Effectiveness of diet modification and manure additives for poultry operations

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September 26, 2012

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

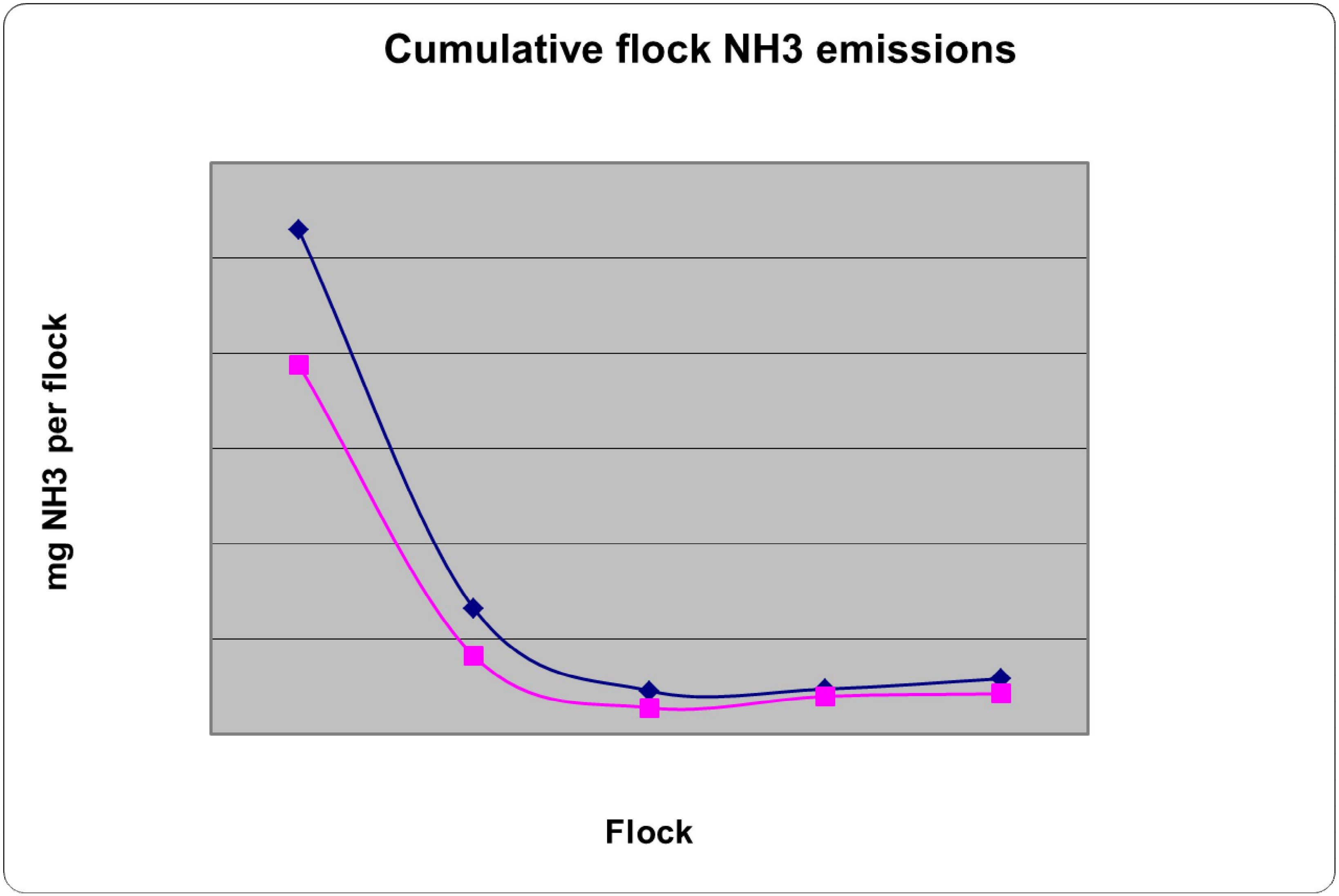
- Conducted study over multiple flocks
  - Consider used litter effect

