Effect of Diet on Air Emissions from Laying Hens of Different Ages

A.S. Leaflet R2208

Wei Wu, graduate student,
Wendy Powers, associate professor,
Roselina Angel, University of Maryland,
Carroll E. Hale III, Rose Acre Farms, and
Todd Applegate, Purdue University

Summary and Implications

Manure from poultry feeding operations is associated with diminished air quality. The objectives of the current study were to evaluate the effectiveness of feeding a reduced emission diet (**R**) containing 6.9% of a gypsum-zeolite mixture and a slightly reduced crude protein (**CP**) to 21-, 38-, and 59-week-old Hy-Line W-36 hens (trials 1, 2, and 3, respectively) on egg production and emissions of NH_3, H_2S, NO, NO_2, CO_2, CH_4 and non-methane total hydrocarbon as compared to feeding a commercial diet (**C**). At each age, 640 hens (body weight = 1.36, 1.47, and 1.52 kg in trials 1, 2, and 3, respectively) were allocated randomly to eight environmental chambers for a 3-week period. On an analyzed basis, the C diet contained 18.0, 17.0, and 16.2% CP and 0.25, 0.20, and 0.20% S in trials 1, 2, and 3, respectively. The R diet contained 17.0, 15.5, and 15.6% CP and 0.99, 1.20, and 1.10% S in trials 1, 2, and 3, respectively. Diets were formulated to contain similar calcium and phosphorus content. Gaseous concentrations were monitored from each chamber in a sequential manner resulting in 10 to 11 daily observations per chamber. Average daily egg weight (**ADEW**; 57.4 g), average daily egg production (**ADEP**; 82.5%), average daily feed intake (**ADFI**; 92.6 g) and body weight change (**BWC**; 24.3 g), across ages, were unaffected by diet ($P>0.05$). Age affected ADEW (52.1, 58.9, and 61.2 g), ADEP (86.7, 87.1, and 73.7%), ADFI (86.8, 96.2, and 94.6 g) and BWC (65.2, 17.3, and –9.7 g) in trials 1, 2, and 3, respectively ($P < 0.01$). Diet ($P < 0.01$) and age ($P < 0.05$) affected NH_3 emissions. 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 × $bird^{-1}$). Daily emissions of H_2S across trials from hens fed the R diet were 4.08 mg × $bird^{-1}$ compared to 1.32 mg × $bird^{-1}$ from hens fed the C diet ($P < 0.01$). Diet ($P < 0.05$) and age ($P < 0.05$) affected emissions of CO_2 and CH_4. A diet effect ($P < 0.01$) on NO emissions and an age effect on SO_2 emissions ($P < 0.01$) was observed. No diet or age effects ($P > 0.05$) were observed for NO_2 and non-methane total hydrocarbons. Results demonstrate that diet and laying age influence air emissions.

Introduction

It is well documented that gaseous emissions from laying hen feeding operations can have potential negative impacts on the environment and on human and bird health. These emissions have been shown to be reduced through diet formulation. Feeding diets formulated to reduce excess crude protein inputs (Elwinger et al, 1996) help to reduce nitrogen (**N**) excreted resulting in lower ammonia (NH_3) emissions. Acidogenic materials reduce manure pH resulting in the protonation of NH_3 to ammonium. Gypsum (calcium sulfate) is one of the acidogenic compounds that has been tested and can serve as a partial replacement for limestone as a calcium (**Ca**) source without reducing hen performance in laying hen diets (Keshavarz, 1991). Zeolite has been shown to be a beneficial feed additive that exhibits a strong preference for binding nitrogenous cations like ammonium resulting in lower NH_3 concentration (Nakaue and Koelliker, 1981; Cabuk et al., 2004). A study conducted by Hale (2005) showed that using a reduced crude protein (**CP**) diet in combination with acidogenic materials such as gypsum and nitrogenous binding compounds like zeolite decreased NH_3 emission (as measured in vitro) from laying hen excreta. However, the effectiveness of feeding such a diet on all gaseous emissions has not been reported. The objective of the current study was to evaluate the effectiveness of feeding a reduced emissions diet (**R**) containing 6.9% of a gypsum-zeolite mixture which replaced 35% of the limestone and slightly reduced CP to laying hens of different ages on egg production and emission of NH_3, H_2S, NO, NO_2, CO_2, CH_4 and non-methane total hydrocarbon as compared to feeding a commercial diet (**C**).

