Feeding a Combination of Acidogenic Materials and Cation Exchangers Reduces Manure Ammonia Emissions and Improves Laying Hen Performance

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Species: Poultry
Use Area: Animal Housing
Technology Category: Diet Modification
Air Mitigated Pollutants: Ammonia

Description:

Poultry manure ammonia emissions can be significantly reduced by dietary manipulation. Feeding suitable levels of acidogenic materials and indigestible cation exchangers to laying hens in a production environment resulted in average manure ammonia emission reductions of up to 68%.

Improvements in the production environment reduce bird stress, resulting in improved performance and reduced production costs.

Mitigation Mechanism:

The mitigation mechanism is a two-step process. Ammonia (NH3) is a neutrally charged molecule that protonates to form the cationic molecule ammonium (NH4+) when subjected to acidic pH levels.

As excreted, poultry manure exhibits a basic pH, so substantially all of the ammonia produced by enzymatic degradation of uric acid exists as ammonia. When acidogenic materials are introduced into the diet, manure pH is reduced. When fed in sufficient amounts, manure pH can be reduced so that substantially all the ammonia is protonated, forming ammonium. It would be ordinarily expected that the cationic ammonium would react with the acidic anion causing the pH reduction, but this reaction tends to be inefficient.

When an indigestible cation exchanger with a strong preference for binding ammonium is fed along with sufficient levels of an acidogen to reduce manure pH to 7 SU or below, the ammonium strongly binds to the cation exchanger, and is effectively sequestered in the manure.

Applicability:

This feed program is suitable for use by egg producers who wish to improve bird health through reducing levels of ammonia in the production environment. The feed program is suitable for use in high-rise, belt-battery, aviary, and free-range housing environments.

Limitations:

In general, overfeeding acidogens can affect the acid-base balance of the bird to a point where performance is adversely affected. Two acidogens have been evaluated as part of the combined feed system--gypsum and sodium bisulfate.

For laying hens, the highest ammonia emission reductions were noted when gypsum supplied approximately 35% of the calcium in the diet. Using gypsum as the source for more than about 60% of dietary calcium resulted in slightly reduced overall production and thinning eggshells. The adverse effects increase as gypsum levels increase beyond the point where they supply 60% of dietary calcium. At levels where gypsum supplied 72% of dietary calcium, marked decreases in egg numbers and shell quality were noted.

Sodium bisulfate is also an effective acidogen for laying hens, and can be used to reduce ammonia emission rates for broilers, as well. Sodium bisulfate is a source of dietary sodium, and can be used as a replacement for other sodium sources in the diet. Sodium bisulfate should comprise between 0.5% and 0.75% of the feed for either layers or broilers, with a 0.75% inclusion rate being the more effective of the two at reducing manure pH. At those levels, sodium bisulfate does not supply sufficient sodium or chloride to meet the dietary needs of the bird. A combination of sodium chloride and potassium chloride should be used with sodium bisulfate to meet dietary sodium and chloride levels. Sodium bisulfate should not be fed at levels which would cause overfeeding of sodium.

Two indigestible cation exchangers have been evaluated, zeolite and humate. Both are similarly effective at sequestering ammonium cations, and can be used in concert with gypsum or sodium bisulfate.

Zeolite and humates generally exhibit either neutral or slight basic slurry pH levels, and have significant buffering capacities. In general, as long as the buffering capacity of the cation exchanger does not too significantly affect the pH reduction caused by the acidogen, the higher the inclusion rate of the cation exchanger for any given level of acidogen fed, the higher the ammonia emission reduction noted.

With regard to feeding zeolites and humates at levels well in excess of the amount needed for optimal ammonia emission reductions, no adverse effects have been noted.

Cost:

If there is available bin space at a feed mill, no initial capital expenditures are needed to implement the diet. The gypsum/zeolite version is available in a pre-mixed form and can be delivered in bulk, or the materials can also be sourced on the open market and blended directly at the feed mill as needed.

Sodium bisulfate/zeolite or sodium bisulfate/humate versions are not currently available in a pre-mix version, but each component comprises a small enough percentage of the feed that they can be added to the ration via an existing micro-bin system.

For laying hens, per-ton amended feed costs are increased compared to per-ton standard feed costs. However, increased overall production, improvements in saleable egg numbers, improved feed conversion ratios, and reductions in mortality more than offset the increased feed cost.

Implementation:

A diet comprising 5.75% gypsum and 1.25% zeolite was fed to 125,000 hens in a high rise house. An additional 125,000 hens of the same age acted as control. Temperature set-points were the same, airflow controls, and fan stage operation was set the same to cause both houses to be under the same operating conditions. Both houses were constructed alike, and had the same number and type of fans installed in analogous locations. Manure amounts in the storage pit were the same. Hen diets were nutritionally equivalent, despite differences in formulation.

Insuring that airflow, temperature, etc., were the same between both houses enabled those factors to be removed from consideration when determining emission rate differences, so that any differences in ambient ammonia levels corresponded with differences in emission rates.

In order to determine the average ambient ammonia concentration in exhaust air, 10 analogous fans that were always in operation were identified in each house. An ammonia meter (Bacou-Dalloz ToxiPro) was placed in the airflow of each fan, allowed to equilibrate, and the reading recorded. This was done in each of the two houses, and an average ammonia level was calculated for each house. Then, the two values were compared to determine the difference in ammonia levels between the two houses.

Prior to collecting data, the test house was fed the amended diet for a period of one week, to allow the hens to acclimatize to the new diet. Data was collected every other day for a period of a month after the acclimatization period. The average reduction over the trial period was 68%. Graph 1 illustrates the results of the trial.