Dietary Treatments

Trt	Control		Reduced CP	
Age, days	Phase	% CP	Phase	% CP
H - 6	Starter	22.1	Pre-Starter	22.0
7 - 16			Starter	18.6
17 - 23	Grower	20.0	Grower 1	18.1
24 - 29			Grower 2	17.3
30 - 35	Finisher	17.2	Finisher	15.8
36 - 42	Withdrawal	16.6	Withdrawal	15.0

Findings

- As a result of feeding the 6-phase program, NH_3 emissions (mg kg^{-1}bodyweight) was reduced from 41%, from 131 to 76 mg kg^{-1} bodyweight.
- Emission reductions were observed for NO, NO_2, H_2S 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

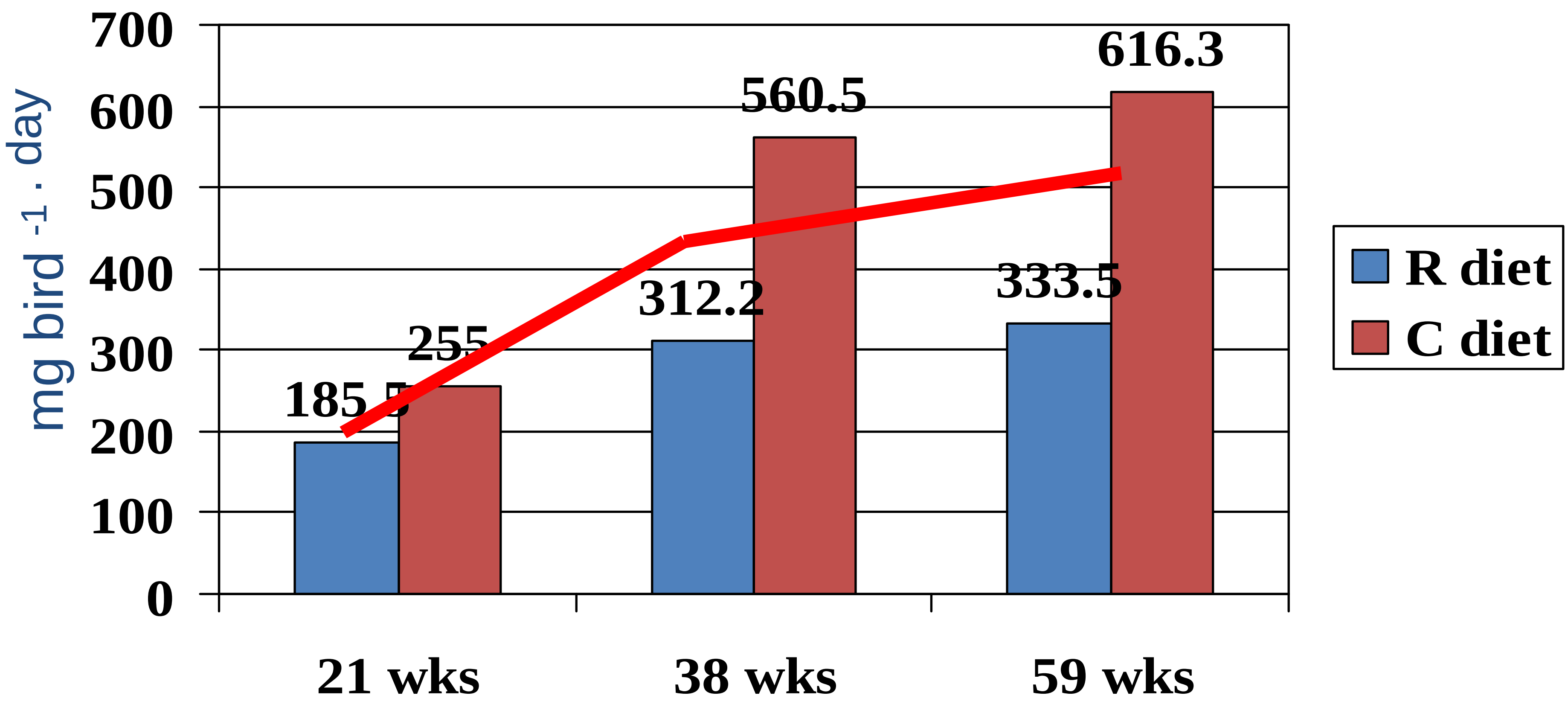
- Average daily egg weight (ADEW; 57.4 g), average daily egg production (ADEP; 82.5%), average daily feed intake (ADFI; 92.6 g) were unaffected by diet
- In trials 1, 2, and 3, daily NH_3 emissions from hens fed the R diets (185.5, 312.2, and 333.5 mg bird^{-1}) were less than those of hens fed the C diet (255.0, 560.5, and 616.3 mg bird^{-1})