Materials and Methods

The study consisted of three trials utilizing birds which were initially 21, 38, 59 weeks old. During each trial, 640 Hy-Line W-36 hens (body weight = 1.36, 1.47, and 1.52 kg in trials 1, 2, and 3, respectively) were randomly assigned to one of eight air emissions chambers for a 3-week period. Between each trial, chambers were completely cleaned. In each chamber, eight cages of 10 birds per cage were used (355 cm^2 per bird; Figure 1).

Feed, in mash form, and water were available for ad libitum consumption. On an analyzed basis, the C diet contained 18.0, 17.0, and 16.2% CP and 0.25, 0.20, and

Figure 1. Each chamber housed 80 laying hens with eight cages of 10 hens per cage.

0.20% S in trials 1, 2, and 3, respectively while the R diet contained 17.0, 15.5, and 15.6% CP and 0.99, 1.20, and 1.10% S in trials 1, 2, and 3, respectively. Diets were formulated to contain similar calcium and phosphorus concentrations. The R diet contained a 35% replacement of Ca with gypsum and clinoptilolite. All diets were formulated to meet National Research Council (1994) nutrient recommendations.

Gaseous concentration and air flow were monitored from each chamber in a sequential manner resulting in 10-11 daily observations per chamber. During each 15 minutes observation period, the concentration of NH_3, H_2S, NO, NO_2, CO_2, CH_4 and non-methane total hydrocarbon were recorded through computer.

Data were analyzed using a mixed model with the day as random variable (SAS v 8.0). Emission data were adjusted for number of birds. Significance was accepted at or below a $P < 0.05$.

Results and Discussion

Average daily egg weight (**ADEW**; 57.4 g), average daily egg production (**ADEP**; 82.5%), average daily feed intake (**ADFI**; 92.6 g) and body weight change (**BWC**; 24.3 g), across ages, were unaffected by diet. Age affected ADEW (52.1, 58.9, and 61.2 g), ADEP (86.7, 87.1, and 73.7%), ADFI (86.8, 96.2, and 94.6 g) and BWC (65.2, 17.3, and -9.7 g) in trials 1, 2, and 3, respectively.

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 lower than those of hens fed the commercial diet (255.0, 560.5, and 616.3 mg × bird^{-1}). Age effects on daily NH_3 emission were greater from older hens than from younger hens. Daily H_2S emissions from hens fed the R diets (1.6, 7.1 and 3.7 mg × bird^{-1}) were lower than those of hens fed the commercial diet (0.5, 1.9 and 0.8 mg × bird^{-1}). Daily CO_2 emissions from hens fed R diet (64,626; 79,799; and 80,335 mg × bird^{-1}) were less than those of hens fed the commercial diet (65,627; 86,243; and 82,694 mg × bird^{-1}). Additionally, age affected CO_2 emissions. Daily methane emissions from hens fed R diet (138.5, 28.2 and 9.4 mg × bird^{-1}) were lower than those of hens fed the commercial diet (153.1, 43.8 and 11 mg × bird^{-1}). Age affected methane emission with younger birds producing more methane than older birds. Daily emissions of NO from hens fed R diets (0.71, 0.11 and 0.21 mg × bird^{-1}) were less than those from the control diet (0.94, 0.2 and 0.28 mg × bird^{-1}). No diet or age effects were observed for NO_2 non-methane total hydrocarbons.

Diet acidification, CP reduction, and zeolite supplementation reduced the emissions of NH_3 (by 39%; Figure 2), CO_2 (by 5%), CH_4 (by 17%) and NO (by 48%). Diet acidification increased the gaseous emissions of H_2S mainly because of the high concentration of sulfate in the acidifying agent used. More research is needed to address the increased H_2S emissions and to explore the impact of graded concentrations of the additive on emissions.

Implication

Emergency Planning and Community Right-to-Know Act (**EPCRA**) and Comprehensive Environmental Response, Compensation, and Liability Act (**CERCLA**) reporting requirement allow daily emissions 100 lb of both NH_3 and H_2S from poultry farms. The current study illustrated that feeding a reduced emission diet could increase hen population by 40% without exceeding the requirements. Even though gypsum addition increases H_2S emissions considerably, these concentrations did not surpass reporting limits even for the larger laying hen complexes. Reporting requirements for laying hens operations for CERCLA/EPCRA, therefore, will be driven by NH_3.

References

Cabuk, M., A. Alcicek, M. Bozkurt, and S. Akkan, 2004. Effect of yucca schidigera and natural zeolite on broiler performance. Int. J. of Poultry Sci. 10:651–654.

Hale III, E.C. 2005. Reduction of ammonia emission, phosphorus excretion, and potassium excretion in laying hen manure through feed manupulation. 2005 Animal Waste Management Symposium, Research Triangle Park, North Carolina.

