<td>0.0845</td>
<td>1.21</td>
<td>1.88</td>
<td>7.94</td>
<td>2.69</td>
<td>10.5</td>
<td>0.64</td>
<td>2.5</td>
</tr>
<tr>
<td>P-value</td>
<td>0.05</td>
<td>0.05</td>
<td>0.44</td>
<td>0.44</td>
<td>0.73</td>
<td>0.73</td>
<td>0.21</td>
<td>0.69</td>
<td>0.56</td>
<td>0.71</td>
</tr>
<tr>
<td>Std err</td>
<td>8.11</td>
<td>68.45</td>
<td>0.015</td>
<td>0.26</td>
<td>0.10</td>
<td>1.39</td>
<td>0.51</td>
<td>3.2</td>
<td>0.06</td>
<td>0.86</td>
</tr>
</tbody>
</table>

- NH₃ concentration and emission reduced linearly with increasing application rate of the pH amendment.
- Concentration and emission of other gases not different as a result of the pH amendment.
Manure amendment treatments: pH modifiers

- Alum on laying hen manure
  - Alum added at 3 rates (0, 2 and 4% of manure weight)
  - Manure not mixed (29 d)
Least squares means of gas concentration and emissions from laying hen excreta treated with a pH amendment

<table>
<thead>
<tr>
<th></th>
<th>NH₃</th>
<th>H₂S</th>
<th>N₂O</th>
<th>CH₄</th>
<th>NMTHC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
<td>mg d⁻¹</td>
<td>ppm</td>
<td>mg d⁻¹</td>
<td>ppm</td>
</tr>
<tr>
<td>Amendment effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>859.57ᵇ</td>
<td>7335.80ᵇ</td>
<td>0.0032</td>
<td>0.01</td>
<td>1.35</td>
</tr>
<tr>
<td>2% Alum</td>
<td>719.41ᵃ</td>
<td>5495.23ᵃ</td>
<td>0.0028</td>
<td>0.01</td>
<td>1.30</td>
</tr>
<tr>
<td>4% Alum</td>
<td>734.73ᵃ</td>
<td>5887.87ᵃ</td>
<td>0.0042</td>
<td>0.01</td>
<td>1.40</td>
</tr>
<tr>
<td>P-value</td>
<td><strong>0.02</strong></td>
<td><strong>&lt;0.01</strong></td>
<td>0.13</td>
<td>0.40</td>
<td>0.11</td>
</tr>
<tr>
<td>Std err</td>
<td>55.96</td>
<td>577.32</td>
<td>0.0010</td>
<td>0.01</td>
<td>0.06</td>
</tr>
</tbody>
</table>

- Reduced NH₃, CH₄, and NMTHC concentrations and emissions, and N₂O emission, with application of the pH amendment.
- Increased application rates did not improve concentrations or emissions of any gas.
Manure amendment treatments: microbial product

• Effective Microorganism on turkey litter
  - EM added at 0 or 0.283 ml/m² (manufacturer rate)
  - Litter not mixed during the 33-d storage period
Least squares means of gas concentration and emissions from turkey litter treated with a microbial additive.

<table>
<thead>
<tr>
<th></th>
<th>NH₃</th>
<th>H₂S</th>
<th>N₂O</th>
<th>CH₄</th>
<th>NMTHC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
<td>mg d⁻¹</td>
<td>ppm</td>
<td>mg d⁻¹</td>
<td>ppm</td>
</tr>
<tr>
<td>Amendment effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>42.43</td>
<td>323.33</td>
<td>0.0206</td>
<td>0.18</td>
<td>1.90</td>
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<tr>
<td>EM</td>
<td>40.69</td>
<td>308.44</td>
<td>0.0195</td>
<td>0.16</td>
<td>1.89</td>
</tr>
<tr>
<td>P-value</td>
<td>0.56</td>
<td>0.56</td>
<td>0.55</td>
<td>0.54</td>
<td>0.62</td>
</tr>
<tr>
<td>Std err</td>
<td>3.78</td>
<td>31.56</td>
<td>0.0015</td>
<td>0.03</td>
<td>0.05</td>
</tr>
</tbody>
</table>

No amendment effects on NH₃, H₂S, N₂O, CH₄, and NMTHC concentrations or emissions were observed.
Manure amendment treatments
Urease inhibitor

• Agrotain Plus on broiler chicken litter
  • Agrotain Plus diluted in water (1 g/10 ml) and sprayed evenly on the litter surface (7.5 g per kg litter) for half the samples
  • Litter not mixed during the 22 d storage period
Least squares means of gas concentration and emissions from broiler litter treated with a urease inhibitor

<table>
<thead>
<tr>
<th>Amendment effect</th>
<th>NH₃ ppm</th>
<th>NH₃ mg d⁻¹</th>
<th>H₂S ppm</th>
<th>H₂S mg d⁻¹</th>
<th>N₂O ppm</th>
<th>N₂O mg d⁻¹</th>
<th>CH₄ ppm</th>
<th>CH₄ mg d⁻¹</th>
<th>NMTHC ppm</th>
<th>NMTHC mg d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>162.19</td>
<td>1278.03</td>
<td>0.039</td>
<td>0.33</td>
<td>2.46</td>
<td>28.46</td>
<td>6.60</td>
<td>35.67</td>
<td>0.75</td>
<td>6.29</td>
</tr>
<tr>
<td>Agrotain Plus</td>
<td>170.32</td>
<td>1343.16</td>
<td>0.037</td>
<td>0.36</td>
<td>2.53</td>
<td>29.81</td>
<td>6.65</td>
<td>34.66</td>
<td>0.71</td>
<td>5.13</td>
</tr>
<tr>
<td>P-value</td>
<td>0.54</td>
<td>0.57</td>
<td>0.55</td>
<td>0.54</td>
<td>0.60</td>
<td>0.63</td>
<td>0.93</td>
<td>0.81</td>
<td>0.17</td>
<td>0.08</td>
</tr>
<tr>
<td>Std err</td>
<td>10.86</td>
<td>92.74</td>
<td>0.0043</td>
<td>0.065</td>
<td>0.23</td>
<td>4.99</td>
<td>0.64</td>
<td>4.14</td>
<td>0.080</td>
<td>1.97</td>
</tr>
</tbody>
</table>

No amendment effects on NH₃, H₂S, N₂O, CH₄, and NMTHC concentrations or emissions were observed
Adding saponins to manure (steer)

• Addition of saponins were made daily (0% saponin (C), 2% Quillaja Saponaria (Q), 2% Yucca Schidigera (Y) and 2% Camellia Sinensis (T) on a wet weight basis)

• Adding the T to the manure increased cumulative hydrogen sulfide emissions over a 30-d monitoring period

• No differences in ammonia, methane, nitrous oxide or VOC emissions were observed
Conclusions

• There are amendments that can be effective at controlling releases of gases from stored manures

• Choice of amendment should be carefully matched with type of manure and gas of interest