Results of performance—diet effect

			P-value
ADEW, g	57.4		>0.05
ADEP, %	82.5		>0.05
ADFI, g	92.6		>0.05
BWC, g	24.3		>0.05

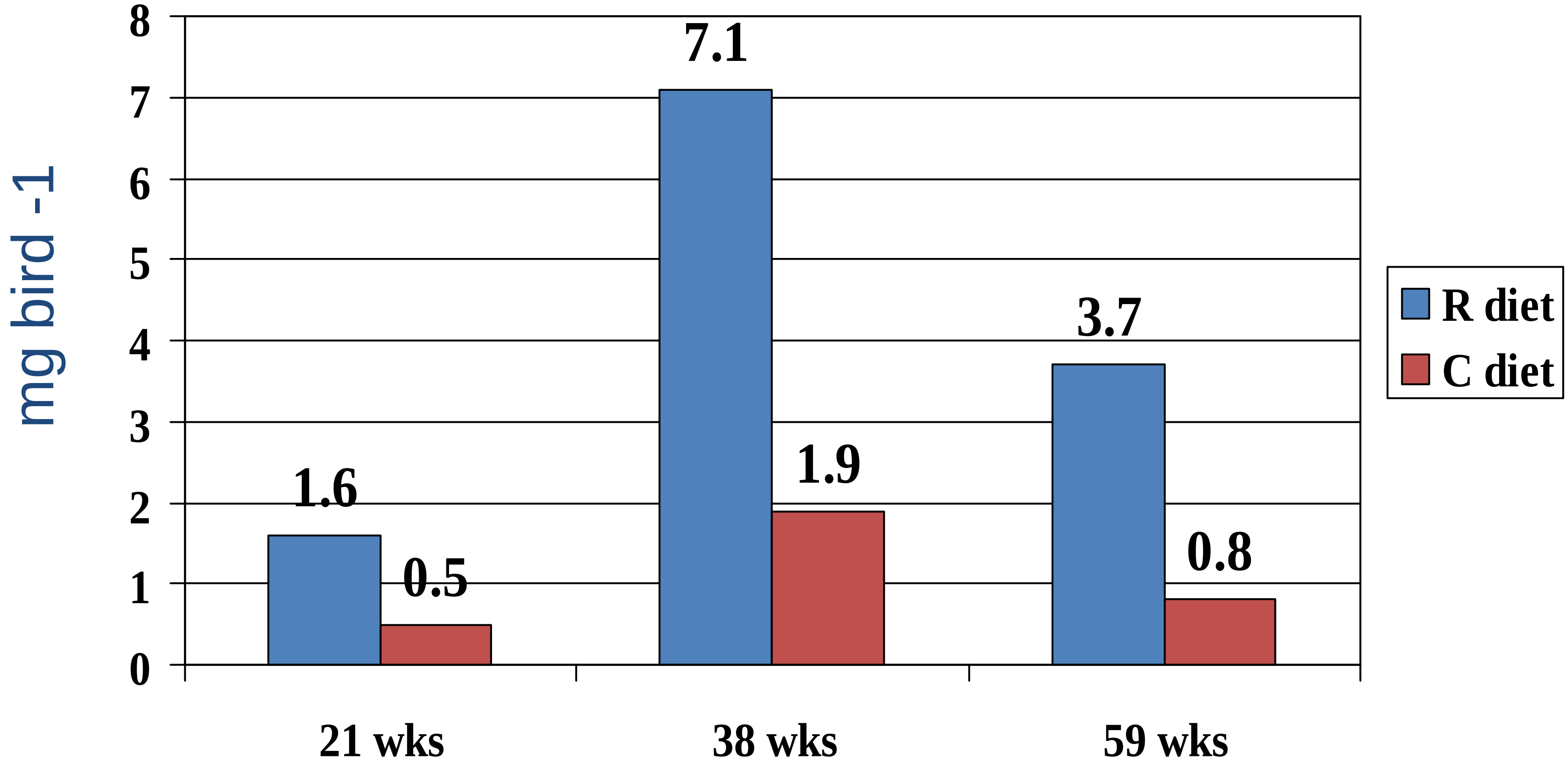
- ADEW - Average daily egg weight
- ADEP - Average daily egg production
- ADFI - Average daily feed intake
- BWC - BW change