Keshavarz, K. 1991. The effect of calcium sulfate (gypsum) in combination with different sources and forms of calcium carbonate on acid-base balance and eggshell quality. Poultry Sci. 70:1723-1731.

McCrory, D. F., and P. J. Hobbs. 2001. Additives to Reduce Ammonia and Odor Emissions from Livestock Wastes: A Review. J. Environ. Qual. 30:345–355.

National Research Council. 1994. Nutrient Requirements of Poultry, 9th rev. ed. National Academy Press, Washington, DC.

H.S. Nakaue, J.K. Koelliker. 1981. Studies with clinoptilolite in poultry. I. Effect of feeding varying levels of clinoptilolite (zeolite) to dwarf single comb white leghorn pullets and ammonia production. Poultry Sci. 60:944–949.

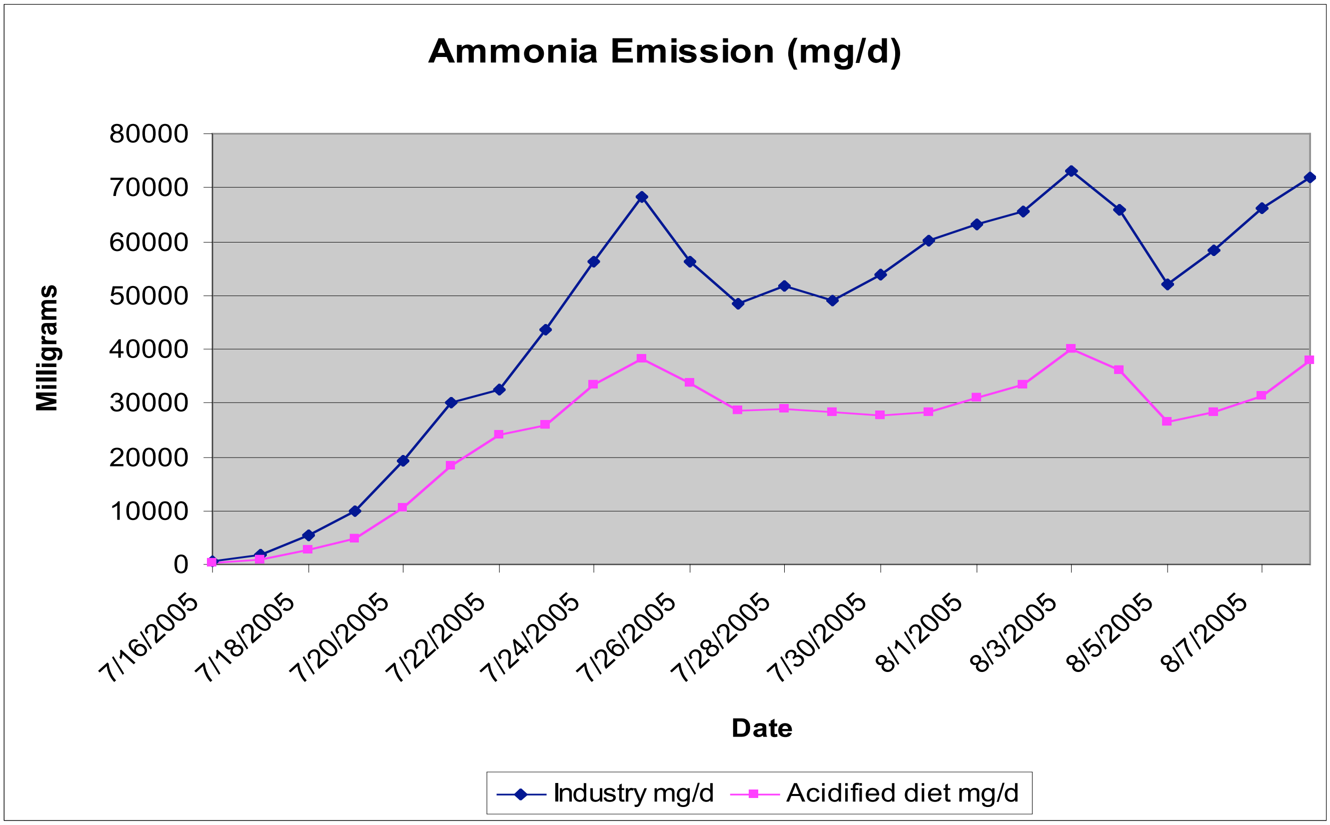

Figure 2. Ammonia emissions over a 3-week period following feeding of two dietary treatments to 38-week old hens.