Over a 14-week period, 375,000 laying hens of varying ages were fed a diet comprising 2.5% gypsum and 1.0% zeolite. An additional 375,000 hens of varying ages were fed industry standard rations as a control. Production parameters were monitored for both groups. Prior to implementing the diet, production data from both groups was compared to determine any innate differences between the two groups. No statistically significant differences in any of the monitored parameters were noted. After implementation, hens fed the test diet exhibited statistically significant improvements in production. The parameters monitored and any increases or decreases in those parameters exhibited by the hens fed the test diet are shown in Table 1.

For 12 weeks of the 14 week period, relative ambient ammonia level data was collected, using the same controls and methods previously outlined. As before, controlling temperature and fan operation to insure consistant airflow between the houses allowed the difference between average ambient ammonia levels to adequately represent differences in emission rates. Over the 12 week period, the average reduction was 44%. The results are reported in Graph 2.

Graph 1

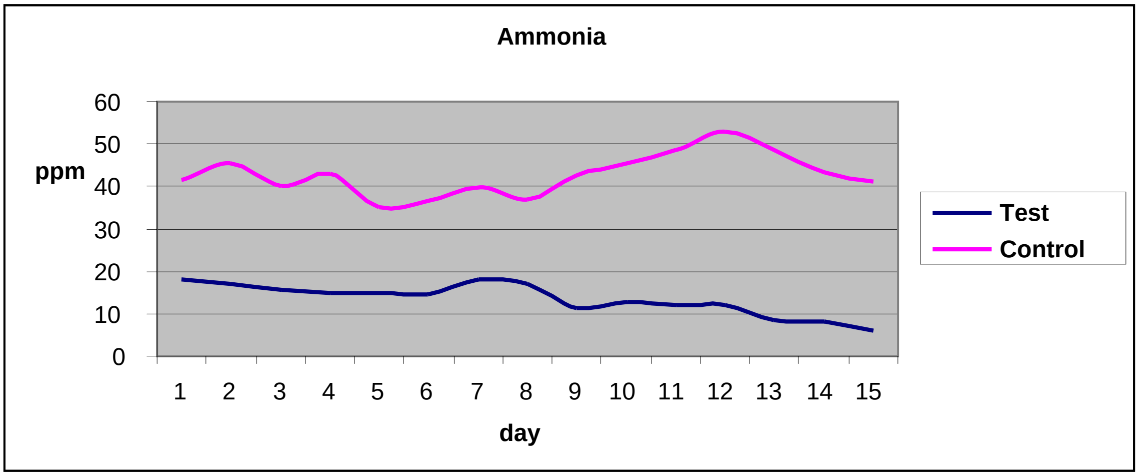
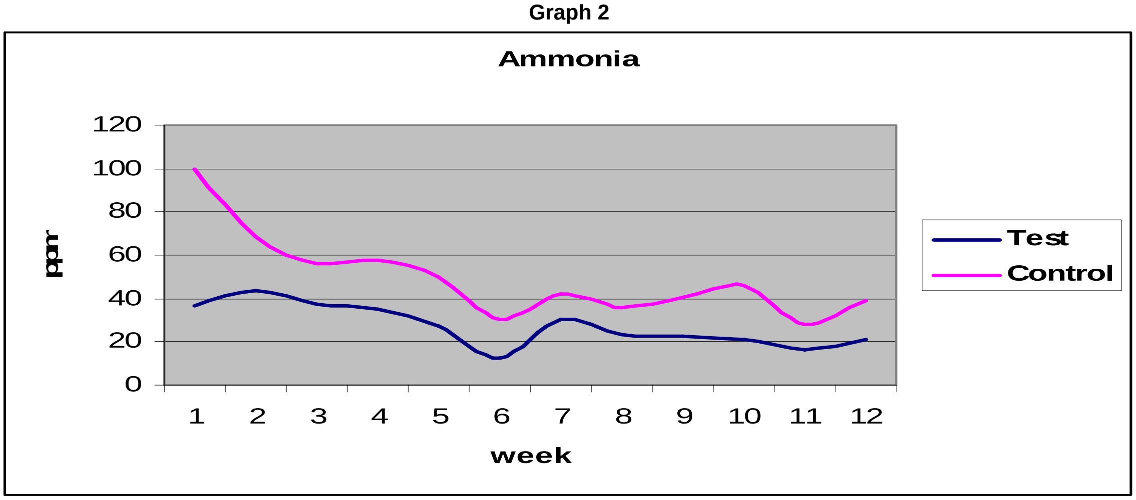


Table 1

14 Week Implementation Cost Test, Production Scale (~750,000 hens)

	Difference, %
Total Production, dozen eggs/week	+5.92
Grade A, Lg+, dozen eggs/week	+5.28
Grade A Total, dozen eggs/week	+3.50
Mortality, hens/week	-21.51
Lbs Feed to produce a dozen eggs/week	-1.95
Feed Cost, per ton	+2.23
Undergrade, dozen eggs/week	-0.40
Total Feed Consumed/week	+3.49
Cost to Produce a Dozen Eggs	-3.24

Graph 2



Technology Summary:

Feeding laying hens a combination of acidogenic materials and indigestible cation exchangers reduces manure ammonia emissions by effectively sequestering ammonium in the manure. Reductions of between 44% and 68% were noted, depending on the amounts of acidogens and cation exchangers fed.

Initial feed costs were elevated, but improvements in performance translated into a reduction of per-dozen production costs.

Additional Resources:

Additional information regarding feeding acidogens, cation exchangers, and combinations of the two is available on the internet through a variety of sites.

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Thanks to Dr. Albert Heber for his assistance in designing the strategy used to estimate relative differences in emission rates between poultry houses using simple equipment that can be implemented at farm level.

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