Results of daily NH_3 emissions



Diet $P < 0.01$ Age $P < 0.01$ Diet × Age $P > 0.05$

Results of daily H_2S emissions



4-fold increase; 6 million hens to trigger EPCRA

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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 H_2S 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 NH_3 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%)

Averag

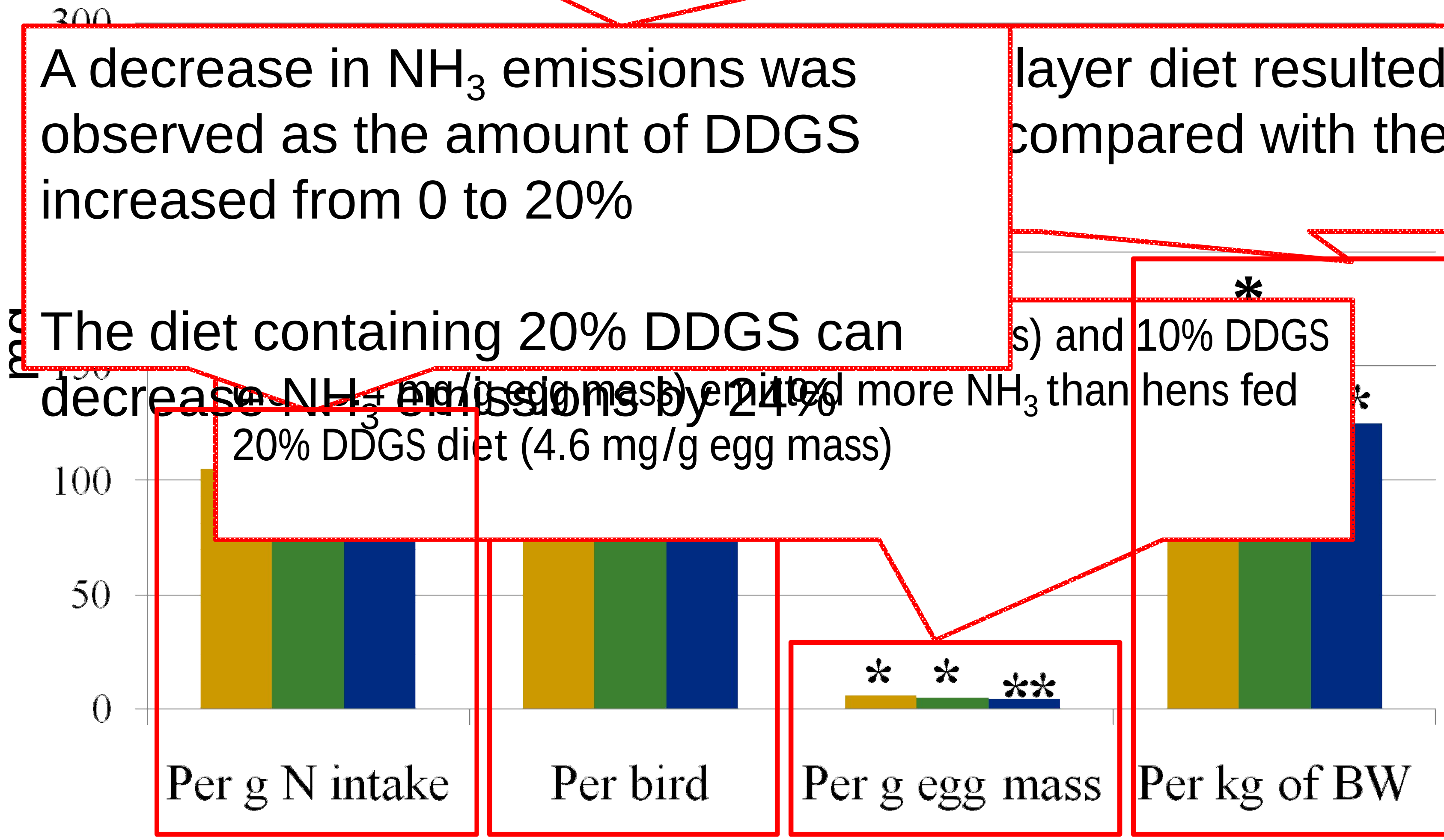
Including 20% DDGS in layer diet resulted in lower NH_3 emissions compared with the 0% or 10% DDGS diet

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%

layer diet resulted compared with the

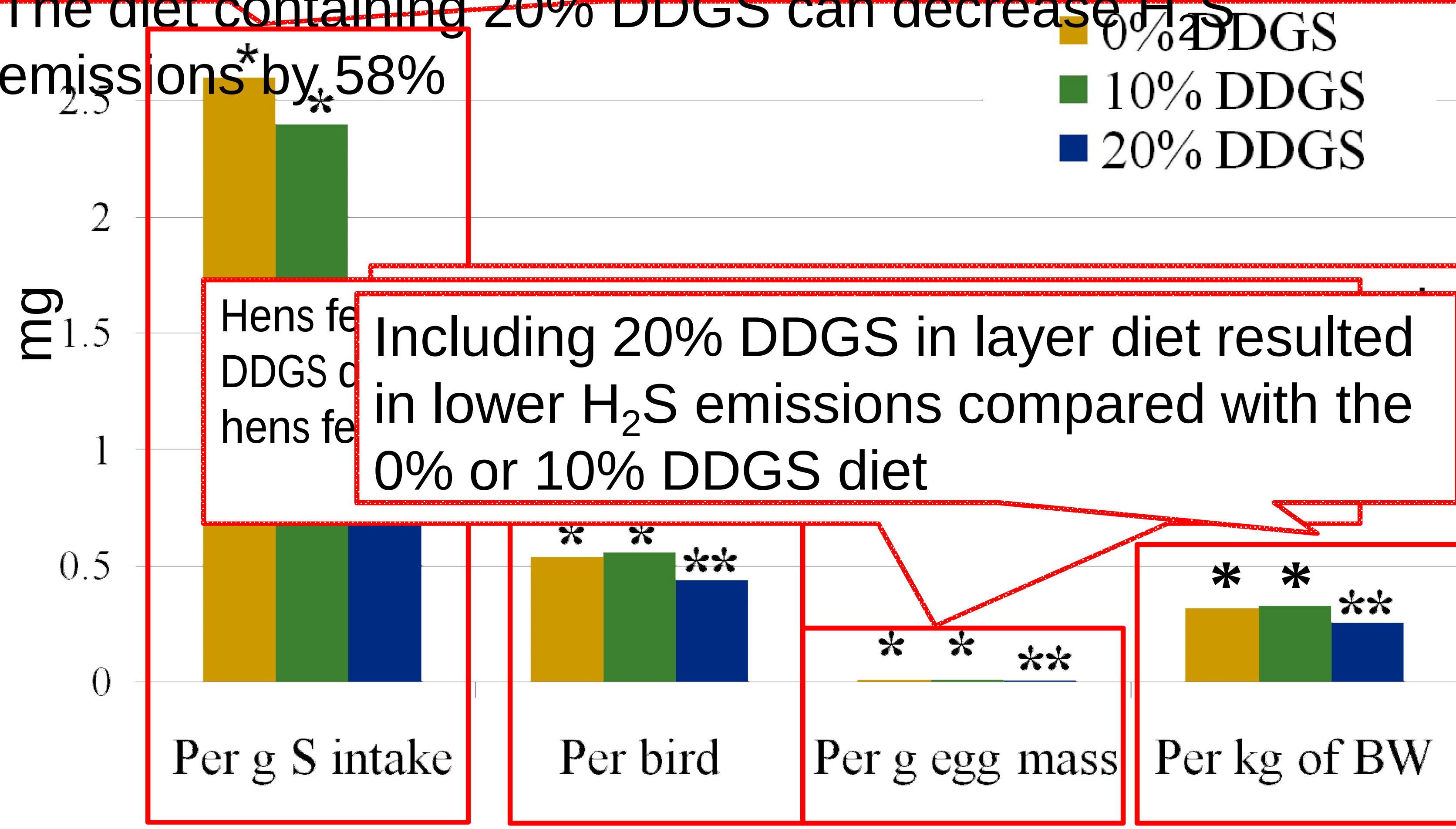
s) and 10% DDGS mg/g egg mass) emitted more NH_3 than hens fed 20% DDGS diet (4.6 mg/g egg mass)



*Lacking common superscripts differ (P < 0.05)

A decrease in H_2S emissions was observed as the amount of DDGS increased from 0 to 20%

The diet containing 20% DDGS can decrease H_2S emissions by 58%



Hens fe
DDGS c
hens fe

Including 20% DDGS in layer diet resulted in lower H_2S 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 $CaCl_2$ 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 $CaCl_2$ 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/m^2
    - ½ Manufacturer rate = 0.183 kg/m^2

  - 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™)

	NH_3		H_2S		N_2O		CH_4		NMTHC	
	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}
Amendment effect										
Control	84.51^{c}	669.98^{c}	0.0768	1.07	1.91	8.79	3.11	13.2	0.65	2.8
Half dose	75.45^{b}	591.49^{b}	0.0741	1.02	1.88	8.13	2.89	11.8	0.67	3.0
Full dose	67.70^{a}	524.33^{a}	0.0845	1.21	1.88	7.94	2.69	10.5	0.64	2.5
P-value	**0.05**	**0.05**	0.44	0.44	0.73	0.73	0.21	0.69	0.56	0.71
Std err	8.11	68.45	0.015	0.26	0.10	1.39	0.51	3.2	0.06	0.86

- NH_3 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

	NH_3		H_2S		N_2O		CH_4		NMTHC	
	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}
Amendment effect										
Control	859.57^{b}	7335.80^{b}	0.0032	0.01	1.35	16.05^{b}	45.79^{b}	342.5^{b}	1.69^{b}	29.1^{b}
2% Alum	719.41^{a}	5495.23^{a}	0.0028	0.01	1.30	13.63^{a}	38.34^{a}	252.3^{a}	1.29^{a}	17.5^{a}
4% Alum	734.73^{a}	5887.87^{a}	0.0042	0.01	1.40	16.70^{b}	38.68^{a}	266.7^{a}	1.37^{a}	18.0^{a}
P-value	**0.02**	**<0.01**	0.13	0.40	0.11	**<0. 01**	**0.01**	**<0.01**	**0.01**	**0.01**
Std err	55.96	577.32	0.0010	0.01	0.06	1.43	2.88	28.8	0.23	6.0

- Reduced NH_3, CH_4, and NMTHC concentrations and emissions , and N_2O 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/m^2 (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.

	NH_3		H_2S		N_2O		CH_4		NMTHC	
	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}
Amendment effect										
Control	42.43	323.33	0.0206	0.18	1.90	5.63	1.67	4.6	0.75	2.6
EM	40.69	308.44	0.0195	0.16	1.89	5.47	1.61	4.1	0.69	2.5
P-value	0.56	0.56	0.55	0.54	0.62	0.65	0.57	0.55	0.44	0.88
Std err	3.78	31.56	0.0015	0.03	0.05	0.90	0.27	1.5	0.07	0.9

No amendment effects on NH_3, H_2S, N_2O, CH_4, 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

	NH_3		H_2S		N_2O		CH_4		NMTHC	
	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}	ppm	mg d^{-1}
Amendment effect										
Control	162.19	1278.03	0.039	0.33	2.46	28.46	6.60	35.67	0.75	6.29
Agrotain Plus	170.32	1343.16	0.037	0.36	2.53	29.81	6.65	34.66	0.71	5.13
P-value	0.54	0.57	0.55	0.54	0.60	0.63	0.93	0.81	0.17	0.08
Std err	10.86	92.74	0.0043	0.065	0.23	4.99	0.64	4.14	0.080	1.97

No amendment effects on NH_3, H_2S, N_2O, CH_4, 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